ROW PATTERN, ROW SPACING, AND SEEDING RATE EFFECTS ON CORN AND PEANUT

by

MICHAEL THOMAS PLUMBLEE

(Under the Direction of R. Scott Tubbs)

ABSTRACT

In recent years, non-conventional planting configurations in corn (*Zea mays* L.) and peanut (*Arachis hypogaea* L.) have received renewed interest, thus an evaluation of multiple planting scenarios using current cultivars, cultural practices, and technologies were conducted. Based on the results of studies conducted in 2012–2014 in corn and 2008-2010 and 2014 in peanut, Georgia farmers have greater flexibility in selecting between row spacings and row patterns (76- and 91-cm single-row and 91-cm twin-row) for production without major concern for yield decline or pest increase. In peanut, producers may not observe yield or TSWV reducing benefits from twin-row patterns using high-yielding TSWV-resistant cultivars as they once had with previous cultivars in current TSWV conditions. Based on this research, 91-cm single-row patterns are the most economical for production of corn and peanut in Georgia overall.

INDEX WORDS: *Arachis hypogaea, Zea mays,* Twin-Row Pattern, Single-Row Pattern, Seeding Rate, Tomato Spotted Wilt Virus, Planter Cost, 76-cm Row Spacing, 91-cm Row Spacing

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MICHAEL THOMAS PLUMBLEE

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MICHAEL THOMAS PLUMBLEE

Major Professor: R. Scott Tubbs
Committee: Eric P. Prostko
Nathan B. Smith

Electronic Version Approved:

Julie Coffield
Interim Dean of the Graduate School
The University of Georgia
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DEDICATION

I would like to dedicate this thesis to my family. Without the love and support that I have received from my family over the last few years I would not be where I am today. I would also like to dedicate this thesis to my grandfather, William Hal Plumblee, who I never had a chance to meet but have heard many stories about his passion for agriculture, helping farmers in times of need, and educating the future farming generation.

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CHAPTER 1

INTRODUCTION

With the world population now exceeding seven billion people and growing, the demand for improving crop yields, crop quality, and farm efficiency is important to ensure that food production is adequate to feed the people in the world (United States Census Bureau, 2014). With any type of cropping system there are many factors that can affect crop yield and quality. These factors include climate, insect damage, disease damage, weed competition, and the use of different production practices (Haferkamp, 1988). Although producers do not have the ability to control all factors that influence a cropping system, there are certain fundamental production practices that can be controlled and will help maximize crop yield, quality, and net revenue (Tubbs *et al*., 2011).

In 2013 in Georgia, agriculture alone contributed approximately 13 billion dollars annually to Georgia's economy (University of Georgia [UGA], 2014a). With Georgia's climate, weather, and soil types; many different crops can be produced including, but not limited to row crops, orchard crops, and vegetable crops. On average from 2009 to 2013, two out of the 10 most economically important commodities in Georgia were peanut (*Arachis hypogaea* L.) (ranking 5^{th}) and corn (*Zea mays* L.) (ranking 9^{th}) (UGA, 2015a). In Georgia, approximately 220,000 hectares of peanuts and 180,000 hectares of corn were planted on average from 2009 to 2014 (NASS, 2015a). With many row crop farmers growing corn and peanut, production guides and timely crop information are important to help farmers determine production practices that will allow them to be successful both agronomically and economically. In order to maximize yields, reducing pest pressure and good crop rotation are often suggested. Common crop rotations in the Southeast are comprised of corn, peanut, and cotton (*Gossypium hirsutum* L.) (Sturkie and Buchanan, 1973; Beasley, 1997).

Planting configurations with commonly grown crops have been researched to help determine which combination is best to maximize yield and producer net revenues. Often these planting configurations can be different depending on what crop is to be planted, which can lead to many factors affecting each decision that is made. In addition to the likelihood of additional or specific equipment needed to plant different crops, factors such as harvesting equipment, tractor tire width settings, and pest management plans may also have to be adjusted (Farnham, 2001). If growers have only one planter, having to adjust planters to adapt to proper planting configurations for multiple crops can be logistically problematic especially during narrow planting windows. If a grower was able to use the same planting equipment across multiple crops in their rotation, beneficial economic and logistic incentives may result. However, in order for a producer to switch or modify current practices, there should be some economic benefit (Hallman and Lowenberg-DeBoer, 1999; Farnham, 2001).

Corn, also referred to as maize, is a tall-growing, C_4 monoecious monocot, with broad horizontal leaves growing alternately along the length of the main culm that produces grain (Smith, 1995). It is used in many products such as food, feed, and fuel (USDA, 2015). In Georgia and much of the southeastern United States, corn is often grown in rotation with cotton, soybean (*Glycine max* (L.) Merr.), wheat (*Triticum aestivum* L.), and peanut. With the United States being the number one corn producing country in the world (USDA, 2015), many universities and companies have conducted research on corn production practices. New commercial corn hybrids are released every year with different plant characteristics such as growth habit, disease resistance, and yield potential. Therefore, there is an ongoing need for research of agronomic practices to optimize yield and revenue.

