EVALUATING PLANT POPULATIONS AND REPLANT CONSIDERATIONS ACROSS MULTIPLE PEANUT (*ARACHIS HYPOGAEA* L.) PRODUCTION METHODS

by

JASON MICHAEL SARVER
(Under the Direction of R. Scott Tubbs)

ABSTRACT

The University of Georgia Extension recommendation for optimum plant stand in peanut (*Arachis hypogaea* L.) is 13.1 plants $m^{-1}$, although previous work has shown that yield potential can be maintained at plant stands lower than optimum. The unpredictable and often extreme weather and the ubiquity of pathogens in the region often contribute to poor emergence and a resultant poor plant stand. When plant stand is adversely affected, a point may be reached where replanting the field via either supplemental addition of seed or complete destruction and full replanting becomes a viable option. Field trials were conducted across peanut-growing regions in Georgia and Florida to determine i) the effect of plant stand on pod yield, market grade, and disease incidence, ii) at what plant stand peanut benefits from replanting, and iii) the best method for replanting peanut when an adequate stand is not achieved. Trials were conducted on peanut planted in single rows, twin rows, in strip tillage, and across multiple planting dates and time durations between initial planting and replanting. When seeded in single rows, pod yield increased linearly and tomato spotted wilt virus decreased linearly as plant stand was increased from 3.3 to 13.1 plants $m^{-1}$. In twin rows, both pod yield and grade were maximized at 12.3 plants $m^{-1}$, with losses observed by reducing plant stand and no gains observed by increasing stand. Yields were increased by supplementing the original stand at 3.3 and 8.2 plants $m^{-1}$ in single rows and at 9.8 plants $m^{-1}$ in twin rows. Completely replanting was never a viable option. In strip tillage, yield was increased by supplementing the initial stand and by completely replanting the initial stand in one of four site-years. Yield was generally reduced at a later planting date when testing planting dates and multiple replant dates, while yield was only improved by replanting in three of eight site-year by planting date combinations. Overall, this data stresses the importance of establishing an adequate plant stand at the initial planting date, as replanting below-optimum stands rarely restores pod yield to a level equal to an optimum stand at the initial planting date.

INDEX WORDS: Arachis hypogaea, Peanut, Replanting, Replant decisions, Conventional-tillage, Strip-tillage, Planting date, Plant stand, Plant population, Tomato spotted wilt virus, Southern stem rot, Market grade, Total sound mature kernels, Glufosinate

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# DEDICATION

I dedicate the work that went into this project first and foremost to my wife, Erin. You supported me mentally, emotionally, and financially throughout this process of 'going back to school'. You agreed to put your plans on hold and to move away from Kentucky for the first time and never once complained. You were nothing but supportive throughout the process, and for that I am grateful. Next, I would like to dedicate the work to my Daughter, Madeleine Kate. Maddie, I had you in mind long before you were born. It made doing the work much easier knowing the reward would ultimately be the ability to better support you and your mother in the future. I would also like to dedicate this work to my Dad and Mom, Mike and Karen. You both have always shown me the value of a strong work ethic. In fact, I don't know anyone that works harder than either of you. I appreciate that and your constant encouragement of me to continue my education as far as I could.

Lastly, I would like to dedicate the contents of this dissertation to the peanut growers of the United States. Without you, our work would be futile and this country would not be what it is today. Hopefully this project will be of some benefit to you and your operations.

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# CHAPTER 1

## INTRODUCTION AND LITERATURE REVIEW

Determining when and how to replant a poor stand of peanut (*Arachis hypogaea* L.) are research topics that has received a disproportionate amount of attention compared to its agronomic and economic utility for peanut producers. 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 less than 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 (Culbreath et al., 2011; Sconyers et al., 2007, Sorenson et al., 2004), 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 in the area of replant decisions in peanut, numerous articles exist on the reasons why peanut may exhibit poor emergence and plant stands. Of major concern are the multitude of seedborne and soilborne pathogens that can infect peanut seed and seedlings. These pathogens include *Rhizopus* spp., *Penicillium* spp., *Fusarium* spp., *Aspergillus niger*, and *Aspergillus flavus* (Sullivan, 1984). Because of this wide range of pathogens, peanut is susceptible to infection no matter the planting conditions. Aspergillus crown rot is most common in hot and dry conditions (Jackson and Bell, 1969), as opposed to *Rhizopus* seed rot, which is most common in cool and wet conditions (Sullivan, 1984). Because there is no perfect condition for planting seed as it relates to seed and seeding disease incidence, growers will continually deal with plant stand issues related to these diseases. Fungicide seed treatments have proven to be effective at controlling seedling diseases and improving plant stands (Melouk and Backman, 1995; Ruark and Shew, 2010; Tubbs et al., 2013; Turner and Backman, 1991), but significant stand loss can still occur when treatments are employed.

Herbicide injury by either carryover from applications to previous crops or by unintentional misuse of products on the peanut crop can lead to poor plant stands or significant damage to the crop during the season. Numerous commonly used herbicides have been shown to cause peanut seedling injury including diclosulam (Grey et al., 2001; Murphree et al., 2003) and flumioxazin (Burke et al., 2002; Grichar et al., 2004; Price et al., 2004). Lassiter et al. (2008) described the effect of glyphosate on peanut. They discovered yield losses ranging between 336 and 4916 kg $ha^{-1}$ depending on the rate of application. The authors determined that replanting was the more economical option when crop injury totaled 48% or greater. Serious peanut injury has also been observed with multiple rates of glufosinate (Prostko et al., 2013) and dicamba (Prostko et al., 2011) herbicides. While none of the aforementioned herbicides are labeled for use on peanut, it is not uncommon for the products to be mistakenly applied to a peanut crop (Grey and Prostko, 2010). The most common routes of application include drift when the product is being applied to an intended crop or error by an applicator mistakenly applying these products to peanut rather than the intended crop, most commonly corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), and soybean (*Glycine max* L. Merr).

Mechanical issues at planting may also contribute to less-than-adequate plant stands. In general, today's most widely-used cultivars are larger than commonly planted cultivars from the past. Today's vacuum style planters are more prone to have difficulty picking up and placing larger seeded cultivars in the seed furrow on a consistent basis, leading to 'skips' in the row and a lower seeding rate than intended. This problem can be exacerbated by increased planting speed. Tubbs and Sarver (2013) reported a consistent decrease in plant stand as planter speed increased in five environments in Georgia. While it is often tempting for growers to plant at the maximum possible rate of speed, especially in situations where the optimum planting window has become shortened, plant stand establishment should be considered.

Poor seed quality is a common cause for poor germination and emergence. Seed quality can largely be attributed to production practices, cultural practices, and environmental factors where the seed is produced. Proper Ca nutrition is essential for proper embryo development in peanut seed, as evidence by Sullivan et al. (1974), Cox et al. (1976), and McLean and Sullivan (1981) who found improved germination in peanut following adequate Ca levels and gypsum ($CaSO_4$) applications. Dickens and Khalsa (1967), and McLean and Sullivan (1981) reported that high moisture at peanut harvest may also reduce percent germination. Reduction in seed quality may also be attributed to poor handling, either by the grower or prior to the grower receiving the seed. Bell (1969) showed that mechanical shelling can significantly reduce seedling emergence when compared to seed shelled by hand. Dey et al. (1999) reported that mechanically-shelled seed had lower germination when the testa had slipped or been removed.

Nielsen (2003) listed nine pieces of information that must be considered when making replant decisions: 1) original target plant population, 2) after-damage plant population, 3) after-damage stand uniformity, 4) after-damage plant defoliation, 5) original planting date, 6) expected replanting date, 7) expected replanting costs, 8) expected "normal" yield, and 9) expected market price. While Nielsen listed these factors for corn, they are applicable for any row crop, including peanut. The reason for a poor plant stand must be determined in order to make the best decision possible for replanting. If adverse soil conditions are suspected as the cause of the poor plant stand after the initial planting, it is advisable for a producer to wait until these conditions improve, whether from increased temperatures, increased rainfall or the correction of other factors that led to poor emergence. Likewise, a producer would need to recalibrate or fix any other issues with their equipment that may have prevented satisfactory initial plant stands.

When all considerations have been made and the decision to replant peanut is the best circumstance, a grower generally has two options: 1) destroy all vegetation from the initial planting with either a herbicide treatment or tillage and completely replant at a full seeding rate, or 2) offset the planter 7.6-10.2 cm and supplement the initial stand with a reduced seeding rate. Some producers prefer to start over, which holds an advantage by ensuring all plants are at the same maturity level when harvest decisions are to be made. A disadvantage to this treatment is the increased costs associated with planting a full seeding rate multiple times in the same field and an additional herbicide application or tillage pass. Because seed costs are consistently the largest single variable cost in peanut production (Smith, 2012; Smith, 2013), this becomes a significant expense for peanut producers. Direct costs are reduced using the supplemental method, as the second planting allows for the use of a lower seeding rate to achieve an optimum plant stand, and because neither herbicide nor tillage is needed for initial plant removal. The disadvantage of this system is that maturities vary between plants from the initial planting and the second planting, making it more difficult to properly time harvest.

Improper timing can potentially lead to lower yield and/or grade for peanuts, reducing revenue potential. The decision to replant is desired as soon after initial planting as possible, especially in scenarios of supplemental seed addition. As the duration between plantings becomes longer, the maturity differences become more pronounced. A general disadvantage of any replant treatment is that planting date is pushed later in the year. Research has shown pod yield losses when moving from the ideal planting window of early- to mid-May to late-May and June (Drake et al., 2014; McKeown et al., 2001; Tillman et al., 2007). In some cases the later planting date associated with replanting may be advantageous, such as when the initial planting date is in April (McKeown et al., 2001; Nuti et al., 2013; Tillman et al., 2007), but yield potential tends to decline once planting date moves outside of the optimum window. Deciding not to replant and thus leaving plots at stands below optimum reduces costs, but may result in the loss of yield and revenue potential if the loss associated with plant stand is greater than the loss associated with a later planting date.

Replant decisions have been more widely studied in other row crops. In cotton, Wrather et al. (2008) reported that early-planted cotton should only be replanted if plant population is below 16,988 plants $ha^{-1}$ with a uniform spacing. In a soybean replant test using two varieties, one variety showed a reduction in yield when supplementing initial stands of 67 and 33% of optimum, while the other variety had a yield increase of 134 and 537 kg $ha^{-1}$, respectively, when replanting into those same initial stands (Vasilas et al., 1990).

The overriding purpose of this research was to develop a base of knowledge about optimum plant stands and replanting options across a variety of peanut production methods, in order to make research supported recommendations to growers when plant stands are below optimum.  The multitude of potential causes for poor plant stands warranted further exploration into best management practices for how to handle these issues.   Specific objectives were 1) to determine the effect of plant stand on pod yield, market grade, and disease incidence, 2) to determine at what plant stand a peanut crop could gain an advantage from replanting, and 3) to determine the best method of replanting across peanut in single rows, twin rows, when planted in strip-tillage, and across various planting dates and time durations between initial planting and replanting.

Chapters two through five of this document each represent a manuscript reporting on replanting in single rows, replanting in twin rows, replanting in strip tillage, and replanting after multiple planting dates and durations between initial planting and replanting.  Each of the manuscripts will be submitted for publication in peer-reviewed scientific journals.

# CHAPTER 2

# EFFECT OF PLANT POPULATION AND REPLANT METHOD ON PEANUT (*ARACHIS HYPOGAEA* L.) PLANTED IN SINGLE ROWS[1]

[1] Sarver, J.M., R.S. Tubbs, J.P. Beasley, Jr., A.K. Culbreath, D.L. Rowland, and N.B. Smith. To be submitted to *Agronomy Journal*.

**Abstract:** The University of Georgia Extension recommendation for optimum plant stand in peanut (*Arachis hypogaea* L.) is 13.1 plants $m^{-1}$, although previous work has shown that yield potential can be maintained at lower plant stands. The unpredictable and often extreme weather and the ubiquity of pathogens in the region often contribute to poor emergence and poor plant stands. When plant stand is adversely affected, a point may be reached where replanting the field becomes a desirable option. The objectives of this study were to determine i) the effect of plant stand on yield, grade and disease incidence, ii) at what plant stand peanut gains an advantage from replanting and iii) the best method for replanting peanut when an adequate stand is not achieved. Field trials took place in Plains, GA in 2011, 2012, and 2013; and Tifton, GA in 2012 and 2013 to evaluate peanut production at six plant stands (3.3, 4.9, 6.6, 8.2, 9.8, and 11.5 plants $m^{-1}$) in combination with three replant practices (no replant, destroy the original stand and replant at a full seeding rate, and add a reduced rate of seed to supplement the original stand) in a randomized complete block design. A positive linear trend for yield and a negative linear trend for tomato spotted wilt virus incidence were discovered as plant stand increased. Yield advantages from replanting occurred via supplemental seed addition at initial stands of 3.3 and 8.2 plants $m^{-1}$. Completely replanting always resulted in lower yield than the other two replant practices.

**Introduction**

Establishing a non-yield-limiting, uniform plant stand is an important factor in growing a successful peanut crop. The University of Georgia's recommendation for peanut seeding rate in single-row peanuts is 19.7 seeds $m^{-1}$ of row in an effort to obtain a final stand of 13.1 plants $m^{-1}$ (Beasley et al., 1997). While 13.1 plants $m^{-1}$ is the standard by which recommendations have been made, research has shown that in some cases, yield potential can be maintained at reduced plant stands (Augusto et al., 2010; Bell et al., 1987; Tewolde et al., 2002).

While data is limited on true plant stand effects on peanut yields, numerous other studies have described the relationship between seeding rates and pod yields. Sorenson et al. (2004) reported an 8.5% pod yield increase when seeding rates were increased from 10 to 20 seeds $m^{-1}$. Sconyers et al. (2007) showed increased yield at 22.6 seeds $m^{-1}$ versus 12.5 seeds $m^{-1}$, although yields at the high rate were not greater than those at 17.4 seeds $m^{-1}$. When testing seeding rates from 34 to 123 kg $ha^{-1}$, Wehtje et al. (1994) reported maximum yield at 101 kg seed $ha^{-1}$. With Spanish peanuts in Oklahoma, yield increased linearly as seeding rate increased from 7 to 22 seeds $m^{-1}$ (Chin Choy et al., 1982). That research went on to show that yield per plant decreased as population increased, although the total yield increased “faster” than the yield per plant decreased. Sternitzke et al. (2000) described similar results, in which pod mass per plant increased at lower plant stands; however, total pod yield was higher at higher plant stands. When testing intra-row spacings from 5 to 40 cm, Kvien and Bergmark (1987) reported increased yields at the decreased spacing when peanut was planted within the recommended planting date window.