Peanut is an annual dicotyledonous legume that matures its fruit underground (Smith, 1995). Peanut seed contains approximately 42 to 52 percent oil and 25 to 32 percent protein (Dwivedi *et al*., 1990; Beasley, 1997; Smith, 1995) and is used in a variety of oils, food products, and snacks. Due to the increased incidence of Tomato Spotted Wilt Virus (*Tospovirus*) (TSWV) in peanut in the early-1990s, the use of twin-row planters was widely adopted to reduce TSWV incidence and thus increase yield (Sconyers *et al.,*2007*;* Sorensen *et al.,* 2007*;* Tubbs *et al*., 2011; Culbreath *et al*., 2012). Tomato Spotted Wilt Virus is spread by vectors which in peanut are often tobacco thrips (*Frankliniella fusca*) and/or western flower thrips *(Frankliniella occidentalis)* (UGA, 2010). Similar to corn, peanut cultivars with new characteristics are released from breeding programs annually. Common characteristics that change are seed size and disease resistance, both of which can have economic impacts on peanut production. Continued agronomic research to evaluate new cultivars and the current recommended planting configurations is needed in order to let growers know how to maximize revenue.

Since a majority of the current peanut cultivars have resistance to TSWV, the need for twin-row planters to aid in the reduction of TSWV may not be as important as it once was when cultivars were less resistant. Even though twin-row pattern may not have the effects on TSWV that it once did, this row pattern may still have benefits. Without adequate research, the real need for twin-row planters in peanut cannot be determined. Because twin-row planters cost approximately 1.63 times more than a single-row planter on average according to planter manufacturers, growers investing in twin-row planters without any benefit over single-rows may observe economic impacts from added expense.

In addition to benefitting from corn and peanut production in terms of net income, other beneficial aspects of rotational crop production can be important, especially in dealing with pest control. Since the release of glyphosate resistant crops, mechanical weed control has declined and more growers have adopted the used of conservation tillage and no-till planting systems (Givens *et al*., 2009). In reduced tillage or no-till cropping systems, the use of herbicides has allowed for less conventional tillage to be used for weed control (Fernandez-Cornejo *et al*., 2012). Over the last decade, herbicide resistant Palmer amaranth (*Amaranthus palmeri*) has become a major problem in the southeastern United States. By changing herbicide modes of action, which often can be done by default in a crop rotation, the likelihood of weeds becoming herbicide resistant is reduced and pest pressure is therefore controlled more easily (Vencill *et al*., 2012). Although chemical methods have become the primary way to control weeds, agronomic factors such as row spacing, plant density, or row pattern could also have some beneficial impacts on weed control (Brecke, 1995). By planting seed closer together or spacing plants in certain patterns such as twin-row, the plants often have much faster canopy closure, thus reducing light penetration for weed seed to germinate and seedlings to photosynthesize.

As the increasing world population becomes an even greater issue in the future, continued research in agriculture is going to become even more important. As new technologies and issues arise, production practices will likely adapt over time as they have done in the past. By utilizing our resources responsibly, increased yield, quality, and net revenue will assist in continuing to meet the demands of agriculture globally.

CHAPTER 2

LITERATURE REVIEW

Row Pattern

Row pattern can be defined as the spatial arrangement of plants within a given area. In Georgia, there are two primary row patterns that are currently being used for peanut and corn, single-row and twin-row patterns. Previous research in corn has shown no significant advantages or yield differences for twin versus single-row (Balkcom *et al*., 2010; Robles *et al*., 2012; Bruns *et al.*, 2012). Although row pattern has not shown any positive yield impacts, Bruns *et al.* (2012) reported that no negative yield impacts were observed in twin-row pattern when compared to single-row pattern at similar plant populations. The University of Georgia (UGA) currently recommends planting corn in single-row pattern (Lee, 2013). However, for equipment uniformity and agronomic benefits as well as quicker canopy closure, farmers are expressing renewed interest in the potential of twin-row corn.

Unlike corn, previous research in peanut has shown that significant peanut yield increases can be seen in twin-row over single-row (Colvin *et al.,* 1985; Baldwin *et al*., 1998; Baldwin *et al.*, 2001; Brown *et al*., 2003; Tillman *et al*., 2006; Tubbs *et al*., 2011). Twin-row planted peanut can offer other benefits besides yield, such as weed control, soil temperature moderation, and reductions in disease. By the crop canopy covering the soil surface, shading effects can be observed on the soil surface preventing weeds from germinating and photosynthesizing (Colvin *et al*., 1985; Wehtje *et al*., 1994). A majority of the peanut crop is grown where the soil can reach temperatures up to 60°C (Kvien, 1995; Beasley, 1997). High soil temperatures can lead to pollen sterility and inhibit pegs from entering the soil which is essential for pod production (Kvien, 1995). By utilizing row patterns such as twin-row, increased rate of canopy closure, improved plant stand, and reduced soil temperatures can result (Johnson *et al*., 1987). Row pattern in peanut can also aid in cultural disease control by affecting incidence of TSWV and southern stem rot (*Sclerotium rolfsii* Sacc.) (Minton and Csinos, 1986; Brown *et al*., 2003; Tillman *et al*., 2006; Culbreath *et al*., 2008). Although yield, soil temperature, disease incidence, and weed suppression have been observed to be affected by row pattern, neither Jaaffar and Gardner (1988) nor Sullivan, (1991) observed any effects on peanut grade, but Sorensen *et al*. (2004) did see a one point increase in grade (TSMK) in twin-row over single. Currently, UGA recommends planting peanut in either twin or single-row pattern depending on grower preference and equipment availability (Beasley, 1997).

Row Spacing

A row is defined as a line of cultivated plants, therefore, row spacing can be defined as the distance between rows of cultivated plants. Planting crops in different row spacing can vary for many reasons as well as grower preferences. When determining or recommending the appropriate row spacing to use for a crop, seed quality, seed size, and cultivar often can have an influence (Henning *et al*., 1982). Different row spacings can cause the distance between plants within the row to increase or decrease if the seeding rate remains constant. By decreasing row spacing, less intra-row competition between plants would occur allowing for a larger rooting zone for the plant (Humphrey and Schupp, 2000). In addition to less intra-row competition, narrowing row spacing could also allow for faster canopy closure to suppress weeds (Hauser and Buchanan, 1981).

Along with the effects that row spacing can have on corn plants and yield, row spacing can affect harvest equipment. By narrowing row spacing from conventional row spacing, corn harvest headers may have to be adjusted as well as any other equipment that may be used throughout the season to manage the crop (Nelson and Smoot, 2009). The current UGA recommended row spacing for corn is 76 to 91 cm row spacing (Lee, 2013).

Narrowing row spacing in peanut from conventional (91 cm) to narrower (76 cm or less) has shown yield advantages, especially in peanut with bunch-type growth habits (Norden and Lipscomb, 1974; Lanier *et al*., 2004). Runner market-type peanuts are currently the most common market type grown in Georgia and have a prostrate or decumbent growth habit, although yield increases from narrowing row spacing not commonly observed with runner peanut (Duke and Alexander, 1964; Cox and Reid, 1965; Harrison, 1970; Monzingo and Coffelt, 1984). When comparing conventional row spacing of 91-cm to 76-cm, agronomic affects similar to twin-row pattern can be observed. By the rows of plants being spaced closer together, the amount of time it takes for canopy closure is less. Due to faster canopy coverage, reduced weed competition has been observed with narrow row spacings (Johnson *et al*., 2005; Stephenson and Brecke, 2011). In Georgia, the current row spacing recommendation for peanut is 91 cm, but often row spacing is based on growers preference and the equipment that they own, especially harvest equipment such as diggers (Johnson *et al*., 1987).

Seeding Rate

Seeding rate is defined as the amount of seed of an individual species that is needed to achieve an adequate stand (Houck, 2009). When determining an optimum seeding rate, germination of the seed should be taken into consideration. Optimum plant density (plant ha^{-1}) to maximize yield is the objective, and can be done by studying the relationship between yield per plant and population (Brown *et al.*, 1970). Altering seeding rate in a crop can affect many different factors within production such as disease and pest pressure, seed cost, and plant competition. Corn seeding rates have increased over the years as commercial hybrids have been bred with better genetics for pest resistance, reduced lodging, and yield potential (Reeves and Cox, 2013). As a result of better hybrids, higher plant populations can be maintained and higher yields can be achieved. Previous research on seeding rates in corn production in the United States has often resulted in large ranges of optimum seeding rates because seeding rates are influenced by environmental conditions, growing region, and other factors such as irrigation. Typically, environments with high yield potential can accommodate higher plant populations (Pioneer Hi-Bred International, 2011). By increasing the seeding rate, eventually a yield plateau will be reached and can cause plants to be too close together resulting in greater plant competition for nutrients, water, and sunlight (Casper and Jackson, 1997; Lee, 2013). Other considerations for determining seeding rate are whether a particular row pattern or row spacing can support the same seeding rate. When keeping plant population constant but narrowing row spacing, the linear seeding rate (seed m^{-1}) decreases, suggesting that less intra-row competition may be observed. The current desired final plant population for corn in Georgia recommended by UGA is between 64,200 and 88,900 plants ha^{-1} (Lee, 2013).

Seeding rate in peanut can impact producer economics as well as disease control and yield. Peanut has been found to have decreased TSWV incidence at high seeding rates in conventional 91-cm single-rows and twin-rows (Sconyers *et al*., 2007). Thus, reducing seeding rate in peanut may increase the incidence of TSWV (Culbreath and Srinivasan, 2011; Tubbs *et al*., 2011; Culbreath *et al.*, 2013). Other diseases in peanut such as southern stem rot (which has become the most important disease in peanut since 2008 in the southeastern U.S.), can be affected by seeding rate (Kemerait *et al*., 2011). By decreasing seeding rate in peanut, the intra-row spacing between plants is increased, thus slowing the spread of southern stem rot from plant to plant (Minton and Csinos, 1986; Black *et al*., 2001; Sconyers *et al*., 2007). With this being said, extremely high or low seeding rates can lead to unwanted consequences in peanut especially with disease pressure, so selecting optimum seeding rate is important.

In most crops, production economics are very important to the producers growing them. In peanut, seed is sold on a weight per bag basis, and not on a seed per bag basis like many other crops. As a result, individual seed size has an impact on seed cost per hectare, therefore, planting peanut at excessive seeding rates without a benefit in yield or grade is not recommended (Tubbs *et al*., 2011). The current UGA seeding rate recommendation is 19.7 seed m^{-1} (Baldwin *et al.*, 1997), and the recommendation for a final plant stand in peanut is 13 plants m^{-1} (Kemerait *et al*., 2011).

Economic Impact of Row Pattern, Row Spacing, and Seeding Rate

Production costs can vary depending on cultivar characteristics such as seed size, pure live seed, and seedling vigor. With new cultivar technologies in commercial corn hybrids, corn seed prices have increased which often increases the input costs for farmers (Fernandez-Cornejo *et al*., 2014). Due to the increase in input costs, yield increases would help to justify the added costs of the seed. Similarly in peanut, seed size has increased considerably with newer cultivar releases compared to previous cultivars such as the small seeded ‘Georgia Green’ (362 seed kg^{-1}) (Branch, 1996; UGA, 2015c). In addition to seed costs and size, planting equipment can vary in purchase price, such as the price difference between twin and single-row planters. The input costs can also vary with twin and single-row production, especially in peanut with in-furrow insecticides, fungicides, and inoculant applications that are frequently used. Total product application usually increases with additional furrows that are planted.