Research has shown that farmer stock grade (% total sound mature kernels, TSMK) can also be affected by plant stand. Mozingo and Coffelt (1984) reported a higher farmer stock grade in a virginia-type peanut in a higher versus a lower plant population. These results were similar to Sorenson et al. (2004), who showed a 0.7 point increase in TSMK when seeding rate was increased from 10 to 20 seeds $m^{-1}$. Sconyers et al. (2007) found similar results, with higher TSMK at a seeding rate of 17.4 seeds $m^{-1}$ versus a rate of 12.5 seeds $m^{-1}$ in one study and higher

TSMK at 22.6 seeds $m^{-1}$ than at 12.5 seeds $m^{-1}$ in another. Numerous other studies have reported increased grade at increased plant population (Cox and Reed, 1965; Wynne et al., 1974). Plant stand and seeding rate effects on market grade are not always consistent, though. Chin Choy et al. (1982) found no differences for TSMK values between seeding rates of 7, 15, and 22 viable seeds $m^{-1,}$ while Knauft et al. (1981) showed a significant difference in grade in only one of six cultivars when varying plant population. Hurt et al. (2004) reported mixed results with a 7 plants $m^{-1}$ stand having a higher TSMK than a 17 plants $m^{-1}$ stand in two of five experiments, the greater stand having a higher TSMK in two of five experiments, and no difference in TSMK in the fifth experiment.

It has been widely reported that increasing plant stands decreases incidence of tomato spotted wilt virus (*Tospovirus)* (TSWV). While the mechanism behind this phenomenon is not completely understood, there are multiple theories as to why it occurs. One potential reason for the decrease could be less exposed ground at higher plant stands. Two species of thrips; western flower thrips (*Frankliniella occidentalis* (Pergande)), and tobacco thrips (*Frankliniella fusca* (Hinds)) which vector the disease in peanut, are thought to be more attracted to this exposed ground than to ground covered by a crop canopy (Reddy and Wightman, 1988). Another line of thought is that the reduction may be a function of fewer plants being fed on by thrips as a percentage of the total number of plants in the field (Brown et al., 2005). Wehtje et al. (1994) reported a decrease in TSWV incidence when increasing seeding rates from a low of 34 to a high of 123 kg $ha^{-1}$. Similarly, Gorbet and Shokes (1994) reported increased TSWV as within-row plant spacing increased. Field surveys in Georgia in 1992 revealed a reduction in the percentage of peanut plants infected with TSWV when plant density increased from <6.6 to 6.6-

13.12 to >13.12 plants $m^{-1}$ (Culbreath et al., 1999). While data trends toward reduced TSWV at increased population, this does not always hold true, as evidenced by Sconyers et al. (2007), who found no differences in TSWV when rating the disease across three seeding rates.

Southern stem rot (SSR), caused by the fungus *Sclerotium rolfsii,* has also been shown to be affected by seeding rates and plant populations. Sconyers et al. (2005) reported increases in SSR incidence when plant spacing decreased from 30 cm to 5 cm in 5-cm increments. Wehtje et al. (1994) found that SSR increased in a linear fashion when seeding rate increased from 34 kg $ha^{-1}$ to 124 kg $ha^{-1}$. Similarly, Sconyers et al. (2007) reported increased SSR in plots seeded at 22.6 seeds $m^{-1}$ when compared to those seeded at 12.5 and 17.4 seeds $m^{-1}$, respectively. Augusto et al. (2010) reported consistent increases in SSR at increased plant populations in areas with significant levels of the pathogen.

The multitude of potential causes for a poor plant stand and a lack of previous results in peanut necessitated research designed to better understand the agronomic and pathological ramifications of replant decisions. There were three main objectives of this test. The first was to determine the effect of plant stand on pod yield, market grade, TSWV, and SSR in peanut seeded in single rows. Building on the first objective; the second objective was to determine at what plant stands a peanut crop gains an advantage from replanting. The last objective was to determine the method of replanting that was most advantageous when replanting is warranted.

**Materials and Methods**

Irrigated field trials were conducted on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2014) at the University of Georgia (UGA) Ponder Farm in 2012 and at the NESPAL Farm in 2013; both near Tifton, GA. Tests were also conducted under irrigation on a Greenville sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults) (USDA-NRCS, 2014) at the UGA Southwest Research and Education Center near Plains, GA in 2011, 2012, and 2013.

Land preparation at the Tifton sites included disc-harrowing, deep-turning with a moldboard plow to a depth of 30 to 35 cm, and rotary-tilling to form peanut beds 1.8 m wide. Preparation at the UGA Southwest Research and Education Center was similar with the exception of 2012, in which moldboard plowing did not occur. All fertilizer requirements and applications, including those for calcium and boron, were based on UGA Extension recommendations (Harris, 1997). Pre-emergent herbicides application at all site-years consisted of a tank-mix of pendimethalin[1] (0.93 kg a.i $ha^{-1}$), diclosulam[2] (27 g a.i. $ha^{-1}$), and flumioxazin[3] (107 g a.i./ha), which were watered with 1.3 cm of water via center pivot irrigation.

Peanut cultivar Georgia-06G (Branch, 2007) was planted using a two-row Monosem precision air planter[4] at a depth of 5 cm and a row spacing of 0.91 m in rows 12.2 m in length. Seed was treated with azoxystrobin, fludioxonil, and mefenoxam[5] fungicide seed treatment. Planting dates and replant dates for each site-year (location X year) are listed in Table 2.1.

Trials were designed as a randomized complete block design with four replications, in a 6 x 3 factorial arrangement with six peanut plant stands (3.3, 4.9, 6.6, 8.2, 9.8, and 11.5 plants $m^{-1}$) and three replant options:

1. Leave the initial peanut plant stand and do not replant.
2. Retain the original plant stand, move the planter units 8.9 cm to the side and supplement with additional seed at a reduced seeding rate (Table 2.2).
3. Burn down the original peanut plant stand with glufosinate[6] herbicide and replant at the full 19.7 seeds $m^{-1}$ seeding rate.

A non-replanted control plot of the UGA recommended 13.1 plants $m^{-1}$ was also included. All plots were initially planted at 19.7 seeds $m^{-1}$ 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.

Fungicide applications were made based on guidelines provided by the high risk model of the Peanut Disease Risk Index (Kemerait et al., 2011). Post emergence herbicide applications at Tifton included clethodim[7] (280 g a.i. $ha^{-1}$), bentazon[8] (0.841 kg a.i. $ha^{-1}$) and crop oil concentrate[9] (2.34 L $ha^{-1}$) on 21 June 2012, and clethodim[7] (280 g a.i. $ha^{-1}$), bentazon[8] (0.841 kg a.i. $ha^{-1}$) and crop oil concentrate[9] (2.34 L $ha^{-1}$) on 18 June 2013. At Plains, post emergence herbicide applications included bentazon[8] (0.841 kg a.i. $ha^{-1}$) on 23 June 2011; bentazon[8] (0.841 kg a.i. $ha^{-1}$), acifluorfen[10] (0.421 kg a.i. $ha^{-1}$) and 4-(2,4-Dichlorophenoxy)butyric acid[11] (280 g a.i.

ha$^{-1}$) on 5 July 2012; and 4-(2,4-Dichlorophenoxy)butyric acid (420 g a.i. ha-1)[11] on 9 July 2013 and sethoxidim[12] (315 g a.i. ha-1) and crop oil concentrate (2.34 L ha$^{-1}$)[8] on 22 August 2013.

Treatments were evaluated for pod yield, grade (% TSMK), incidence of TSWV (Plains-2011 and 2012; Tifton 2012 and 2013) and incidence of SSR (Plains 2012; Tifton 2012 and 2013). Tomato spotted wilt virus levels were too low to warrant rating in Plains 2013 and SSR levels were too low to warrant rating in Plains in 2011 and 2013. Ratings for TSWV were conducted on 23 September 2011, and 28 September 2012 in Plains; and 28 September 2012 and 30 September 2013 in Tifton. Ratings for SSR were conducted on the date of plant inversion for each treatment. Peanut maturity was determined at each site-year using the hull scrape method (Williams and Drexler, 1981). Inversion and harvest dates are listed in Table 2.3. There were two inversion and two harvest dates for each site-year, except in Tifton 2013 which had three inversion and harvest dates. All peanuts receiving the no-replant and supplemental seed treatments were inverted and harvested earlier than those destroyed and replanted at the full seeding rate. In Tifton 2013, the no-replant treatment was inverted and harvested first, followed by the supplemental and then the complete replant treatment. Peanuts were inverted using a two-row KMC digger-shaker-inverter[13] and harvested using a two-row Lilliston peanut combine. Yields were adjusted to 7% moisture. Peanuts were graded by the USDA Federal-State Inspection Service in Tifton, GA (Davidson et al., 1982).

For the purpose of determining plant stand effects on pod yield, grade, TSWV and SSR; non-replanted plots were analyzed separately with PROC MIXED in SAS 9.3[14]. Plant stand was treated as a fixed effect, while location, and site-year (representing location x year effect) were treated as random effects. There were no interactions between locations, years and plant stand for any of the factors measured so further analyses were completed with data combined across locations and years. Because plant stand followed a logical structure, further analyses were completed using orthogonal polynomial contrasts in PROC MIXED in SAS 9.3[14]. For the purpose of determining replant treatment and replant treatment X plant stand effects, all data were analyzed together using PROC MIXED in SAS 9.3[14]. Data were analyzed by analysis of variance and differences among least square means were determined using multiple pairwise t-tests ($P \leq 0.05$). Replant treatment and plant stand were treated as fixed effects, while site-years, replications, and interactions with these factors were treated as random effects. Because replant treatment X plant stand interactions were present, replant treatment effects are reported for each plant stand separately (Table 2.4). There were no interactions between site-years, plant stands, and replant treatments. As a result, plant stand X replant treatment data is reported across locations and years.

**Results and Discussion**

***Plant stands.*** Plant stand significantly affected pod yield ($p=0.0084$) (Table 2.5). When looking further at the data, there was a significant linear trend for yield across plant stand ($P<0.0001$, $R^2=0.9131$), indicating that as plant stand increased, pod yield increase proportionately (Figure 2.1). This positive linear trend in pod yield is similar to results reported by Chin Choy et al. (1982), who found a linear yield trend in seeding rates of 7, 15, and 22 seeds $m^{-1}$. Linear trendline analysis of the data resulted in an equation of $y = 201.57x + 5023.3$, meaning that for every unit increase in plant stand, a resultant 201.57 kg $ha^{-1}$ increase in pod yield would be expected.

Overall, TSWV incidence was low. While the main effect of plant stand was not significant (P=0.2255) for TSWV incidence, there was a significant negative linear trendline (P=0.0097, R2=0.7813), indicating that as plant stand increased, TSWV incidence decreased proportionately (Figure 2.2). This reduction in TSWV as plant stand increased is similar to findings in multiple other studies (Gorbet and Shokes, 1994; Wehtje et al., 1994; Culbreath et al., 1999; Hurt et al. 2004). The linear trendline had an equation of y = -0.3536x + 4.2143, meaning that for every unit increase in plant stand, percent TSWV incidence would be expected to decrease by 0.3536 percentage points.

Neither grade nor SSR incidence were affected by plant stand. Because grade data as it relates to plant stand has been highly variable in previous studies, it is not surprising that grade was not affected. The majority of literature, though, reports that increased plant stand leads to increased SSR incidence (Wehtje et al. 1994; Sconyers et al., 2005; Sconyers et al., 2007). The lack of difference observed in our trials could be due to the exhaustive methods used to control initiation and spread of the disease. In the reference studies where disease incidence increased as plant stand increased, either a less-intensive fungicide program was used or plots were inoculated with the pathogen in order to ensure heavy pressure and uniformity of disease across the field. In this study, the high-risk model of the Peanut Disease Risk Index (Kemerait et al., 2011) was used at all site-years and overall SSR pressure was low. Augusto et al. (2010) reported that a greater number of plants $m^{-1}$ of row are allowable without increasing SSR incidence in areas of low pressure. While they described low incidence as 3% and below, average incidence of 4.3% in our study was only slightly above that level. Because more exhaustive control measures were utilized in our study and because disease pressure was low overall, it is not a complete surprise that SSR was unaffected by plant stand.

***Replant Treatment.*** The interaction of plant stand X replant treatment for yield (P=0.0255) indicated that the optimum replant treatment was dependent on initial plant stand (Table 2.6). The supplemental replant treatment significantly increased yield over not replanting at two initial plant stands; 3.3 plants $m^{-1}$ and 8.2 plants $m^{-1}$ (Table 2.6). At an initial stand of 3.3 plants $m^{-1}$, yield increased by 13.4% by supplementing with additional seed, while at an initial stand of 8.2 plants $m^{-1}$, supplementing with additional seed increased yield by 6.6%. Pod yields were similar between non-replanted and supplemental treatments at initial stands of 4.9, 6.6, and 11.5 plants $m^{-1}$ and yields were reduced by 10.1% when supplementing an initial stand of 9.8 plants $m^{-1}$. Completely replanting did not improve yield over the non-replanted treatment at any initial plant stand. At 6.6, 9.8, and 11.5 plants $m^{-1}$, yield was reduced when completely replanting, while at 3.3, 4.9, and 8.2 plants $m^{-1}$, no yield differences were observed. When comparing supplemental and complete replanting, a yield advantage was observed for the supplemental treatment at four of six initial plant stands (3.3, 6.6, 8.2, and 11.5 plants $m^{-1}$), while yields were equal at 4.9 and 9.8 plants $m^{-1}$. When taking all of these results into account, the supplemental replant treatment appears to be the superior option when compared to completely replanting. Grade, TSWV, and SSR were not affected by replant treatment or the interaction of plant stand X replant treatment.

**Summary and Conclusions**

The results from these trials illustrate the importance of establishing the recommended plant stand on the initial planting date. The strong, positive linear trend observed between plant stand and pod yield shows that pod yield potential is increased as plant stand per meter of row increases. When considering the standard error or the data, a minimum of 9.8 plants $m^{-1}$ were needed in order to statistically equal the yield obtained at the 13.1 plants $m^{-1}$ standard. While overall pressure of the disease was low, increased plant stand also helped to reduce TSWV incidence in a linear fashion, which is consistent with previously reported results. While yield and TSWV trended in opposite directions, effects of the disease on yield was likely minimal due to low overall disease pressure.