Objectives

Fundamental production practices for field corn and peanut are very important especially in the southeastern United States and the state of Georgia. Often producers call upon Extension specialists, agents, and agronomists asking how they can change agronomic practices to increase yield and reduce production costs. A few ways that crops can be agronomically altered are to change row pattern, row spacing, and seeding rate. Because of the recent changes within peanut cultivar releases, the question of whether to purchase a twin or single-row planter when it comes time to replace equipment often arises from growers. Thus, knowing how profits can be maximized using basic fundamental agronomic strategies is key information that growers need. Additional research is needed to evaluate seeding rate effects in more detail for both single-and twin-row patterns (Tubbs *et al*., 2011). Corn yields have also been observed to increase as row spacing narrows but there have been many inconsistencies in research (Farnham, 2001). Therefore, the objectives of this research are to:

1. Determine the optimum row spacing, row pattern, and seeding rate needed to achieve maximum yield, adequate grade, least TSWV incidence, and optimum net revenue in corn and peanut.
2. Determine if equipment can be simplified for growers planting both corn and peanut while still maintaining adequate production revenues.
3. Perform an assessment of all production economics for both corn and peanut.
4. Conduct an investment analysis on purchasing a twin-row planter versus a single-row planter for corn and peanut.

CHAPTER 3

ROW PATTERN, ROW SPACING, AND SEEDING RATE IN FIELD CORN (*Zea mays* L.)[1]

[1]Plumblee, M.T., R.S. Tubbs, N.B. Smith, and E.P. Prostko. To be submitted to *Crop, Forage, and Turfgrass Management.*

Abstract

With major commodity prices constantly fluctuating, the need for growers to maximize yield and reduce production cost is crucial. The objectives of this research were to determine the optimum agronomic and economic planting scenario for field corn planted in Georgia. A randomized complete block design was used with nine planting treatments comprised of 76 and 91-cm single and 91-cm twin-row patterns, and three target plant populations (61,500; 76,000; and 92,000 seed ha^{-1}). Studies were conducted in Tifton, GA and Blairsville, GA from 2012 to 2014. In Tifton, an interaction between row type and seeding rate for yield was observed in 2012, but not in 2013 and 2014. Seeding rate was significant ($P \leq 0.05$) in terms of vegetative biomass in 2012–2014, where low seeding rates had 26, 32, and 32% higher biomass than high seeding rates in 2012, 2013, and 2014 respectively. In Blairsville, no consistent differences in row type or seeding rate were observed from 2012–2014 for yield or biomass. Based on these results, planting corn in single or twin-row (whether 76 or 91-cm single-row), or at a low, medium, or high seeding rate does not result in a yield advantage for one treatment over another. Net present value (NPV) was determined for each planter using average grain yield across plant population and year by location. The recommended investment option for both Tifton and Blairsville was to purchase a 91-cm single-row planter. This study suggests that farmers who currently own two different planters (a single and twin-row planter) for use in multiple crops (including corn and common rotation crops in the southeastern U.S.), can simplify planting operations by utilizing only one planter, which can be a 45-55% reduction in annual planter ownership costs.

Introduction

In Georgia, approximately 180,500 hectares of corn were planted per year on average from 2009–2014 (NASS, 2015a). With corn prices ranging from \$0.14 to \$0.26 kg^{-1} in 2009 and 2012 respectively, corn growers must do what is necessary to maximize grain yield and reduce input costs (NASS, 2015b). In recent years, a push to research non-conventional planting configurations with crops has become popular with hopes to increase yield without the cost of additional inputs such as fertilizer or water (Farnham, 2001). Many researchers across the United States have conducted trials with twin-row planters, where twin-rows are spaced approximately 20 cm apart (Sorensen *et al*., 2006; Nelson and Smoot, 2009; Bruns *et al*., 2012). In theory, the advantage of this is to increase the distance between plants allowing a greater area for plants to uptake water, nutrients, and absorb sunlight which are often yield limiting factors in crops such as corn (Farnham, 2001). Although research has not been consistent as to whether twin-row pattern is advantageous in terms of corn grain yields, some producers have adopted the practice (Bruns *et al*., 2012). Since research is limited on twin-row pattern for corn in Georgia, one objective of this research is to determine if there are any yield advantages or disadvantages to using the twin-row pattern. Due to high equipment costs, financial components in all cropping systems and investments in new or additional equipment can be important decisions. Knowing that using the same planter across multiple crops would help allocate planter cost and reduce risk, simplifying planting configurations with multiple crops could also be beneficial to many growers. While purchasing a twin-row planter solely for corn may not be recommended, using a twin-row planter in corn that was purchased for another crop such as peanut (*Arachis hypogaea* L.) or soybean (*Glycine max* L.) may be appropriate.

In addition to row pattern and row spacing, seeding rate research has also been conducted widely across the United States, especially with the release of higher yielding transgenic hybrids (Reeves and Cox, 2013). As a result of hybrid yield potential and efficiency increasing, the amount of area that a single plant needs to maintain or increase yield can often be decreased by increasing the plant population (plants ha^{-1}) (Reeves and Cox, 2013). When increasing the plant population, narrowing row spacing is typically a common alternative in hopes to reduce intra-row competition or overcrowding of plants (Butzen and Paszkiewicz, 2008). Although extensive research has been conducted on row spacing in corn (Brown *et al*., 1970; Lutz *et al*., 1971; Farnham, 2001; Lauer and Rankin, 2004), specific row spacings and seeding rates are not currently established in Georgia (Lee, 2013). A secondary objective of this research is to determine the optimum row spacing and seeding rate for yield and vegetative biomass. If a current production practice is going to be changed or a different recommendation made, it must also be economically beneficial to the producer. Thus, total costs of production, net income, and net present value (NPV) (taking into account planter prices) will also be analyzed.