Supplementing the initial stand increased yield at initial stands of 3.3 and 8.2 plants $m^{-1}$ by 13.4 and 6.5%, respectively, and did not increase yield at any other stand. Destroying the initial stand and completely replanting was never a viable option when compared to either the non-replanted or supplemental replant treatments. While the 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 was likely a primary cause of lost yield when compared to the other replant options. Initial planting dates ranged from 7 May to 21 May, with an average date of 13 May; while replant date ranged from 27 May to 12 June, with an average date of 4 June. The yield reduction at the later planting date was consistent with multiple other studies (Beasley, 2013; McKeown et al., 2001; Tillman et al., 2007) that showed decreased yield for peanut planted in late-May and June versus peanut planted in mid-May. This is not always the case, however, as extreme weather conditions or pest pressure may affect an earlier planting more so than a later planting in a given season (Moss et al., 2012). 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 affected by replant treatment and showed not to be a limitation when deciding on what replant method to employ.

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. This is supported by both the linear trend for pod yield across plant stands and the finding that peanut only benefitted from replanting at two initial plant stands. Replanting should not be considered at plants stands greater than or equal to 9.8 plants $m^{-1}$, because replanting never resulted in a yield benefit at that stand or above. Because of the relatively large pod yield increase observed at 3.3 plants $m^{-1}$, it would be advisable for a grower to replant at that level if the replant treatment can be applied in a reasonable time window after the initial planting date. 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, especially as the initial planting date becomes later. Because grade, TSWV, and SSR were unaffected by replant method, pod yield, and ultimately profitability should be the deciding factors when making decisions about replanting a peanut field.

Table 2.1. Planting dates and replant dates in 2011, 2012, and 2013 in Plains, GA and 2012 and 2013 in Tifton, GA.

| | Plains 2011 | Plains 2012 | Tifton 2012 | Plains 2013 | Tifton 2013 |
|---|---|---|---|---|---|
| Planting Date | 9-May | 17-May | 21-May | 10-May | 7-May |
| Replant Date | 27-May | 8-Jun | 12-Jun | 5-Jun | 31-May |
| Replant Days After Initial Planting | 18 | 22 | 22 | 26 | 24 |

Table 2.2. Initial plant stand and replant seeding rate for supplemental replant treatments.

| Initial Stand (plants $m^{-1}$) | Replant Rate (seeds $m^{-1}$) |
|---|---|
| 3.3 | 19.7 |
| 4.9 | 16.4 |
| 6.6 | 13.1 |
| 8.2 | 9.8 |
| 9.8 | 6.6 |
| 11.5 | 3.3 |

Table 2.3. Inversion and harvest dates for three replant treatments in 2011, 2012, and 2013 at Plains and 2012 and 2013 at Tifton, GA.

| Replant Treatment | | Plains 2011 | Plains 2012 | Tifton 2012 | Plains 2013 | Tifton 2013 |
|---|---|---|---|---|---|---|
| None | Inversion Date | 4-Oct | 10-Oct | 16-Oct | 10-Oct | 30-Sep |
| | Harvest Date | 7-Oct | 17-Oct | 23-Oct | 16-Oct | 3-Oct |
| Supplemental | Inversion Date | 4-Oct | 10-Oct | 16-Oct | 10-Oct | 8-Oct |
| | Harvest Date | 7-Oct | 17-Oct | 23-Oct | 16-Oct | 16-Oct |
| Complete | Inversion Date | 23-Oct | 24-Oct | 25-Oct | 29-Oct | 24-Oct |
| | Harvest Date | 27-Oct | 29-Oct | 2-Nov | 4-Nov | 30-Oct |

Table 2.4. Peanut pod yield as influenced by replant method at six initial plant stands in peanuts planted in single rows across five site-years in Georgia.

| | Plant Stand (plants $m^{-1}$ of row) | | | | | |
|---|---|---|---|---|---|---|
| | 3.3 | 4.9 | 6.6 | 8.2 | 9.8 | 11.5 |
| Replant | ----------kg $ha^{-1}$---------- | | | | | |
| None | 5188 b[a] | 5383 | 5738 a[a] | 5750 b[a] | 6248 a[a] | 6036 a[a] |
| Supplement | 5881 a | 5476 | 5847 a | 6127 a | 5617 b | 5866 a |
| Complete | 5348 b | 5258 | 4868 b | 5443 b | 5350 b | 5276 b |
| SE[b] | ± 189 | | | | | |

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

[b]Standard error of the mean

Table 2.5. Plants stand effects on pod yield, grade, tomato spotted wilt virus (TSWV), and southern stem rot (SSR) across two locations and three years in Georgia.

| Source | Pod Yield | TSWV | Grade | SSR |
|---|---|---|---|---|
| | --------------------------------Pr > F | -------------------------------- | | |
| Stand | 0.0084 | 0.2255 | 0.9747 | 0.7238 |
| Linear | 0.0001 | 0.0097 | 0.5708 | 0.3315 |
| Quadratic | 0.4522 | 0.3510 | 0.8195 | 0.8015 |
| Cubic | 0.8876 | 0.3432 | 0.7280 | 0.2218 |
| Quartic | 0.7505 | 0.8813 | 0.4806 | 0.3640 |

Analysis includes only those plots that were not replanted.

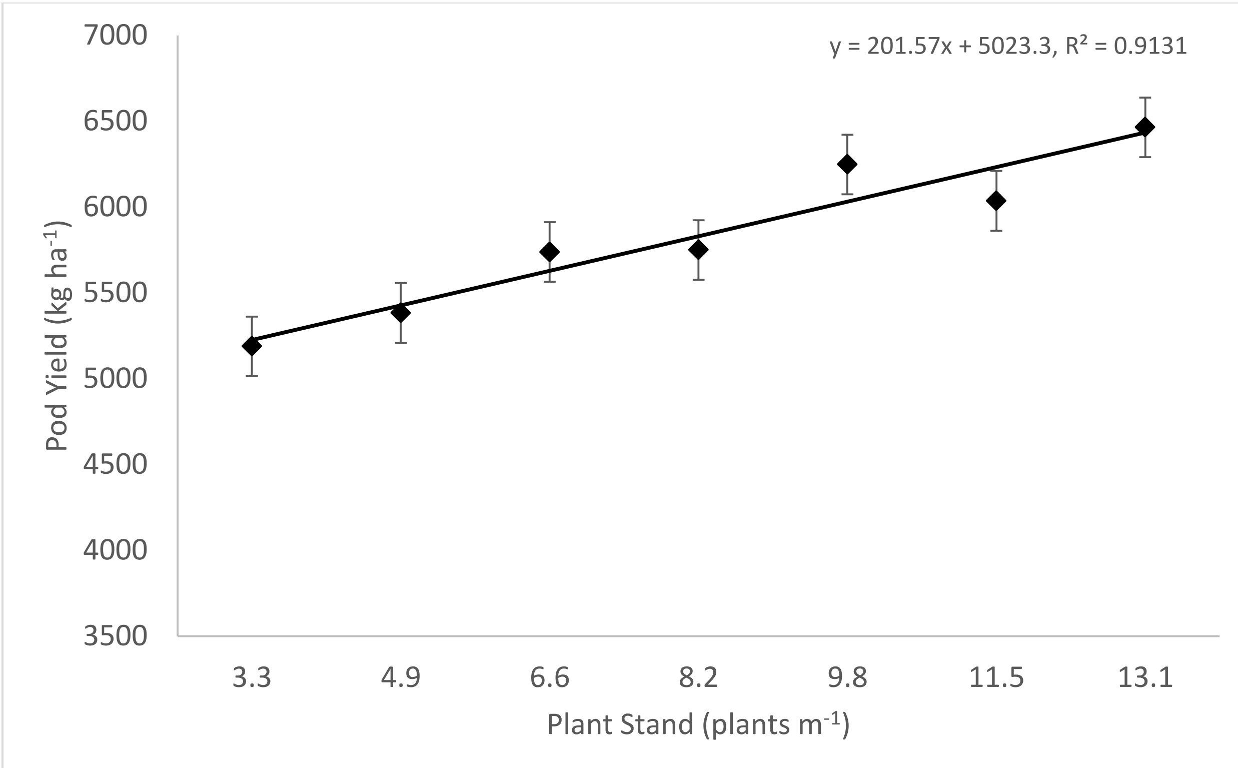


Figure 2.1. Linear trend for peanut pod yield across seven plant stands in peanuts planted in single rows across five site-years in Georgia.

Error bars represent ± standard error of the mean.

Equation and $R^2$ value are a result of analysis across the treatment means.

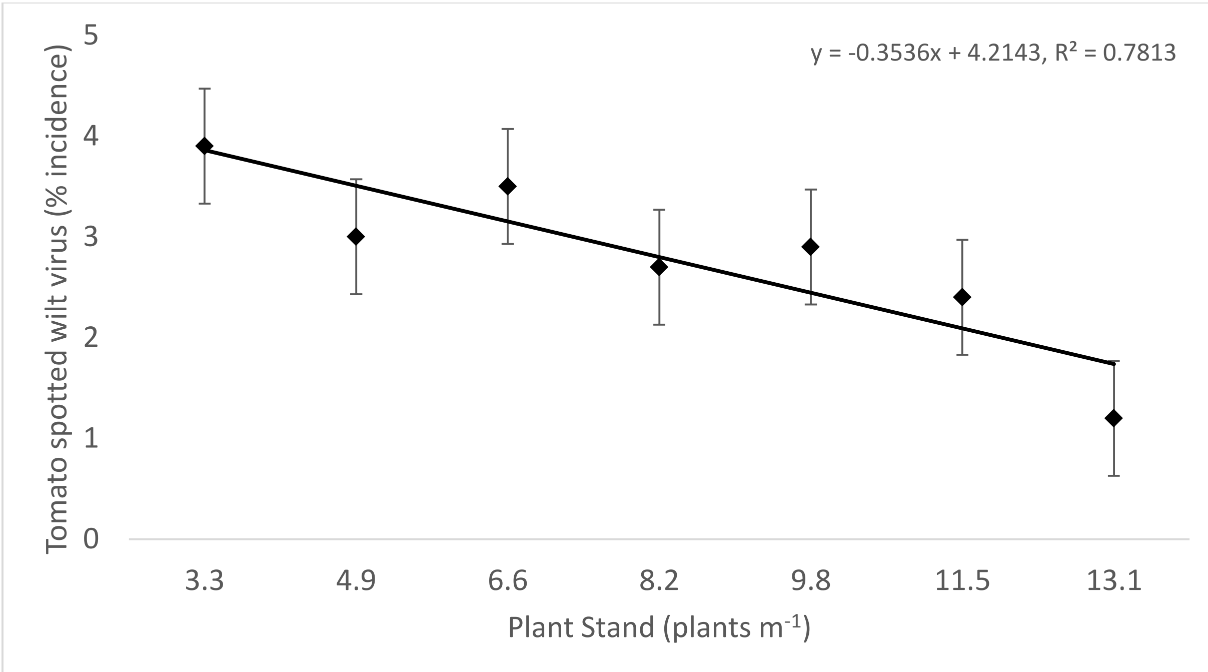


Figure 2.2. Linear trend for tomato spotted wilt virus incidence at seven plant stands in peanuts planted in single rows across five site-years in Georgia.

Error bars represent ± standard error of the mean.

Equation and $R^2$ value are a result of analysis across the treatment means

Table 2.6. Analysis of Variance for replant treatment, plant stand, site-year, and their interactions for pod yield, grade, tomato spotted wilt virus (TSWV), and southern stem rot (SSR) in Plains, GA in 2011, 2012, and 2013 and Tifton, GA in 2012 and 2013.

| Source | Pod Yield | Grade | TSWV | SSR |
|---|---|---|---|---|
| | --------------------------------Pr > F-------------------------------- | | | |
| Replant Treatment (RT) | 0.0903 | 0.1289 | 0.0931 | 0.4071 |
| Plant Stand (PS) | 0.0016 | 0.6464 | 0.1401 | 0.5609 |
| RT*PS | 0.0255 | 0.9552 | 0.6504 | 0.4104 |
| Site-Year (SY) | 0.0047 | 0.0020 | 0.0061 | 0.1129 |
| SY*PS | 0.7140 | 0.9662 | 0.7149 | 0.2368 |
| SY*RT | 0.0004 | 0.0023 | 0.2208 | <0.0001 |
| SY*RT*PS | 0.6319 | 0.0599 | 0.2561 | 0.9063 |

# CHAPTER 3

# EFFECT OF PLANT POPULATION AND REPLANT METHOD ON PEANUT (*ARACHIS HYPOGAEA* L.) PLANTED IN TWIN ROWS[1]

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[1] Sarver, J.M., R.S. Tubbs, J.P. Beasley, Jr., A.K. Culbreath, D.L. Rowland, and N.B. Smith. To be submitted to *Peanut Science*.

**Abstract:** Plant stand establishment is a major consideration when making planting and early season management decisions in peanut (*Arachis hypogaea* L.). The unpredictable and often extreme weather and the ubiquity of pathogens in the southeastern United States often contribute to poor emergence and resultant plant stands below optimum. When plant stand is adversely affected, a point may be reached where replanting the field becomes agronomically viable. The objectives of this study were 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 at the Lang-Rigdon Farms in Tifton, GA in 2012 and at the Animal and Dairy Science Farm and the NESPAL Farm in Tifton, Ga in 2013 to evaluate peanut production at four plant stands (7.4, 9.8, 12.3, and 14.8 plants $m^{-1}$) 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) in a randomized complete block design. A minimum of 12.3 plants $m^{-1}$ were needed in order to maintain yield potential, with no benefit from increasing plant stand when averaged across all site-years. Market grade was also maximized at 12.3 plants $m^{-1}$. Disease incidence was unaffected by plant stand. Yields were increased by supplementing an initial stand of 9.8 plants $m^{-1}$ 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 yields when compared to the no replant and supplemental replant

treatments. While an initial stand of 12.3 plants $m^{-1}$ was needed in order to maintain yield potential, replanting via supplemental seed addition can recover lost yield at below-optimum plant stands.

**Introduction**

The yield benefits of a twin-row planting pattern have been widely researched and published (Baldwin, 1997; Besler et al., 2006; Brecke and Stephenson, 2006; Colvin et al., 1985; Lanier et al., 2004; Mozingo and Coffelt, 1984; Nuti et al., 2008; Sorensen and Lamb, 2009; Sorenson et al., 2004; Sorensen et al., 2007; Tillman et al., 2006; Tubbs et al., 2011; Wehtje et al., 1984). Research has shown that a myriad of reasons; including improved disease control, improved weed suppression, shortened time to full ground cover, and improved light interception can be credited for this reported yield advantage.

A portion of the yield increase is likely due to the reduction in disease pressure observed in twin-rows when compared to single rows. Tomato spotted wilt virus (T*ospovirus*) (TSWV) is common throughout the peanut growing regions of the southeastern United States (Culbreath et al., 2003) and can cause severe yield reductions and monetary losses for peanut growers. As a result of the disease, Georgia peanut producers lost an estimated \$4.8 and \$2.0 million in 2008 and 2009, respectively (Kemerait, 2009, 2010). Tomato spotted wilt virus levels have been shown to decrease when peanut is seeded in twin rows versus single rows (Brown et al., 2003; Brown et al., 2005; Culbreath et al., 2008; Hurt et al., 2003; Sconyers et al., 2007; Tillman et al., 2006). Since 2008, southern stem rot (SSR), caused by the fungus *Sclerotium rolfsii*, has been the disease of the greatest economic importance in the southeastern United States. While some studies have reported no advantage in control of SSR in twin rows when compared to single rows (Besler et al., 2006; Harrison, 1970; Sconyers et al., 2002; Tubbs et al., 2011), several others have reported a decrease in incidence of the disease when peanuts are seeded in a twin row pattern (Minton and Csinos, 1986, Sorenson et al., 2004; Sconyers et al., 2007).

Mozingo and Coffelt (1984) found that peanut grade was also enhanced when the cultivar Virginia 81 Bunch was seeded in twin rows versus single rows. Nuti et al. (2008) reported a grade increase of 0.7 points in twin rows when compared to single rows in Georgia. Sorenson et al. (2004) reported an increase in grade of 1% in twin rows versus single rows, similar to results reported by Sorenson et al. (2007) and Sorenson and Lamb (2009).

Research has also revealed that peanut planted in a twin-row pattern achieves complete canopy ground cover faster than peanut planted in single rows (Jaaffar and Gardner, 1988), improving leaf area indices, canopy light interception, and ultimately yield. Yield enhancement in a twin row pattern could also be attributed in part to enhanced weed control when compared to a single row pattern (Wehtje et al., 1984). Brecke and Stephenson (2006) and Yoder et al. (2003) found that Florida beggarweed (*Desmodium tortuosum*) control was improved in a twin versus single row planting pattern. Sicklepod (*Senna obtusifolia*) control also increased by 7-9% in twin row versus single row peanut using identical herbicide programs (Brecke and Stephenson, 2006; Hauser and Buchanan, 1981; Lanier et al., 2004).

Hewitt and Smith (2007) and Sorensen and Lamb (2009) reported economic advantages of \$123.50 and \$148.20 $ha^{-1}$, respectively, in favor of twin rows resulting from a combination of benefits in yield, grade, and disease levels. Sorenson et al. (2007) found a \$213 $ha^{-1}$ advantage in twin rows when compared to a single row pattern. Sorenson et al. (2004) reported increased value in twin rows versus single rows when seeded at the recommended seeding rate. Nuti et al. (2008) and Tubbs et al. (2011) also reported economic advantages in a twin row versus single row pattern in Georgia.

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 $m^{-1}$ when compared to a seeding rate of 23 seeds $m^{-1}$. While not implicitly studied, the 17 and 20 seeds $m^{-1}$ rates resulted in plant stands of 13.6 and 15.7 plants $m^{-1}$, respectively, while the 23 seeds $m^{-1}$ seeding rate corresponded to a final plant stand of 16.3 plants $m^{-1}$. Sorenson et al. (2004) reported no yield difference between peanut seeded in twin rows at a 20 seeds $m^{-1}$ and a 10 seeds $m^{-1}$ rate. Lanier et al. (2004) showed no differences between stands of 12, 8, and 4 plants $m^{-1}$ in a narrow twin row pattern. Sconyers et al. (2007) reported increased yield at seeding rates of 17.8 and 23.0 seeds $m^{-1}$ when compared to a seeding rate of 12.4 seeds $m^{-1}$. In that same study no differences in SSR or TSWV incidences 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. 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 method for replanting when replanting is warranted.

**Materials and Methods**

Irrigated field trials were conducted on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2014) at the University of Georgia (UGA) Lang Farm in 2012 and at the UGA NESPAL Farm in 2013. Non-irrigated trials on the same soil series also took place at the UGA Rigdon Farm in 2012 and at the UGA Animal and Dairy Science (ADS) Farm in 2013. 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 peanut beds 1.8 m wide. All fertilizer requirements and applications, including those for Ca and B, were based on UGA extension recommendations (Harris, 1997). Pre-emergent herbicides application at all site-years (location X year combination) consisted of a tank-mix of pendimethalin[1] (0.93 kg a.i. $ha^{-1}$), diclosulam[2] (27 g a.i. $ha^{-1}$), and flumioxazin[3] (107 g a.i. $ha^{-1}$); all of which were watered into the soil after application in irrigated locations. At both non-irrigated locations, sufficient rain was received to activate herbicides within seven days of planting.

Peanut cultivar Georgia-06G (Branch, 2007) was planted using a two-row twin row Monosem precision air planter[4] (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. Seeds were treated with azoxystrobin, fludioxonil, and mefenoxam[5] fungicide seed treatment.

Trials were arranged in a 3x4 factorial with three plant stands (7.4, 9.8, and 12.3 plants $m^{-1}$) and four replant options in a randomized complete block design with four replications. Replant options included:

1. Leave the initial plant stand and do not replant.
2. Retain the original stand and supplement with additional seed at a reduced rate between the original 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[6] (0.656 kg a.i. $ha^{-1}$) 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 configuration was directly between the original rows and the other unit was 9.5 cm to the opposite side of the original rows and seed was added according to the rates in Table 3.1. In treatment 2, seed was added only to those units running between the original rows. All supplemental seed from Table 3.1 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 3.1 were divided between two units for each row. In treatment 4, the original stand was sprayed with glufosinate[6] herbicide (656 g a.i. $ha^{-1}$) upon full plant emergence and was immediately replanted at a full

20.3 seeds $m^{-1}$ seeding rate. A non-replanted control plot of the UGA recommended 14.8 plants $m^{-1}$ was also included. All plots were initially planted at 20.3 seeds $m^{-1}$ 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. Planting and replanting dates for each site-year are listed in Table 3.2.

Fungicide applications were made based on guidelines provided by the high risk model of the Peanut Disease Risk Index (Kemerait et al., 2012). Post-emergence herbicide applications included clethodim[7] (280 g a.i. $ha^{-1}$), bentazon[8] (0.841 kg a.i. $ha^{-1}$) and crop oil concentrate[9] (2.34 L $ha^{-1}$) in the non-irrigated field on 14 June 2012; and clethodim[7] (280 g a.i. $ha^{-1}$), bentazon[8] (0.841 kg a.i. $ha^{-1}$) and crop oil concentrate[9] (2.34 L $ha^{-1}$) on 18 June and clethodim[7] (280 g a.i. $ha^{-1}$) on 8 August in the irrigated field in 2013.

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 irrigated 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. Southern stem rot incidence was rated in both trials in 2012 and the non-irrigated field in 2013 immediately following inversion of the peanut plants. Peanut maturity was determined at each site-year using the hull scrape method (Williams and Drexler, 1981). There were three inversion and three harvest dates for each site-year (Table 3.2). 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[13] and harvested using a two-row Lilliston peanut combine. Yields were 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[14]. Data were analyzed by analysis of variance and differences among least square means were determined using multiple pairwise t-tests ($P \leq 0.05$). 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, SSR, and grade, non-replanted plots were analyzed separately. Because site-year X 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 X plant stand effects, all data were initially analyzed combined over all years and locations. Because plant stand X replant treatment interactions were present, replant treatment effects are reported for each plant stand separately. There were no interactions among site-year, plant stand, and replant treatment. As a result, plant stand X replant treatment data are reported combined over site-years.

**Results and Discussion**

***Plant stands.*** Peanut pod yield was significantly affected by plant stand (Table 3.3). When averaged across site-years, a minimum of 12.3 plants $m^{-1}$ were required in order to maintain yield potential (Table 3.4). No yield benefit was observed when increasing plant stands to 14.7 plant $m^{-1}$, while yields were reduced at all stands below 12.3 plants $m^{-1}$. When compared to a stand of 12.3 plants $m^{-1}$, reductions to 9.8 and 7.4 plants $m^{-1}$ 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 $m^{-1}$. 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 $m^{-1}$ producing higher yields than stands of 15.7 and 13.6 plants $m^{-1}$.

Peanut grade was also affected by plant stand. Similar to pod yield, the highest grade value was observed at 12.3 plants $m^{-1}$. Grades at 12.3 plants $m^{-1}$ were not higher than those at 9.8 plants $m^{-1}$, but they were higher than grades at both 7.4 and 14.7 $m^{-1}$, respectively. A general increase in grade from 7.4 to 12.3 plants $m^{-1}$ without an increase at 14.7 plants $m^{-1}$ 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 $m^{-1}$ without an increase when seeding rate was upped to 22.6 seeds $m^{-1}$ in one study. Numerous other studies support increased grade at increased stand (Cox and Reed, 1965; Mozingo and Coffelt, 1984; Sorenson et al., 2004; Wynne et al., 1974). Tomato spotted wilt virus and SSR incidence were unaffected by plant stand. While results generally trend toward reduced TSWV and elevated SSR at higher populations, this is not always the case. Sconyers et al. (2007) found no differences in TSWV or SSR incidence in naturally-infected fields between seeding rates of 12.5, 17.4, and 22.6 seeds $m^{-1}$. In that study, average TSWV and SSR incidence were 1.1% and 8.2%, respectively. In our study TSWV and SSR 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 (P=0.0486) indicated that the optimum replant treatment was dependent on initial plant stand (Table 3.5). While significant pod yield gains were achieved through replanting only at 9.8 plants $m^{-1}$, yields trended higher from supplementing the initial stand when compared to not replanting at all initial plant stands. At an initial plant stand of 9.8 plants $m^{-1}$, supplemental planting between the initial rows by adding seed with one hopper resulted in the greatest yield advantage (Table 3.6), with an 8.3% increase over not replanting. Adding seed in both hoppers increased yield by 6.6% when compared to not replanting. While supplemental replanting did not significantly increase yield at an initial stand of 7.4 plants $m^{-1}$, yields trended higher with both methods. Because similar gains resulted in significant improvement at 9.8 plants $m^{-1}$, it is reasonable to suggest that a grower would see a benefit from replanting at an initial stand of 7.4 plants $m^{-1}$ in addition to 9.8 plants $m^{-1}$. At all 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 complete replant treatment (77.5% TSMK) than both the no-replant (76.0% TSMK) and supplemental (75.4% TSMK) 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. Neither TSWV nor SSR 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; Brown et al., 2005; Tillman et al., 2007) and SSR (Brenneman and Hadden, 1996; Bowen, 2003; Hagan et al. 2001), low overall pressure from both diseases was likely part of the reason why there were no significant differences between treatments in this study. Part of the reason for low TSWV infection was likely due to the use of cultivar Georgia-06G, which shows high resistance to the disease (Branch, 2007).

**Summary and Conclusions**

The results from these trials illustrate the importance of establishing an adequate plant stand on the initial planting date, as results indicated that a minimum stand of 12.3 plants $m^{-1}$ 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 $m^{-1}$. Yield increases were observed at an initial 9.8 plants $m^{-1}$ stand, meaning that a grower can make up for lost yield at sub-optimum plant stand through supplemental seed addition. While yield increases were not significantly higher by replanting at 7.4 plants $m^{-1}$, yield did trend higher through supplemental replanting. When considering this in addition to the positive results at 9.8 plants $m^{-1}$, it is would be reasonable to recommend that a grower supplement stand at initial stands 9.8 plants $m^{-1}$ and below.

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. 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. Replanting should not be considered at plants stands of 12.3 plants $m^{-1}$ and above. Replanting via supplemental addition either between or both between and outside of the initial twin rows was a viable option for increasing pod yield at an initial stand of 9.8 plants $m^{-1}$. Yield also trended higher for supplemental addition via both methods at 7.4 plants $m^{-1}$. 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, especially as the initial planting date becomes later. 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 SSR were unaffected and grade was negligibly affected by replant method, pod yield, and ultimately profitability should be the deciding factor when making replant decisions.

Table 3.1. Initial plant stands and replanting rates for supplemental replant treatments for peanut seeded in twin rows.

| Initial Stand (plants $m^{-1}$) | Replant Rate (seeds $m^{-1}$) |
|---|---|
| 7.4 | 14.4 |
| 9.8 | 10.2 |
| 12.3 | 4.9 |

Table 3.2. Inversion and harvest dates for irrigated and non-irrigated locations in Tifton in 2012 and 2013.

| Treatment | Field Practice | Irrigated 2012 | Non-Irrigated 2012 | Irrigated 2013 | Non-Irrigated 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 |

Table 3.3. Analysis of Variance for site-year, plant stand, and their interactions for pod yield, grade, tomato spotted wilt virus (TSWV), and southern stem rot (SSR) in irrigated and non-irrigated locations in 2012 and 2013.

| Source[a] | Pod Yield | Grade | TSWV | SSR |
|---|---|---|---|---|
| | ----------------------------------- | 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

Table 3.4. Peanut pod yield, grade, tomato spotted wilt virus incidence (TSWV), and southern stem rot (SSR) incidence at six plant stands averaged across four site-years in Georgia.

| Plant Stand | Pod Yield | Grade | TSWV | SSR |
|---|---|---|---|---|
| Plants $m^{-1}$ | kg $ha^{-1}$ | ----------------------- | % | ----------------------- |
| 7.4 | 6455 c[a] | 75.4 c[a] | 6.4 | 4.4 |
| 9.8 | 6511 bc | 76.2 ab | 3.7 | 4.2 |
| 12.3 | 6911 a | 76.8 a | 6.0 | 5.3 |
| 14.7 | 6852 ab | 75.6 bc | 4.2 | 3.0 |
| SE[b] | ± 176.0 | ± 0.3 | ± 1.5 | ± 1.7 |

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

[b] standard error of the mean

Table 3.5. Analysis of Variance for replant treatment, plant stand, site-year, and their interactions for pod yield, grade, tomato spotted wilt virus (TSWV), and southern stem rot (SSR) averaged across four site-years in Georgia.

| Source | Pod Yield | Grade | TSWV | SSR |
|---|---|---|---|---|
| | | 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 |

Table 3.6. Peanut pod yield as influenced by replant method at three initial plant stands in peanuts planted in twin rows across four site-years in Georgia.

| | Plant Stand (plants $m^{-1}$ of row) | | |
|---|---|---|---|
| | 7.4 | 9.8 | 12.3 |
| Replant Method | ---------------------kg $ha^{-1}$--------------------- | | |
| None | 6455 a[a] | 6511 b[a] | 6911 a[a] |
| Complete | 5894 b | 5817 c | 5905 b |
| Supplement one hopper | 6766 a | 7052 a | 7195 a |
| Supplement two hoppers | 6888 a | 6939 a | 6516 ab |
| 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 P = 0.05.