Materials and Methods

This experiment was conducted at The University of Georgia (UGA) Coastal Plain Experiment Station in Tifton, GA and at the UGA Mountain Research and Education Center in Blairsville, GA in 2012, 2013, and 2014. Tifton is located in South GA, and the field was irrigated on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2015) at the Lang-Rigdon farm in 2012, Gibbs farm in 2013, and RDC farm in 2014. Blairsville is located in North GA, and field trials were rain-fed and conducted on a Suches loam (Fine-loamy, mixed, semiactive, mesic Fluventic Dystrudepts) (USDA-NRCS, 2015). At each location, the experimental design was a randomized complete block design consisting of four replications and nine treatments. The nine treatments used are as follows:

1. Single-Row Pattern (76-cm Row Spacing) x Low Seeding Rate
2. Single-Row Pattern (76-cm Row Spacing) x Medium Seeding Rate
3. Single-Row Pattern (76-cm Row Spacing) x High Seeding Rate
4. Single-Row Pattern (91-cm Row Spacing) x Low Seeding Rate
5. Single-Row Pattern (91-cm Row Spacing) x Medium Seeding Rate
6. Single-Row Pattern (91-cm Row Spacing) x High Seeding Rate
7. Twin-Row Pattern (91-cm Row Spacing) x Low Seeding Rate
8. Twin-Row Pattern (91-cm Row Spacing) x Medium Seeding Rate
9. Twin-Row Pattern (91-cm Row Spacing) x High Seeding Rate

Each plot was approximately 5.48 m wide (six rows) and 9.15 m long for plots with row spacing of 91-cm. Plots containing 76-cm row spacing were approximately 4.57 m wide (six rows) and 9.15 m long.

Corn planting date was determined by the UGA Corn Production Guide (Lee, 2013) and occurred after soil temperatures at a 10 cm depth had surpassed approximately 13°C at each location. The planting and harvest dates for each year and location are presented in Table 3.1. Planting was done with Monosem Precision Vacuum Planters (Monosem-Inc., Edwardsville, KS) and seed was planted approximately 2.5-cm deep in the soil. Three seeding rates were used for each row spacing treatment (76-cm single-row = 4.6, 5.6, and 7.2 seed m^{-1}; 91-cm single-row = 5.6, 7.2, and 8.3 seed m^{-1}; 91-cm twin-row = 5.8, 6.8, and 8.6 seed m^{-1}). By using these seeding rates, three final plant populations (61,500; 76,000; and 92,000 plants ha^{-1}) were targeted. In twin-rows, the two outer most row units were spaced 91-cm apart with inner most row units spaced approximately 20 cm toward the interior of the planted bed, leaving 51-cm spacing between interior twin-rows. This type of pattern was used because it is the most representative of how twin-row planters are set up in Georgia.

The hybrid used was DeKalb DKC 66-97 (Monsanto, St. Louis, MO). This hybrid was selected because it is a common commercial hybrid that is currently grown in Georgia, and is adapted for both North and South Georgia growing conditions. The hybrid has a 116 d relative maturity and according to Monsanto's AgSeedSelect, "DKC 66-97 offers a complete package of yield potential and agronomics" (Monsanto, 2015).

In Tifton 2012–2013, field preparation was done by subsoiling to a depth of 40 cm using 76-cm and 91-cm wide strip-till/bedder implements (Kelley Mfg. Co., Tifton, GA) depending on treatment. In 2014, field preparation was done by first subsoiling with a Para-till subsoiler (Tye-AGCO, Duluth, GA), followed by subsoiling to a depth of 40 cm. In all years of this study, the corresponding width of the subsoiler was used directly underneath the planted row for the single-row spacings, and the 76-cm strip-till/bedding implement was used for subsoiling in the 91-cm twin-row treatments. By using this spacing for twin-rows, the tool/shank was placed in between the twin-rows rather than under only one row. In Blairsville, the field was prepared by moldboard plowing the previous fall. Then a disc harrow and field conditioner were used to smooth and prepare the seedbed prior to planting in all three years of this trial.

A soil sample was taken and fertilizer was applied in accordance with UGA recommendations for both Tifton and Blairsville locations (Plank *et al*., 2001). High rates of fertilizer were used in Tifton because of greater leaching potential from sandy soil and higher yield potential since it was irrigated (Harrison and Lee, 2013). A yield goal of 18,840 kg ha^{-1} was used to determine the N rate for the Tifton location assuming a 56 kg grain yield for every kg of

N. A total of 336 kg N ha^{-1} was applied to the soil surface by hand using a 50:50 mixture of 28-0-0-5(S) and 10-34-0 at planting, and Urea Ammonium Nitrate (32-0-0) at side-dress. Fertilizer was applied in a split application with 96 kg N ha^{-1} at-plant, and the remaining N was side-dressed at V5 growth stage (30 cm in height) (Ritchie *et al*., 1996; Abendroth *et al*., 2011; Harris, 2013). For twin-row pattern treatments, the fertilizer was applied on a per twin-row basis; with half of the total amount of fertilizer applied to each twin-row compared to the single-row equivalent. Approximately 2.5 cm of irrigation water was supplied immediately following N application in Tifton to minimize volatilization. In Blairsville, supplemental N was applied by broadcast spreading granular Ammonium Nitrate (34-0-0) in a top-dress application at a rate of approximately 252 kg N ha^{-1} at approximately V5 growth stage to obtain a targeted yield of 15,700 kg ha^{-1}. In 2014 at Tifton, nutrient deficiencies were detected by nutrient analysis of ear leaves at approximately VT growth stage with low Mg. Thus, Epsom Salt ($MgSO_4$) was applied as a foliar application at a rate of 5.56 kg Mg ha^{-1}.