[b] standard error of the mean

# CHAPTER 4

# ASSESSMENT OF REPLANT OPTIONS FOR REDUCED PLANT STANDS IN PEANUT (*ARACHIS HYPOGAEA* L.) PLANTED IN STRIP TILLAGE[1]

[1] Sarver, J.M., R.S. Tubbs, J.P. Beasley, Jr., A.K. Culbreath, D.L. Rowland, and N.B. Smith. To be submitted to *Peanut Science*.

**Abstract:** Conservation tillage in crop production has shown numerous benefits, including reduced soil erosion, increased soil organic matter, and optimized soil moisture and hydraulic conductivity, amongst others. While peanut has traditionally been a tillage-intensive crop, growers have begun to experiment with, and accept conservation tillage as a legitimate option in peanut production. Strip tillage is a conservation tillage practice commonly used in peanut that uses a specialized subsoil shank pulled through crop reside to bust compacted soil and create a strip of bare ground in which seeds can be planted without disturbing row middles. Replanting peanuts may be agronomically beneficial when plant stands are below optimum. Because the seedbed is narrower in strip-tillage than in conventional tillage, replanting options may be limited in this scenario. Field trials took place in Tifton, GA and Citra, FL in 2012 and 2013 to explore the effects of multiple replant scenarios in strip tillage on peanut pod yield, market grade, tomato spotted wilt virus incidence, and stem rot incidence and to ultimately determine the most agronomically sound system for replanting peanut in strip tillage. Replanting benefitted peanut that was at below optimum intial plant stand at the Citra, FL location in 2012 and 2013. Pod yield was increased by 24.5% by supplemental addition of seed within the original seedbed in 2012, while yield was increased by 16% by destroying the initial stand and completely replanting in 2013. Market grade, tomato spotted wilt virus incidence, and stem rot incidence were variable and were unaffected by replant treatment.

**Introduction**

The benefits of reduced/conservation tillage have been widely studied and published. Benefits include reduced soil erosion (Cogo et al., 1983; Johnson et al., 2001; Phillips et al., 1980; Yu et al., 2000), increased soil organic matter (Blevins et al., 1983; Reicosky et al., 1995), and optimized soil moisture and hydraulic conductivity (Blevins et al., 1983), among others. While peanut (*Arachis hypogaea* L.) has traditionally been a very tillage-intensive crop, growers have begun to accept reduced tillage in production with the introduction of new effective herbicide options and the advent of strip-tillage (Wright et al., 2009). Strip-tillage differs from other reduced-tillage systems through use of a specialized subsoil shank that is pulled through either the previous crop's residue or a winter cover crop at a depth of around 30 cm, breaking soil compaction at shallower depths and creating a strip of bare ground in which seeds can be planted that will often warm more rapidly than undisturbed soil, and provide maximum seed-to-soil contact; all without disturbing row middles.

While the environmental and soil property benefits of strip-tillage are undeniable, yield results from studies comparing strip-tillage to conventional tillage are mixed. In six experiments comparing strip-till versus conventionally tilled peanut production, Jordan et al. (2003) reported four of the six being equal, one showing an advantage in strip-till, and the last showing an advantage in conventional-till. Hartzog et al. (1998) completed 17 on-farm experiments in Alabama in which pod yields were greater for strip-tillage than conventional tillage at three sites, lesser at five sites, and equal at the other nine. Tubbs and Gallaher (2005) reported no difference in yield between conventional tillage and multiple strip-tillage practices into a rye (*Secale cereale* L.) cover crop. Jordan et al. (2001) found a yield disadvantage in peanut planted in strip-till after either the previous crop residue or after a wheat (*Triticum aestivum* L.) cover crop when compared to peanut planted into a conventionally tilled seedbed. Numerous other studies have reported equivalent or greater yields using conservation tillage systems (Baldwin and Hook, 1998; Colvin and Brecke, 1988; Hartzog et al., 1998; Minton et al., 1993; Williams et al., 1998), while others have reported yield losses (Brandenberg et al., 1998; Grichar, 1998; Minton et al., 1990) in some scenarios.

A major potential advantage of conservation tillage specific to peanut is a reported decrease in the incidence of tomato spotted wilt virus (*Tospovirus)* (TSWV) (Baldwin and Hook, 1998; Brenneman et al., 1999; Cantonwine et al., 2006; Johnson et al., 2001; Jordan et al., 2003). Because strip-tillage has been shown to reduce TSWV incidence, the peanut crop in this tillage scenario may react differently to reduced plant populations or replanting than a crop planted in a conventionally tilled seedbed. The effects on southern stem rot (SSR) (*Sclerotium rolfsii*) incidence in reduced tillage when compared to conventional tillage are mixed. Multiple studies have shown increases of SSR in reduced tillage scenarios (Boswell and Grichar, 1981; Grichar, 1998; Monfort et al., 2007), while others have shown equal (Cheshire et al., 1985; Grichar and Boswell, 1987; Grichar and Smith, 1991; Minton et al., 1991; Sorensen et al., 2010) or even reduced (Minton et al., 1990) incidence of the disease.

The use of cover crops also provides numerous benefits both agronomically and environmentally. Cover crops reduce erosion via both wind and water (Dabney, 1998; Frye et al., 1985; Langdale et al., 1991), increase solar energy harvest and carbon flux into the soil (Kuo et al., 1997; Reeves, 1997), aid in weed suppression (Evers, 1983; Hoffman et al., 1996; Smeda and Putnam, 1988) and prevent leaching by scavenging residual nitrogen and other mobile nutrients (Isse et al., 1999; Jones, 1942; Jones et al., 1977). Cover crops also increase soil quality by improving organic carbon content, cation exchange capacity, aggregate stability, and water infiltration (Dabney et al., 2001). Research has shown that cover crop usage is of particular importance in the southeastern United States, where higher temperatures lead to increased oxidation of organic matter (Duiker and Myers, 2005). Soils of the southern region benefit from the ability to actively grow crops 365 days per year and cover crops can compensate for organic matter losses from increased heat (Duiker and Myers, 2005). This test will combine both cover crops and strip-tillage in order to determine the best practice for replanting in a system that has shown numerous advantages for peanut growers.

While numerous benefits have been reported with strip tillage, it can present logistical issues when deciding how to replant peanut seed. The relative narrow width of the stripped seedbed may prevent adding seed without mechanically damaging the original stand, and may necessitate a new strip to the side of the original in order to add seed to the previously established stand. The objectives of this study were to explore the effects of multiple replant scenarios in strip tillage on peanut pod yield, grade, TSWV, and SSR incidence and to ultimately determine the most agronomically sound system for replanting peanut in strip tillage.

**Materials and Methods**

Irrigated field trials were conducted on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2014) at the Lang-Rigdon Farm near Tifton, GA and on a Candler fine sand (hyperthermic, uncoated Lamellic Quartzipsamments) (USDA-NRCS, 2014) at the University of Florida Plant Science Research and Education Unit near Citra, FL in 2012 and 2013.

The rye cultivar Wrens Abruzzi (Morey, 1970) was planted 7 November and 22 October in 2011 and 2012 in Tifton and mid-November in Citra using a Tye Pasture Pleaser no-till grain drill[15]. Rye was planted at a depth of 1.9 cm and at a seeding rate of 101 kg $ha^{-1}$ in all site-years in drilled rows 19.1 cm apart. Rye was planted into land that had been disk-harrowed and separated into beds 1.8 m wide. Termination of the actively growing rye took place on 12 March and 8 April in Tifton in 2012 and 2013, respectively. In Citra, the rye had matured naturally prior to peanut planting. In Tifton, rye was seeded only in those plots receiving treatments that required a cover crop while treatments without cover were left fallow. In Citra, all plots were planted to rye, which was mowed to a stubble height of 5 cm in treatments which were not to include cover, prior to tillage in the spring. A KMC rotary tiller[13] was used in no-cover treatments in order to remove all vegetation (weeds in Tifton, weeds plus wheat residue in Citra) and create raised beds prior to strip tillage and planting. A two-row Unverferth[16] (Tifton) and KMC[13] (Citra) strip-till implement[16] with sub-soil shanks at a depth of 30 cm and ground-driven crumblers was used to create a 18-cm-wide seedbed prior to peanut planting in all treatments .

Pre-emergent herbicide applications at all site-years consisted of a tank-mix of pendimethalin[1] (0.93 kg a.i. $ha^{-1}$), diclosulam[2] (27 g a.i. $ha^{-1}$), and flumioxazin[3] (107 g a.i. $ha^{-1}$); all of which were watered into the soil after application. At Citra in both 2012 and 2013, glyphosate[17] (2.24 kg a.i. $ha^{-1}$) was also applied in order to assist in removal of vegetation prior to peanut plant emergence. Base fertility management decisions were made according to University of Georgia Extension recommendations (Harris, 1997). Peanut cultivar Georgia-06G (Branch, 2007) was planted using a two-row Monosem precision air planter[4] at a depth of 5 cm and a row spacing of 0.91 m in rows 12.2 m in length. Seed was treated with azoxystrobin, fludioxonil, and mefenoxam[5] fungicide seed treatment. All plots were initially seeded at 19.7

seeds $m^{-1}$ and replanting treatments occurred when those plants from the initial planting date reached full emergence. Initial planting dates and replanting dates can be found in Table 4.1.

Eight replant regimes were tested:

1) Plant stand of 13.1 plants $m^{-1}$ (optimum) with rye cover and no replanting
2) Plant stand of 5.9 plants $m^{-1}$ (below-optimum) with rye cover and no replanting
3) Re-strip in the original strip, destroying the original stand and replanting at the full seeding rate
4) Re-strip beside the initial row and supplement at a reduced seeding rate
5) Burn down the initial stand with glufosinate herbicide (656 g a.i. $ha^{-1}$) and replant in the original strip at the full seeding rate
6) Supplement the initial stand by adding seed at a reduced seeding rate in the initial strip
7) Plant stand of 13.1 plants $m^{-1}$ (optimum) with no cover and no replanting
8) Plant stand of 5.9 plants $m^{-1}$ (below-optimum) with no cover and no replanting

Peanut plants were thinned by hand to a stand of 5.9 plants $m^{-1}$ in treatments 2-6 and 8 prior to replanting in order to represent a plant stand that would be considered below-optimum. Treatments 1 and 2 represent a peanut crop grown in a strip-till scenario into a rye cover crop at both an optimum and below-optimum stand, respectively that is allowed to grow at that stand throughout the growing season. Similarly, treatments 7 and 8 represent an adequate and below-adequate stand allowed to grow throughout the season, but under a bare-ground scenario with no crop residue interference on the soil surface. Treatments 4 and 6 represent a supplemental replant situation. In treatment 4, the strip-till rig was run approximately 19 cm to the side of the original strip and 11.6 seeds $m^{-1}$ were added in order to supplement the initial below-optimum stand. In treatment 6, the planter units were moved 9 cm to the side and seed were added at 11.6 seeds $m^{-1}$ within the original strip. Treatments 3 and 5 represented a complete replant scenario. In treatment 3, the strip-till rig was run in the original strip in order to destroy the poor stand, while in treatment 5, the original stand was destroyed with glufosinate herbicide at a rate of 656 g a.i. $ha^{-1}$. In both treatments, plots were replanted at the full 19.1 seeds $m^{-1}$ rate. To hand thin stands, 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.

At Citra, gypsum ($CaSO_4$) was applied at a rate of 2240 kg $ha^{-1}$ on 29 May and 7 June in 2012 and 2013 respectively. Soil test levels indicated that calcium levels were adequate both years in Tifton, thus in-season applications of gypsum were not necessary at either of those sites. Fungicide applications were made based on guidelines provided by the high risk model of the Peanut Disease Risk Index (Kemerait et al., 2012). At Citra, in-season herbicide applications included *S*-metolachlor[18] (2.14 kg a.i. $ha^{-1}$) on 17 May and imazapic[19] (70.1 g a.i. $ha^{-1}$) on 21 June 2012 and imazapic[19] (70.1 g a.i. $ha^{-1}$) on 20 June 2013.

Treatments were evaluated for pod yield, grade (total sound mature kernels [TSMK]), and incidence of TSWV (Tifton 2012 and 2013; Citra 2012) and SSR (Tifton 2012 and 2013). Ratings for TSWV were conducted 11 September 2012 and 23 September 2013 in Tifton and 12 September 2012 in Citra. Ratings for SSR were conducted on the date of plant inversion for each treatment. Incidence of TSWV was extremely low in 2013 in Citra and did not warrant rating for TSWV. Likewise, incidence of SSR was too low to warrant rating in Citra in either year. Peanut maturity was determined at each site-year using the hull scrape method (Williams and Drexler, 1981). Inversion and harvest dates can be found in Table 4.2. Peanuts were inverted using a two-row KMC digger-shaker-inverter[13] and harvested using a two-row Lilliston peanut combine. Yields were adjusted to 7% moisture. Peanuts were graded by the USDA Federal-State Inspection Service in Tifton, GA (Davidson et al., 1982).

Treatments were arranged in a randomized complete block with four replications in Tifton in 2012 and 2013 and Citra in 2012; and five replications in Citra in 2013. Statistical analyses were performed using PROC MIXED in SAS 9.3[14]. Data were analyzed by analysis of variance and differences among least square means were determined using multiple pairwise t-tests (P=0.05). For analysis purposes, the replant treatment effect was treated as fixed while year and location were treated as random. Because location X year X treatment interactions were present for yield, grade and SSR incidence (Table 4.3), site-years (location X year) were analyzed and presented separately. Because there was no interaction between site-years and replant treatment for TSWV, data were combined over years and locations and analyzed.

**Results and Discussion**

Pod yield was significantly affected by treatment in three of four site-years (Table 4.4). At both locations in 2012, the optimum plant stand with no cover and no replant treatment resulted in the highest numerical yields. Yield of those plots were matched statistically by the below-optimum stand, no cover, no replant treatments at both locations, and by the optimum stand, rye cover, no replant treatment at Citra 2012. Pod yields were 33.3%, 8.7%, and 9.3%

greater on average in non-replanted, cover-free plots than in non-replanted plots with cover in 2012 Tifton, 2012 Citra, and 2013 Citra, respectively.

When considering only those plots with cover, the yield at the below-optimum plant stand (5.9 plants $m^{-1}$) was only reduced in one site-year (Citra 2012) when compared to the optimum plant stand (13.1 plants $m^{-1}$). In that site-year, yield was increased by 24.5% by supplementing the stand within the original strip. There were no statistical differences between the below-optimum and optimum stands in any other site-year. In Tifton 2012 and 2013, there were no replant treatments that improved yield when compared to the non-replanted below-optimum stand. This result illustrates the peanut plant's ability to make up for gaps in stand associated with lower plant stands and supports previous work that reported maintained yields at reduced plant populations (Augusto et al., 2010; Bell et al., 1987; Tewolde et al., 2002). In Citra 2013 however, all replant treatments resulted in numerically higher yields than the non-replanted, below-optimum plant stand treatment with cover. Destroying the original stand and completely replanting the plot at the full seeding rate increased yield by 16.0%, which represented a significant increase over the non-replanted treatment.

The large yield advantage of the cover free plots in Tifton 2012 could be due in part to differences in SSR incidence, with non-replanted rye cover plots averaging 22.5% incidence and plots without cover averaging 11% incidence (Table 4.5). These results are similar to Boswell and Grichar (1981) and Grichar (1998), who found increased incidence of the disease in cover versus cover-free scenarios. Southern stem rot levels were not significantly affected by treatment in 2013. When comparing only those plots with cover, the two complete replant treatments had less incidence of SSR than any treatment other than supplementing in the original strip, which was statistically equal. Percent incidence in the non-replanted treatments was 8%, which was significantly less than both the optimum stand (25%) and below-optimum stand (20%) plots that were not replanted. These findings are similar to previous work which reported greater incidence of SSR in earlier- than in later-planted peanuts (Brenneman and Hadden, 1996; Hagan et al., 2001). Southern stem rot incidence when supplementing the initial stand was between the no-replant and complete replant treatments; likely due to the mixture of both older and newer plants in the stand. Tomato spotted wilt virus was generally low across all site-years and no differences were observed between treatments.

Grade was affected by treatment in Citra 2012 (P=0.009) and at both Tifton (P=0.0749) and Citra (P=0.0542) in 2013 (Table 4.6). At Citra 2012, the presence or absence of cover crop did not influence grade when replant treatments were not applied. When comparing only those plots with cover, grade of both complete replant treatments were higher than that of the non-replanted plots by an average of 1.9 points. In Citra 2013, results were similar, as those plots receiving the complete replant treatment were among the highest grading, although differences were not as pronounced as in Citra 2012. In contrast, in Tifton 2013 those treatments receiving the complete replanting were among the lowest grading treatments. In that site-year, supplementing always resulted in higher grades than completely replanting. While the hull scrape method was used in order to determine crop maturity, environmental factors often dictate when a field is dug and harvested. While it is difficult to explain exactly why this change in grade was observed in the complete replant treatments, it is possible that those treatments were dug and harvested closer to, or further from, the optimum timing than either the non-replanted or supplemental replant treatments.

**Summary and Conclusions**

While questions about yield and other production factors were the main consideration for this project, there are logistical questions that were answered as well. Of main concern was the possibility of supplementing the original stand in the original strip-tilled seedbed. Observations from these trials indicate that this is possible, although great care needs to be taken when using the original strip. The original plants proved to be resilient, as they were able to remain viable even after being run over by the planter units during the replanting process. Growers would benefit from automated guidance when attempting to supplement below-optimum initial stands within the original strip-tilled seedbed.

Yield results were mixed across site-years. At Tifton 2012 and Citra 2013, yields at 5.9 plants $m^{-1}$ were equal to 13.1 plants $m^{-1}$, illustrating how peanut plants can acclimate to below-optimum plant stands and how yield potential can be maintained at levels below what would be considered optimum. At Citra 2013, yield was decreased by 25% when stand was reduced from 13.1 to 5.9 plants $m^{-1}$. Although a decrease was observed in only one of four site-years, the magnitude of the potential decrease means that replant considerations are still valid when stands fall below optimum. While it is difficult to predict when a yield loss will occur as the result of a reduced plant stand, knowing that a 25% decrease is possible may justify replanting in all poor plant stand situations for the purpose of insurance against that large potential loss.

A major consideration that must be made when deciding on a replant strategy is to determine if a viable replant option is available. In Tifton 2012 and 2013, there were no replant treatments that resulted in significantly higher yields than the 5.9 plants $m^{-1}$ treatment that was not replanted, meaning that although a large yield loss is possible at below-optimum plant stands, there is not always a replant treatment that will enhance yield over the non-replanted, below-optimum plant stand. When replanting the below-optimum stand did show yield benefits, the optimum replant treatment was not consistent. At Citra 2012, a 24.6% yield increase was discovered when supplementing the original stand within the original strip-tilled seedbed. All other replant treatments yielded similarly to the non-replanted treatment. At Citra 2013, destroying the initial stand with herbicide and replanting completely resulted in a 16.0% increase in yield. While all other replant treatments were equal in yield to this treatment, they were not greater than the no-replant treatment.

When taking results from all site-years into consideration, it is difficult to make a recommendation with complete confidence to a grower that has a below-optimum plant stand in a field planted in strip-tillage. Because costs will be less when supplementing versus completely replanting and equal benefit was seen as often from the former as the latter, a grower is likely to be better advised to supplement the initial stand when the decision is made to replant. When considering costs in combination with yield results, the best option would be to supplement the initial stand within the original seedbed. While the logistical difficulties with this option may present a challenge, extra care when replanting make the option feasible. As mentioned previously, growers would benefit from tractor-mounted guidance systems when attempting to utilize this replant method.

Results from two of the four site-years showed no gain in yield by replanting. This result, in combination with the finding that at three of four site-years there was no yield loss when stands are reduced from 13.1 to 5.9 plants $m^{-1}$, should encourage growers to continue to properly manage a peanut crop with a below-optimum plant stand that cannot or will not be replanted. While grade and SSR were affected by replant treatment in some cases, neither made a large enough impact to be strongly considered when a replant decision is made. Pod yield, time management, and ultimately profitability should be the major factors considered when deciding when and how to replant a peanut field with a below-optimum plant stand under strip-till management.

Table 4.1. Initial planting dates and replanting dates in Tifton, GA and Citra, FL in 2012 and 2013.

| | Tifton 2012 | Citra 2012 | Tifton 2013 | Citra 2013 |
|---|---|---|---|---|
| Planting Date | 4-May | 27-Apr | 29-Apr | 1-May |
| Replant Date | 30-May | 23-May | 17-May | 23-May |
| Days between initial planting and replanting | 26 | 26 | 18 | 22 |

Table 4.2. Inversion and harvest dates for each replant treatment in Tifton, GA and Citra, FL in 2012 and 2013.

| Replant Treatment | | Tifton 2012 | Citra 2012 | Tifton 2013 | Citra 2013 |
|---|---|---|---|---|---|
| No-Replant (1, 2, 7, 8) | Inversion | 14-Sep | 21-Sep | 25-Sep | 7-Oct |
| | Harvest | 17-Sep | 25-Sep | 30-Sep | 11-Oct |
| Supplemental (4, 6) | Inversion | 28-Sep | 21-Sep | 25-Sep | 7-Oct |
| | Harvest | 9-Oct | 25-Sep | 30-Sep | 11-Oct |
| Complete (3, 5) | Inversion | 16-Oct | 9-Oct | 8-Oct | 7-Oct |
| | Harvest | 19-Oct | 16-Oct | 17-Oct | 11-Oct |

Table 4.3. Significance and interactions of replant treatment and location on peanut pod yield, grade, tomato spotted wilt virus (TSWV) incidence, and southern stem rot (SSR) incidence across four site-years.

| Source | Pod Yield | Grade | TSWV | SSR |
|---|---|---|---|---|
| | ------------------------------Pr > F------------------------------ | | | |
| Replant Treatment (RT) | 0.4687 | 0.8868 | 0.5864 | 0.9552 |
| Location (Loc) | 0.0004 | <0.0001 | 0.0208 | 0.0419 |
| Loc*RT | <0.0001 | 0.0022 | 0.6959 | 0.0153 |
| Rep | 0.0708 | 0.6658 | 0.8845 | 0.2933 |

Table 4.4. Peanut pod yield for each replant treatment in Tifton, GA and Citra, FL in 2012 and 2013.

| Treatment | Tifton 2012 | Citra 2012 | Tifton 2013 | Citra 2013 |
|---|---|---|---|---|
| | ----------------------------kg $ha^{-1}$---------------------------- | | | |
| OS[a], no replant, rye cover | 4150 bc[d] | 5599 a[d] | 4041 | 5016 c[d] |
| BOS[b], no replant, rye cover | 4626 b | 4174 cd | 4489 | 5465 bc |
| Re-strip, replant at full SR[c] | 3945 bc | 4772 bc | 4450 | 6194 ab |
| Supplement in new strip | 4092 bc | 4021 d | 4336 | 5744 abc |
| Burndown, replant at full SR | 3432 c | 4434 bcd | 4765 | 6337 a |
| Supplement in original strip | 4498 b | 5199 ab | 5111 | 6265 ab |
| OS, no replant, no cover | 6055 a | 5682 a | 3996 | 5478 bc |
| BOS, no replant, no cover | 5645 a | 4947 abc | 4444 | 5981 ab |
| SE[e] | ± 393 | ± 384 | ± 631 | ± 412 |

[a]OS = Optimum Stand

[b]BOS = Below-Optimum Stand

[c]SR = Seeding Rate

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

[e]Standard error of the mean

Table 4.5. Southern stem rot (SSR) incidence for each replant treatment in Tifton, GA in 2012 and 2013.

| Treatment | Tifton 2012 | Tifton 2013 |
|---|---|---|
| | ---------------------%--------------------- | |
| OS[a], no replant, rye cover | 25 a[d] | 23 |
| BOS[b], no replant, rye cover | 20 ab | 14 |
| Re-strip, replant at full SR[c] | 8 c | 27 |
| Supplement in new strip | 19 ab | 23 |
| Burndown, replant at full SR | 8 c | 29 |
| Supplement in original strip | 14 bc | 19 |
| OS, no replant, no cover | 10 bc | 26 |
| BOS, no replant, no cover | 12 bc | 30 |
| SE[e] | ± 5 | ± 8 |

[a]OS = Optimum Stand

[b]BOS = Below-Optimum Stand

[c]SR = Seeding Rate

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

[e]Standard error of the mean

Table 4.6. Peanut grade (% total sound mature kernels (TSMK)) for each replant treatment in Tifton, GA and Citra, FL in 2012 and 2013.

| | Tifton 2012 | Citra 2012 | Tifton 2013 | Citra 2013 |
|---|---|---|---|---|
| Treatment | ------------------------------% | | ------------------------------ | |
| OS[a], no replant, rye cover | 73.3 | 77.1 bc[d] | 73.5 bc[d] | 78.4 a[d] |
| BOS[b], no replant, rye cover | 74.2 | 76.4 cd | 75.3 ab | 76.4 b |
| Re-strip, replant at full SR[c] | 74.1 | 78.9 a | 72.3 c | 78.2 a |
| Supplement in new strip | 73.6 | 76.6 bcd | 75.8 a | 77.4 ab |
| Burndown, replant at full SR | 72.5 | 77.7 ab | 72.0 c | 77.6 ab |
| Supplement in original strip | 74.9 | 76.7 bcd | 75.1 ab | 76.4 b |
| OS, no replant, no cover | 73.2 | 76.2 cd | 76.3 a | 78.4 a |
| BOS, no replant, no cover | 72.8 | 75.6 d | 73.8 bc | 78.2 a |
| SE[e] | ± 1.6 | ± 0.6 | ± 1.4 | ± 0.8 |

[a]OS = Optimum Stand

[b]BOS = Below-Optimum Stand

[c]SR = Seeding Rate

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

[e]Standard error of the mean

# CHAPTER 5

# EVALUATING REPLANT OPTIONS IN PEANUT (*ARACHIS HYPOGAEA* L.) AT MULTIPLE PLANTING DATES AND MULTIPLE DURATIONS BETWEEN INITIAL PLANTING AND REPLANTING[1]

[1] Sarver, J.M., R.S. Tubbs, J.P. Beasley, Jr., A.K. Culbreath, D.L. Rowland, and N.B. Smith. To be submitted to *Peanut Science*.

**Abstract:** Plant stand establishment is a major consideration when making planting and early season management decisions in peanut (*Arachis hypogaea* L.). The unpredictable and often extreme weather and the ubiquity of pathogens in the southeastern United States often contribute to poor emergence and resultant plant stands below optimum. If plant stands are low enough, peanut may benefit form replanting via either supplementation of the original stand or by destroying the original plant stand and completely replanting. Planting date has also shown to be a major factor determining yield potential in peanut. A grower must consider original and potential plant stand from replanting, as well as yield potential of the original planting date when compared to potential at the replanting date. Field trials were completed in Tifton, GA and Attapulgus, GA in 2012 and 2013 to determine the effects of replanting on pod yield, market grade, and disease incidence at three time durations following two initial planting dates. Yield from replanting was greater than yield of the non-replanted, reduced plant stand treatment in two of eight site-year X initial planting date interactions. When replanting was beneficial, it was always at either the early or middle replanting date. In general, replanting via supplemental addition of seed yielded greater than destroying the initial stand and completely replanting. At the early initial planting date, market grade was lowest at the latest replant date. A grower considering replanting should make the decision as quickly after initial planting as possible in order to achieve the maximum yield enhancement possible.