The herbicide program that was used for both locations was based on recommendations from the Georgia Pest Management Handbook (UGA, 2014b). Irrigation in Tifton was applied based on the checkbook irrigation scheduling method recommended by the UGA corn production guide (Harrison and Lee, 2013). Irrigation was not possible at the Blairsville field location, so the trial was rain-fed only.

Harvest at both locations for all years consisted of a two-row plot combine harvesting grain from the center two rows (or center two pairs of twin-rows) of each plot after physiological maturity had occurred (2820 Growing Degree Days)(GDDs), and when grain was at approximately 15.5% moisture content. Moisture content was determined using a grain moisture meter (DICKEY-john, Minneapolis, MN). In addition to plot weights, whole plant vegetative biomass samples were also collected. Three plant samples were selected at random from each plot (in non-harvest rows) and removed at the ground level to determine whole plant biomass. Plant stands for the harvest rows were counted at mid-pollination and again at harvest to ensure that desired plant populations were achieved. In 2012 at both locations, vegetative plant biomass samples were collected and recorded at harvest instead of mid-pollination, and ear weight was removed. Statistical analyses were conducted using PROC GLIMMIX in SAS v.9.3 (SAS Institute, 2010). Data were analyzed by analysis of variance (ANOVA) and differences among least square means were determined by using multiple pairwise t-tests ($P = 0.05$) by year and location.

Economic analysis in the form of an enterprise budget was conducted using the UGA Extension irrigated and non-irrigated conventional corn budgets for 2015 (UGA, 2015b). These budgets were used as a base for expenses which were then adjusted depending on treatment, inputs used, and their cost for each year and location. From these budgets, treatments were compared for total costs and net income. Net income for each treatment took into account all expenses that dealt with production except for land rend and/or land ownership costs. Equipment was adjusted in the enterprise budget to account for fuel, repairs, and labor cost consisting of eight-row planting and harvest equipment that was set up for 76-cm and 91-cm row spacing for single-row and 91-cm for twin-rows. By changing equipment for each treatment, field efficiency and other costs associated with production were altered to best represent each treatment. Using the results for net income from the enterprise budgets, an investment analysis comparing NPV for each planter and treatment was also conducted. By comparing NPV values between eight-row, 91-cm twin and 76- and 91-cm single-row planters at Tifton and Blairsville (irrigated and non-irrigated) the best economic treatment could be determined for each location while taking into account planter price differences, end of life salvage values, and field efficiencies. To calculate NPV, a total lifetime of the planter, whether it was single or twin-row, was assumed to be 1500 h (ASABE, 2011). An average of 157 h per year was used to give the planter a total lifetime of 9 yr. The annual hours put on a planter was determined by calculating the total suitable field work days and assuming one work day is 8 h and a work week of 6 d (ASABE, 2011). For this analysis, it was assumed that at least half of the annual usage hours would be spent planting corn which equals 78.5 h. The effective field capacity (Formula 3.1) of each planter was then determined by using appropriate implement widths, operation speeds, and field efficiencies (ASABE, 2011). From Formula 3.1, EFC for an eight-row 76-cm single-row planter is 3.5 ha hr^{-1} and 4.2 ha hr^{-1} for an eight-row 91-cm single and twin-row planter.

Formula 3.1 *Effective Field Capacity*

$$EFC = \frac{\mathrm{W} \times \mathrm{S} \times \mathrm{FE}}{10}$$

Where,

W = Width of Implement (m)

S = Speed traveled through field (km hr^{-1})

FE = Field efficiency of operation (%)

The NPV (Formula 3.2) was calculated based on cash flows from the 3 yr of this trial, and taking into account the different planter purchase prices and salvage values at the end of their lifetime at an average corn price for 2012–2014 of \$0.22 kg^{-1} (Barry and Ellinger, 2010; NASS, 2015b). A discount rate of 8% to account for time value of money was used.

Formula 3.2 *Net Present Value (NPV)*

$$NPV = -Investment + \frac{P_1}{1+i} + \frac{P_2}{(1+i)^2} + \cdots + \frac{P_N}{(1+i)^N} + \frac{V_N}{(1+i)^N}$$

Where,

Investment = price of planter

P_N = net cash flows

N = length of planning horizon

i = discount rate

V_N = Salvage Value at end of planning horizon

Results and Discussion

Average temperatures and rainfall for both locations for all 3 yr are presented in Table 3.2. It can be noted from this table that Blairsville received less cumulative rainfall during the growing season every year. Maximum and minimum average temperatures were also lower for the Blairsville location across all years of the study, which is typical because of the differences in latitude and elevation compared to South Georgia.

Significant differences between seeding rates (averaged across year and location) were observed, where plant population increased as seeding rate increased, (low = 67,800; medium = 83,200; high = 99,500 plants ha^{-1}). No differences in plant population were observed between row types (data not shown). The average plant population for each treatment was 8 to 10% higher than the original targeted plant population. Even though gearing and seed plate selection was based on the manufacturer’s operating manual, minor fluctuations in calibration and error from double seed adherence to each plate hole can randomly occur in field scale situations causing deviations from the expected seeding rate. However, the difference between actual populations for the varying seeding rates was similar in magnitude to our original target since plant populations were consistently higher for all seeding rates.