**Introduction**

Planting date is an extremely important factor in peanut production. The recommended planting window for peanut in Georgia has traditionally been between April 15 and May 20, with the major qualification being a ≥ 18 C soil temperature at a 10.2 cm depth, with a favorable forecast to follow (Beasley, 2007). Several previous studies have reported on the effect of planting date across the southeastern U.S. peanut production area, most of which support late-April and May planting dates when compared to dates both earlier and later. Nuti et al. (2013) reported higher yield for planting dates between 11 May and 2 June than in dates between 20 April and 1 May in Georgia and Alabama. In Georgia, peanut planted in mid-May out-yielded plantings in April and June under irrigation (McKeown et al., 2001). Similarly, in Florida, Tillman et al. (2007) found that pod yield was greater in mid-May plantings when compared to plantings in both April and June. In North Carolina, Drake et al. (2014) reported yield advantages in two of four years in a 5 May planting date when compared to a 25 May planting date, with no differences in the other two years. In Virginia, research results showed that in non-irrigated situation with inadequate moisture, every 10-day planting delay after 29 April resulted in a loss in yield (Mozingo et al., 1991). Kvien and Bergmark (1987) reported higher yields for a late-April planting date than for an early-June planting date at two locations in Georgia. They went on to describe the relationship between planting date and intra-row plant spacing. For the late-April date, yield increased at both locations when intra-row spacing decreased from 40 cm to 5 cm. When the crop was planted in early-June, there were no yield differences between these intra-row plant spacings. The authors concluded that planting date was likely the yield limiting factor for the early-June date, whereas intra-row plant spacing was more limiting than planting date at the late-April date. Similar to their observations on pod yield, Kvien and Bergmark (1987) also reported a significant reduction in market grade (% total sounds mature kernels (% TSMK)) in the later planting date when compared to the earlier date.

At Tifton, GA, when planting date was shifted from late-April to early-June, grade dropped from 81 to 75% TSMK, and at Plains, grade dropped from 77 to 71% TSMK.

A major limiting factor that has come into play when determining optimum planting dates is the probability of tomato spotted wilt virus (*Tospovirus*) (TSWV) infection and its effect on yield, quality, and profitability. Planting date has been shown to strongly affect TSWV incidence, especially in cultivars that lack resistance to the disease. Studies in the southeastern United States have shown that TSWV incidence is lowest in planting dates in the first two weeks of May when compared to dates in April or June (Brown et al., 1996). Brown et al. (2005) reported lower incidence of TSWV when planting between 10 May and 1 June. In Florida, TSWV ratings were highest in April plantings, followed by May and then June (Tillman et al., 2007). Similary, McKeown et al. (2001) reported increased prevalence of TSWV in April and June peanut plantings when compared to May plantings. Both the Florida and Georgia studies reported similar trends in yield when comparing planting dates.

Prior to TSWV becoming a concern in peanut production, the optimum recommended planting window for peanut was early-April to early-May (Sturkie and Buchanan, 1973; Henning et al., 1982). During that time period, growers would start planting earlier in an attempt to spread out harvest timing and to avoid potentially detrimental cold temperatures in the fall. The relatively narrow window for optimum planting as it relates to TSWV gave little room for error, little tolerance for poor weather conditions, and added stress to grower operations at both planting and harvest time. Much of the research on TSWV incidence and its relationship with yield as effected by planting date was completed using peanut cultivars that had more susceptibility to the disease than today's most commonly grown cultivars. Cultivar Georgia-

06G, which is highly resistant to TSWV (Branch, 2007), is currently grown on the majority of peanut acreage in the southeastern United States. Use of TSWV-resistant cultivars may alleviate some concerns over disease infection and resultant yield and quality loss; and may allow growers to plant the peanut crop when weather conditions allow, rather than attempting to plant when thrips-feeding, and the resultant risk for TSWV infection is minimized. Culbreath et al. (2010) found that cultivars with high levels of resistance to TSWV could be planted in late-April without greatly increasing the risk of loss associated with the disease.

Southern stem rot (SSR), which is caused by the fungal organism *Sclerotium rolfsii*, is a disease of major concern by U.S. peanut growers. The disease can reach levels that make it the limiting yield factor in some situations (Bowen et al., 1996). Planting date has been shown to affect SSR incidence in peanut. In Alabama, Hagan et al. (2001) found reduced levels of SSR stem rot in peanut planted in mid-May when compared to peanut planted in mid-April and early-May. Bowen (2003) found a decrease in SSR stem rot infection in two of three years when moving from a mid-late-April planting date to a mid-May date. Similar results were reported in Georgia (Brenneman and Hadden, 1996), where earlier-planted peanuts had a greater SSR incidence than later-planted peanuts.

This study was designed to determine the effect of planting date and the time between initial planting and the decision to replant, on yield, grade, and the incidence of TSWV and SSR in peanut. The first objective of this study was to determine when a grower should or should not attempt to replant a below-optimum peanut stand when considering both initial planting date and the duration between that planting date and when the decision to replant is made.

The second objective was to determine the optimum method of replanting if the decision is made to replant.

**Materials and Methods**

Irrigated field trials were conducted on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2014) at the University of Georgia (UGA) Lang-Rigdon Farm in 2012 and at the NESPAL Farm in 2013; both near Tifton, GA. Tests were also conducted under irrigation on a Dothan Loamy Sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2014) at the UGA Attapulgus Research and Education Center in Attapulgus, GA in 2012 and 2013. Land preparation at all sites included disc-harrowing, deep-turning with a moldboard plow to a depth of 30 to 35 cm, and rotary-tilling to form peanut beds 1.8 m wide. All fertilizer requirements and applications, including those for calcium and boron, were based on UGA extension recommendations (Harris, 1997). Pre-emergent herbicides application at all site-years included pendimethalin[1] (0.93 kg a.i. $ha^{-1}$), diclosulam[2] (27 g a.i. $ha^{-1}$), and flumioxazin[3] (107 g a.i. $ha^{-1}$); all of which were watered into the soil with 1.3 cm of water through a center-pivot within 24 hr after application.

Peanut cultivar Georgia-06G (Branch, 2007) was planted using a two-row Monosem precision air planter[4] (Monosem Inc., Edwardsville, KS) at a depth of 5 cm and a row spacing of 0.91 m in rows 12.2 m in length. Seed was treated with azoxystrobin, fludioxonil, and mefenoxam fungicide seed treatment[5]. Fungicide applications were made based on guidelines provided by the high risk model of the Peanut Disease Risk Index (Kemerait et al., 2012). Post emergence herbicide applications at Tifton included clethodim[7] (280 g a.i. $ha^{-1}$), bentazon[8] (0.841 kg a.i. $ha^{-1}$) and crop oil concentrate[9] (2.34 L $ha^{-1}$) on 18 June 2013. At Attapulgus, post emergence herbicide applications included imazapic[19] (70.1 g a.i. $ha^{-1}$) on 25 July and clethodim[7] (175 g a.i. $ha^{-1}$) on 29 August 2012, and imazapic[19] (70.1 g a.i. $ha^{-1}$) on 31 July 2013. Insecticide applications at Attapulgus consisted of lambda-cyhalothrin[20] (43.8 g a.i. $ha^{-1}$) on 25 July and 17 August 2012, and lambda-cyhalothrin[20] (36.4 g a.i. $ha^{-1}$) on 29 July 2013).

Two initial planting dates were used in each site-year, with the first date coming in mid-April to Early-May, and the second date occurring in late-May. Replant treatments occurred at three time periods following each initial planting date. The first replant timing took place when it was determined that complete plant emergence had occurred and a grower would have time to make an informed decision on replanting, with two subsequent replant timings occurring approximately one and two weeks after the first replant timing, respectively. All initial planting dates and replant dates can be found in Table 5.1. All plots were seeded at 19.7 seeds $m^{-1}$ and were thinned by hand to desired plant stands at full plant emergence. 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. Two methods for replanting were employed at each replant date. The first method was to retain the initial plant stand and move the planter units 8.9 cm to the side and supplement with additional seed at 11.5 seeds $m^{-1}$. The second method was to destroy the initial plant stand with glufosinate herbicide (656 g ai. $ha^{-1}$) and replant at the full 19.7 seeds $m^{-1}$ seeding rate. A listing of all treatment effects and initial plant stands can be found in Table 5.2.

Plots were arranged in a split-plot design with four replications, with initial planting date as the main plot effect and replant treatment (factorial of replant method x time between initial planting and replanting) as the sub-plot effect. Non-replanted control plots at both the

UGA recommended 13.1 plants $m^{-1}$ and the below-adequate plant stand of 5.9 plants $m^{-1}$ were also included for each initial planting date.

Treatments were evaluated for pod yield, market grade (% TSMK), and incidence of TSWV (Attapulgus 2012 and 2013; Tifton 2012) and SSR (Attapulgus 2013; Tifton 2012 and 2013). Tomato spotted wilt virus levels in Tifton 2013 and SSR levels in Attapulgus 2012 were too low to warrant rating. Ratings for TSWV were conducted on 18 September 2012 in Tifton; and 11 September 2012 and 27 September 2013 in Attapulgus. Ratings for stem rot were conducted immediately after row inversion for each treatment.

Peanut maturity was determined at each site-year using the hull scrape method (Williams and Drexler, 1981). Due to the inclusion of multiple planting and replant dates, multiple inversion and harvest dates were needed. Inversion and harvest dates for each treatment can be found in Table 5.3. Peanuts were inverted using a two-row KMC digger-shaker-inverter[13] in both Tifton and Attapulgus, and harvested using a two-row Lilliston peanut combine in Tifton and a Hobbs two-row peanut combine[21] in Attapulgus. Yields were 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[14]. Data were analyzed by analysis of variance and differences among least square means were determined using multiple pairwise t-tests (P=0.05). For analysis purposes, replant method, initial planting date (early, late), and replanting time (early, mid, late) were treated as fixed while site-year, replication, and interaction with these factors were treated as random. Data were pooled across factors when appropriate.

**Results and Discussion**

Because the interaction of site-year X planting date X replant treatment was significant for pod yield, data were separated by planting dates within each site-year. Replant treatment differences were observed in seven out of eight site-year X initial planting date interactions (Table 5.4). Pod yield was 10% lower on average at the reduced plant stand when compared to the optimum plant stand. While pod yield was numerically lower at the reduced stand in seven of eight situations, significant reductions were only observed at the late initial planting dates in Tifton in 2012 and 2013. Yield was reduced at the reduced plant stand by 20.6% and 12.5% in 2012 and 2013, respectively. The overall trend of reduced yield at the below-optimum stand is magnified at the later initial planting date, where the average pod yield decrease at the below-optimum stand was 13.2%, compared to the early initial planting date which averaged a 5.8% decrease at the sub-optimum stand when losses were present. These results indicate that as planting date becomes later, peanut is less capable of adjusting for reduced stand. Reduced yield at reduced plant stand has been reported previously (Chin Choy et al., 1982; Kvien and Bergmark, 1987, Sconyers et al., 2007; Sorenson et al., 2004).

Increased pod yield from replanting was observed in two of eight site-year x planting date combinations. In the late planting date at Tifton 2013, yield was increased by both a complete and supplemental replant treatment at the early (17 days after initial planting (DAIP)) replant date. Yield at the middle (24 DAIP) and late (38 DAIP) replant dates were not significantly improved for either replant method when compared to the non-replanted plots at either initial plant stand. In the early planting date at Attapulgus 2013, pod yield was improved by both the complete replant at the early (19 DAIP) replant date and the supplemental replant at the middle (26 DAIP) replant date, while yield was not improved at the late date. Although pod yield was reduced at the reduced plant stand in the late planting date at Tifton 2012, there was no replant option that improved yield. In fact, all replant treatments resulted in yields lower than both non-replanted stands. While yield was not significantly reduced at reduced plant stand at the early planting date in Tifton 2012, it was significantly reduced for all replant treatments at all replant timings.

A likely cause of the lack of advantages seen from replanting is the later planting date associated with the replant treatment. Previous research has shown that delayed planting outside of the optimum window can reduced yields (Drake et al., 2014; Kvien and Bergmark, 1987; McKeown et al., 2001; Tillman et al., 2007). The advantage gained by replanting at the early and middle replant dates for the early initial planting date at Attapulgus 2013 is likely due to the extreme early initial planting date (24 April) utilized in that test. While early planting is generally preferred over later planting, research has shown that yields from May plantings can be greater than April plantings (McKeown et al., 2001; Nuti et al., 2013). Replanting at the early and middle replant dates pushed planting date to 13 May and 20 May, respectively, while the latest replant date occurred on 28 May. When a replant decision is to be made, a grower must consider both before and after replanting plant populations, as well as the effect of planting date of the initial stand and the replanted stand on yield potential. While yields have shown to decline as plant stand is reduced, the later planting date associated with replanting may be more of a detriment to yield than the reduced plant stand.

Market grade was also affected by replant treatment for the early planting date when averaged across site-years (Table 5.5). The non-replanted treatment at the recommended plant stand achieved the highest numerical grade, with all others being equal to that treatment except for both replant treatments at the late replant date, which graded lower. This result is similar to those reported by Kvien and Bergmark (1987), who found a decrease in market grade as planting date became later. Disease incidence was variable and generally unrelated to replant treatment. The lack of differences in disease pressure between planting dates and replant dates is likely due to varietal resistance in the Georgia-06G cultivar used. Because of the resistance of the cultivar and the high-risk fungicide program used, overall disease pressure was low, making differences in disease incidence negligible.

**Summary and Conclusions**

While yield trended lower at the reduced plant stand, options for making up for lost yield by replanting were limited. What was clear though, was that replanting is more apt to be successful the sooner it is initiated after initial planting. This is most likely due to a planting date effect, as yields have been shown to decrease as planting date gets past mid-May. The major exception to the planting date observation was at an initial planting date of 24 April, where replant dates at 13 May and 28 May outperformed the initial planting date. The recommendation to growers should be to try to make replanting decisions as early as possible, especially as initial planting becomes later. In addition, a supplemental replant treatment was generally the better option when compared to a complete replant treatment, no matter the initial planting date or time duration between initial planting and replanting. While grade was affected by replant treatment at the early planting date, disease incidence was unaffected. Based on this set of data, pod yield should be the main agronomic factor considered when a replant decision is made. Future research is needed to further investigate the relationship between plant stand and planting date. Future research should also emphasized multiple digging dates in an attempt to optimize harvest timing of peanuts that are replanted via supplemental addition at multiple replanting dates.