Grain Yield

In Tifton, significant interactions between row type and seeding rate were observed in 2012, but not in 2013 or 2014 (Table 3.3) for yield. In 2012, 76-cm single-row at high seeding rate had an 8.4% and 16.0% higher yield than medium and low seeding rates, respectively (Table 3.4). In 91-cm single-row, medium and high seeding rates had 9.6 and 21.0% higher yields than the low seeding rate, respectively. In 91-cm twin-row, yield was equal across all seeding rates. From these results, increasing seeding rate in 76- and 91-cm single-row to provide a higher plant density was beneficial with respect to yield. Within seeding rates, the 91-cm single-row pattern had 9.1 and 8.2% higher yield than both 76-cm single and 91-cm twin-rows at medium seeding rate, and 11.3% higher yield than 91-cm twin–row at the high seeding rate. It is speculated that because Tifton trials were irrigated and growing conditions in 2012 were ideal, (timely and adequate rainfall) high seeding rates were supported and increased yields over the low seeding rate was the result. A similar result was observed in 1 out of 3 yr (Karlen and Camp, 1985), where yield was significantly increased when planting more than 7.1 plants m^{-1}. It was also speculated that because corn plant leaves typically grow outward into the space between rows that plants in a twin-row pattern had greater opportunity for leaf overlap to occur (between each twin row). Because of leaf overlap, plants were experiencing increased competition for sunlight which may have reduced yield. This observation can further be illustrated in Figures 3.1–3.4 where overlapping plants leaves in twin-row can be seen. Furthermore, due to corn being a C_4 plant (complete light saturation occurs at a higher point than a C_3 plant) the difference between single and twin-rows in Tifton may have been because of increased day length (lower latitude than Blairsville), higher temperatures, and increased water supplied (rainfall and irrigation). A study conducted by Dwyer *et al.*(1991) supports this claim by reporting that leaf photosynthetic rates declined in all hybrids at increasing plant densities, although plant densities were not different between single and twin-rows the density of the leaves in twin-row was greater causing overlapping. In 2013 and 2014, all yields were statistically equal between treatments, therefore consistent yield differences were not observed.

In Blairsville, significant treatment effects were only observed for seeding rate in 2012 (Table 3.5). In 2012, medium and high seeding rates had 10.4 and 6.2% higher yield than the low seeding rate (Table 3.6). Similarly to Tifton, it is speculated that increased yields with high seeding rates in 2012 were due to ideal growing conditions. Since Blairsville was non-irrigated, water was more than likely the most yield-limiting factor, and Fulton (1970) reported similar results where high seeding rates increased yield only where soil moisture levels were high. In 2013 and 2014, the row type and seeding rate effects were not significant and all yields were equal.

Even though increased grain yield was observed in 2012 with the high seeding rate in Tifton, consistent yield increases with increased seeding rates were not observed in 2013 and 2014. As a result, neither row type nor seeding rate in corn had consistent yield effects in Tifton or Blairsville to determine if one treatment is better than another. Research conducted by Sorensen *et al*. (2006) and Robles *et al*. (2012) presented similar results, where no yield differences between single and twin-row pattern occurred. Additional research reported that adjusting seeding rate between row spacings did not affect yield (Porter *et al*., 1997; Bitzer and Herbek, 2000; Farnham, 2001). Although a specific row type or seeding rate was not consistently determined in this study, these results suggest that corn growers in regions similar to Tifton and Blairsville have abundant options for planter selection and seeding rate while maintaining yield.

Vegetative Plant Biomass

In Tifton, seeding rate was significant in each year of the study for vegetative plant biomass (g plant^{-1}), and row type was significant in 2012 (Table 3.3). Plant biomass was more per individual plant where low seeding rates occurred than with high seeding rates in all 3 yr (Table 3.7). When analyzing row type averaged across seeding rate, 91-cm single-row had 16.0% higher biomass per plant than 91-cm twin-row in 2012 (Table 3.8), but there were no differences in plant biomass among the row types in 2013–2014. Increased individual plant biomass may have differed in 2012 due to ample rainfall occurring during the growing season, thus allowing plants to have higher vegetative biomass than if it would have been a dry year. As plants matured vegetatively in twin-row pattern, vegetative growth restrictions may have been a result of increased leaf overlap between twin-rows (reducing photosynthesis) leading to a decrease in plant biomass.

Seeding rate was also significant for vegetative biomass at Blairsville in 2012 (Table 3.5), where low and medium seeding rates had on average 15.5% more biomass than the high seeding rate (Table 3.9). In 2013 and 2014, no significant differences in biomass were observed among row type or seeding rate (data not shown). When biomass was analyzed on a per area basis, no significant differences in total biomass per hectare between seeding rates were observed in Tifton or Blairsville, 2012–2014 (data not shown).

Vegetative biomass was determined to represent any row type or seeding rate effects that may occur, which may provide useful information to silage corn producers in the southeastern U.S. Because biomass production results did not differ between seeding rates, silage producers may have the ability to reduce seeding rates (reducing seed costs and increasing forage quality) and still maintain adequate yields (Cusicanqui and Lauer, 1999). Although seeding rate did not provide differences in biomass production, plant size could be altered by adjusting seeding rate where adequate soil moisture for the duration of the growing season or irrigation is available. Factors pertaining to silage production such as palatability, digestion, or fiber concentration may be manipulated agronomically by altering individual plant size, leading to higher quality silage (Cusicanqui and Lauer, 1999).