Table 5.1. Initial planting dates, replanting dates, and time between initial planting and replanting in Tifton, GA and Attapulgus, GA in 2012 and 2013.

| | Tifton-2012 | Attapulgus-2012 | Tifton-2013 | Attapulgus-2013 |
|---|---|---|---|---|
| **Early Planting Date** | 4-May | 27-Apr | 7-May | 24-Apr |
| Early Replant Date | 23-May (19)[a] | 16-May (19) | 24-May (17) | 13-May (19) |
| Mid Replant Date | 29-May (25) | 22-May (25) | 31-May (24) | 20-May (26) |
| Late Replant Date | 4-Jun (31) | 29-May (32) | 14-Jun (38) | 28-May (34) |
| **Late Planting Date** | 30-May | 22-May | 31-May | 20-May |
| Early Replant Date | 15-Jun (16) | 6-Jun (15) | 17-Jun (17) | N/A |
| Mid Replant Date | 20-Jun (21) | 13-Jun (22) | 21-Jun (21) | 11-Jun (22) |
| Late Replant Date | 27-Jun (28) | 19-Jun (28) | N/A | 17-Jun (28) |

[a] Number in parentheses is number of days the replant treatment occurred after the initial planting date for that treatment.

Table 5.2. Initial planting date, replant timing, replant method, initial plant stand, and replant seeding rate for each treatment in Tifton, GA and Attapulgus, GA in 2012 and 2013.

| Treatment Number | Initial Planting Date | Replant Time | Replant Method | Initial Plant Stand (plants $m^{-1}$) | Replant Seed Rate (seeds $m^{-1}$) |
|---|---|---|---|---|---|
| 1 | Early | Early | Complete | 5.9 | 19.7 |
| 2 | Early | Mid | Complete | 5.9 | 19.7 |
| 3 | Early | Late | Complete | 5.9 | 19.7 |
| 4 | Early | Early | Supplement | 5.9 | 11.5 |
| 5 | Early | Mid | Supplement | 5.9 | 11.5 |
| 6 | Early | Late | Supplement | 5.9 | 11.5 |
| 7 | Early | None | None | 5.9 | None |
| 8 | Early | None | None | 13.1 | None |
| 9 | Late | Early | Complete | 5.9 | 19.7 |
| 10 | Late | Mid | Complete | 5.9 | 19.7 |
| 11 | Late | Late | Complete | 5.9 | 19.7 |
| 12 | Late | Early | Supplement | 5.9 | 11.5 |
| 13 | Late | Mid | Supplement | 5.9 | 11.5 |
| 14 | Late | Late | Supplement | 5.9 | 11.5 |
| 15 | Late | None | None | 5.9 | None |
| 16 | Late | None | None | 13.1 | None |

Table 5.3. Inversion and harvest date for all treatments in Tifton, GA and Attapulgus, GA in 2012 and 2013

| Treatment Numbers | | Tifton-2012 | Attapulgus-2012 | Tifton-2013 | Attapulgus-2013 |
|---|---|---|---|---|---|
| 1, 2, 3 | Inversion Date | 10-Oct | 9-Oct | 24-Oct | 17-Oct |
| | Harvest Date | 15-Oct | 16-Oct | 30-Oct | 28-Oct |
| 4, 5, 6 | Inversion Date | 10-Oct | 24-Sep | 10-Oct | 1-Oct |
| | Harvest Date | 15-Oct | 27-Sep | 16-Oct | 4-Oct |
| 7, 8 | Inversion Date | 21-Sep | 24-Sep | 26-Sep | 27-Sep |
| | Harvest Date | 24-Sep | 27-Sep | 1-Oct | 1-Oct |
| 9, 10, 11 | Inversion Date | 29-Oct | 23-Oct | 6-Nov | 28-Oct |
| | Harvest Date | 31-Oct | 1-Nov | 11-Nov | 31-Oct |
| 12, 13, 14 | Inversion Date | 29-Oct | 16-Oct | 24-Oct | 28-Oct |
| | Harvest Date | 31-Oct | 23-Oct | 30-Oct | 31-Oct |
| 15, 16 | Inversion Date | 16-Oct | 16-Oct | 24-Oct | 17-Oct |
| | Harvest Date | 19-Oct | 23-Oct | 30-Oct | 28-Oct |

Table 5.4. Pod yield at two planting dates, three replanting dates, and two replant methods in Tifton, GA and Attapulgus, GA in 2012 and 2013.

| | | | Tifton 2012 | Attapulgus 2012 | Tifton 2013 | Attapulgus 2013 |
|---|---|---|---|---|---|---|
| Initial Planting | Replant Timing | Replant Treatment | ------------------------kg $ha^{-1}$------------------------ | | | |
| Early | None - 13.1[b] | None | 7739 a[a] | 6780 a[a] | 6659 | 4434 d[a] |
| | None – 5.9[c] | None | 7379 a | 6596 a | 5991 | 5086 cd |
| | Early | Complete | 5540 c | 6514 a | 6671 | 7307 a |
| | | Supplemental | 6291 b | 6874 a | 6895 | 6513 abc |
| | Mid | Complete | 4959 cd | 4929 b | 6428 | 6518 abc |
| | | Supplemental | 6263 b | 6836 a | 6854 | 6852 ab |
| | Late | Complete | 4791 d | 5906 ab | 6069 | 5185 cd |
| | | Supplemental | 6252 b | 6456 a | 6595 | 5642 bc |
| | Standard Error | | ± 297 | ± 482 | ± 504 | ± 776 |
| Late | None – 13.1 | None | 5322 a | 7612 a | 6886 a | 7150 ab |
| | None – 5.9 | None | 4225 b | 6740 ab | 5931 b | 6662 abc |
| | Early | Complete | 3031 de | 6722 ab | 6935 a | N/A |
| | | Supplemental | 2878 e | 7421 ab | 6970 a | N/A[d] |
| | Mid | Complete | 3622 c | 5339 cd | 6730 ab | 6210 bc |
| | | Supplemental | 3013 de | 6310 bc | 6102 ab | 7384 a |
| | Late | Complete | 3463 cd | 4826 d | N/A | 4897 d |
| | | Supplemental | 2854 e | 6976 ab | N/A | 5788 cd |
| | Standard Error | | ± 283 | ± 551 | ± 448 | ± 513 |

[a] Numbers with similar letters within a column at either the early or late initial planting date are not significantly different at the P=0.05.

[b] 13.1 plants $m^{-1}$, recommended plant stand according to University of Georgia (Beasley et al., 1997)

[c] 5.9 plants $m^{-1}$, below-optimum plant stand

[d] treatments corresponding to values marked N/A were unable to be completed due to adverse weather conditions

Table 5.5. Market grade (% Total Sound Mature Kernels (%TSMK)) averaged across two planting dates, three replanting dates, and two replant methods across site-years in Tifton, GA and Attapulgus, GA in 2012 and 2013.

| Initial Planting | Replant Timing | Replant Treatment | Grade |
|---|---|---|---|
| Early | None - 13.1[b] | None | 77.5 a[a] |
| | None – 5.9[c] | None | 76.1 ab |
| | Early | Complete | 76.1 ab |
| | | Supplemental | 76.3 ab |
| | Mid | Complete | 76.7 a |
| | | Supplemental | 76.6 a |
| | Late | Complete | 74.9 bc |
| | | Supplemental | 74.5 c |
| | Standard Error | | ± 0.7 |
| Late | None – 13.1 | None | 75.1 |
| | None – 5.9 | None | 75.6 |
| | Early | Complete | 74.8 |
| | | Supplemental | 75.5 |
| | Mid | Complete | 75.3 |
| | | Supplemental | 75.4 |
| | Late | Complete | 76.6 |
| | | Supplemental | 76.6 |
| | Standard Error | | ± 0.9 |

[a] Numbers with similar letters within a column at either the early or late initial planting date are not significantly different at the P=0.05. Data is pooled across years and locations.

[b] 13.1 plants $m^{-1}$, recommended plant stand according to University of Georgia (Beasley et al., 1997)

[c] 5.9 plants $m^{-1}$, below-optimum plant stand

# CHAPTER 6

## SUMMARY AND CONCLUSIONS

Results from these trials illustrate the importance of establishing an adequate plant stand at the initial peanut planting date. The multitude of reasons for poor potential peanut seed emergence and poor stand establishment have been well-documented, as have the effects of reduced plant stands. In general, pod yield trends as they relate to plant stand observed in previous research were also observed in these trials. In peanut seeded in single rows, a positive linear trend was observed as plant stand was increased from 3.3 to 13.1 plants $m^{-1}$. For every one plant per meter increase in stand, yield increase by an average of 201.7 kg $ha^{-1}$. Fortunately for growers, there are effective replant options at below-optimum plant stands. Reviewing all replant options for single row peanuts, yield was increased by supplemental addition of an initial stand of 3.3 and 8.2 plants $m^{-1}$, with consistent numerical advantages to supplementing the initial stand at both 4.9 and 6.6 plants $m^{-1}$. While these gains did improve yield over the non-replanted treatments, they were not large enough to increase yield to the levels achieved at the initial 13.1 plants $m^{-1}$ stand, again magnifying the importance of establishing optimum stands at the initial planting date. Replanting by destroying the initial stand replanting at the full seeding rate was never a viable option and resulted in yields consistently lower than both not replanting and replanting via supplemental seed addition.

In peanut seeded in twin rows, results were similar to those observed in single rows, although rather than continuing to increase, yield plateaued at 12.3 plants $m^{-1}$ with no benefit from increasing plant stand. Yield was reduced at stands below 12.3 plants $m^{-1}$. Unlike in the single row experiment, there were replant options that increased yield to a point even with yield of the non-replanted 12.3 plants $m^{-1}$ stand. Supplementing via either one or two hoppers significantly increased yields over not replanting at an initial stand of 9.8 plants $m^{-1}$ and the increase was large enough to equal yield provided by an initial stand of 12.3 plants $m^{-1}$. Yield also trended higher by supplementing an initial stand of 7.4 plants $m^{-1}$, although increases were not statistically significant. Similar to results in single rows, destroying the initial stand and completely replanting consistently reduced yield when compared to both not replanting and supplementing the initial stand.

In strip-tillage, pod yield was increased by replanting when compared to the reduced plant stand at two of four site-years, but the optimum method was variable, with an advantage being gained by supplementing the initial stand in one site-year and by destroying the initial stand and completely replanting in another. One major takeaway from this experiment was that it is logistically possible to successfully supplement the initial stand in the original strip-tilled seedbed. That treatment was consistently among the highest yielding with yield being the highest in three of four site-years and within 100 kg $ha^{-1}$ of the highest yielding treatment in the remaining site-year.

Additionally, in the experiment investigating replanting at multiple initial planting dates and the duration of time between initial planting and replanting, replanting options were limited. Results from this experiment indicated that replanting via both supplemental seed addition and complete destruction and replanting at the full seeding rate are more likely to be successful the earlier the replant treatment takes place. Although replanting only improved yield in two of eight site-year X planting date combinations, all improvements occurred at the early and middle replant timings, with none of the late replant timings successfully improving pod yields.

In single rows, market grade was unaffected by plant stand, while in twin rows, grade plateaued at 12.3 plants $m^{-1}$, with no advantage gained by increasing stand and a reduction in grade the lowest stand of 7.4 plants $m^{-1}$. In strip-tillage, grade was affected by treatment in three of four site-years, but effects were variable, with completely replanted plots grading either higher or lower than non-replanted and supplemental replanted plots depending on site-year. Grade differences, however, were not large enough to be a primary factor when making replanting considerations.

The most obvious effect on disease was the negative linear trend observed for tomato spotted wilt virus (*Tospovirus*) (TSWV) incidence when related to plant stand in single rows. While overall disease pressure was low, TSWV incidence was reduced by 0.35 percentage points for every one plant per meter increase in stand. In twin rows, neither plant stand nor replant treatment affected disease incidence. This is likely due to low overall pressure and exhaustive efforts employed to minimize disease incidence in those fields. In strip-tillage, the lowest southern stem rot pressure occurred when the complete replant treatment was employed, while there were no differences in TSWV incidence between treatments.

While a major take away generated from these studies is the importance of establishing an adequate initial plant stand, it should also be noted that based on this data, a peanut crop still has high yield potential even at stands that would be considered lower than optimum. These results should encourage growers with plant stands below those expected or recommended to continue to manage a crop properly, even if replanting is not an option in their situation.

Based on these overall results, yield should be the major agronomic factor considered when making a replant decision. Every effort should be made to achieve an adequate plant stand at the initial planting date, especially in single row planting where no replant option was available that could bring yield of initial below-optimum plant stands to a level equal to an initially-established optimum stand. If the decision to replant is made, these data suggest that in nearly every situation, supplementing the initial stand is advantageous when compared to destroying the initial stand and completely replanting.

## SOURCES OF MATERIALS

[1] Prowl®, BASF, Inc., Research Triangle Park, NC 27709

[2] Strongarm®, DOW AgroSciences, LLC., Indianapolis, IN 46268

[3] Valor®, Valent U.S.A, Inc., Walnut Creek, CA 94596

[4] Monosem Inc., Edwardsville, KS 66111

[5] Dynasty®, Syngenta Crop Protection, Inc., Greensboro, NC 27409

[6] Liberty®, Bayer Crop Science, Research Triangle Park, NC 27709

[7] Select®, Valent U.S.A, Inc., Walnut Creek, CA 94596

[8] Basagran®, Arysta LifeScience North America, LLC., Cary, NC 27513

[9] Agri-Oil®, Chem Nut Inc., Albany, GA 31706

[10] Ultra Blazer, United Phosphorus, Inc., King of Prussia, PA 19406

[11]2,4-DB®, Winfield Solutions, LLC., St. Paul, MN 55164

[12] Poast®, BASF, Inc., Research Triangle Park, NC 27709

[13] Kelley Manufacturing Co., Tifton, GA 31793

[14] SAS Institute Inc., Cary, NC 27513

[15] AGCO Corporation, Duluth, GA 30096

[16] Unverferth Manufacturing Co, Inc., Kalida, OH 45853

[17] RoundUp PowerMax®, Monsanto Compay, St. Louis, MO 63167

[18] Dual Magnum®, Syngenta Crop Protection, Inc., Greensboro, NC 27409

[19] Cadre®, BASF, Inc., Research Triangle Park, NC 27709

[20] Lambda-Cy®, United Phosphorous, Inc., King of Prussia, PA 19406

[21] Amadas Industries, Suffolk, VA 23434

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