Based on the results for plant biomass in Tifton, high seeding rates in any row type tend to reduce the individual biomass of a corn plant which was consistent with the findings from Leonard *et al*. (2014), where individual corn plants had less biomass at high seeding rates and Snider *et al*. (2012), where a similar response occurred in grain sorghum (*Sorghum bicolor* L.). Although there was a reduction in individual plant biomass, the total biomass per hectare was equal across all seeding rates. The reduction in plant size observed at the high seeding rate may be due to increased plant competition for sunlight, water, and nutrients in the sandy soils in Tifton. In Blairsville, low and medium seeding rates had higher biomass than the high seeding rate, but only in 2012. The effect of seeding rate on plant biomass at Blairsville was consistent with the findings of Cox and Cherney (2001) and Ferreira *et al*. (2014), that varying seeding rates did not have any effect on plant biomass in non-irrigated trials. Differences in plant biomass across seeding rates in Tifton but not in Blairsville may be attributed to the fact that trials in Tifton were irrigated and the Blairsville trials were rain-fed. While row type did have significant effects on individual plant biomass in 2012 in Tifton, consistent effects were not observed throughout the course of this study, therefore, a confident recommendation is unable to be made.

Economic Analysis

Although yield is an important aspect in crop production, maximizing profit is also important. If yield can be maintained while reducing input costs, larger net profits can be a result. To determine the most profitable treatment in this study, individual treatment budgets were derived from the UGA Extension conventional irrigated and non-irrigated corn enterprise budgets and show the differences in variable, fixed, and total costs of production for each treatment (Table 3.10 and Table 3.11).

Beginning with Tifton, 76-cm single-row at a high seeding rate had the highest total cost (Table 3.10). The higher costs are primarily due to increased seed cost with a high seeding rate, and increased fuel and labor costs as a result of more trips across the field required because of a narrower row spacing. To compare net income between treatments, yield from each treatment was averaged over 2012–2014, and an average corn price of \$0.22 kg^{-1} was used to determine which treatment was most profitable during this test (Table 3.10 and 3.11). According to average net income, 91-cm twin-row at medium seeding rate had the highest net income (\$1177 ha^{-1}). The lowest net income observed was 76-cm single-row at low seeding rate with a 45% lower net income (\$639 ha^{-1}). Although net income is key information, to further compare treatments for row type and seeding rate, planter purchase price and salvage value also needs to be considered. Based on the results of the investment analysis for NPV, treatments with the highest NPV are considered to be the best option for a grower investing in a planter. Similar to the results for net income, 91-cm twin-row at medium seeding rate had the highest NPV (Table 3.12), even though the purchase price of an eight-row-twin row planter is on average 25,000 dollars more than an eight-row single-row planter. Although breaking down NPV by treatment gives a specific planting scenario of which planting configuration and seeding rate is best, NPV analyzed across row type will result in the best planter to purchase, because of flexibility across seeding rates if circumstances dictated the need for variable seeding rate to be considered. When comparing NPV by row type, 91-cm single-row had the highest NPV value, therefore, 91-cm single-row is the best investment option.

The same economic approach was used for Blairsville, using the UGA Extension non-irrigated conventional corn enterprise budget to construct individual treatment budgets. Assuming the price of corn from 2012–2014 was \$0.22 kg^{-1}, net income for each treatment was determined (Table 3.11). Based on net income, 91-cm single-row at a medium seeding rate had the highest net income (\$1301 ha^{-1}). The treatment with the lowest net income was 76-cm single-row at low seeding rate which had a 40% lower net income (\$784 ha^{-1}) than the highest treatment (Table 3.11). The treatment option with the highest NPV is 91-cm single-row at a medium seeding rate (Table 3.13). With NPV averaged across seeding rate for each row type, the planter to invest in would again be a 91-cm single-row planter.

Knowing that corn producers in Georgia may have increased planter selection and economic recommendations for specific planter types may be valuable, additional economic scenarios must be considered. Annual planter costs vary due to planter purchase price and useable life assumptions of the planter. The assumption was made that a planter will last approximately 9 yr by reason of either the occurrence of end of useable lifetime or the equipment becoming obsolete. Taking into consideration all costs associated with a planter including depreciation, interest, shelter, insurance, fuel, lube, and labor the average annual cost for eight-row single and twin-row planters was determined. From these results, a single-row planter has 19% lower annual costs than a twin-row planter (Table 3.14), thus a single-row planter would be the least expensive option.

Considering other crops commonly rotated with corn in Georgia have shown yield advantages with twin-row planters, such as peanut, many farmers currently own a twin-row planter and some may own both a twin and single-row planter. If a farmer only owns a twin-row planter for use in another crop, planting corn in twin-row pattern would be the best option instead of purchasing an additional single-row planter. If a farmer already owns both planters and one planter could be shared across multiple crops allowing one planter to be sold, it could save them as much as 45-55% annually in ownership costs. With this being said, recommendations can be based on three scenarios. First, if investment in a planter for corn arises as a result of replacing old equipment, purchasing a single-row planter would be the recommended option. Second, if a twin-row planter has already been purchased for use in another crop, instead of purchasing another planter for use in corn, it would be recommended to plant corn in twin-rows. Third, if a farmer currently owns both a single and twin-row planter but has the ability to use the same planter for multiple crops, substantial savings could possibly be observed, therefore making this another option.

Conclusion

The results of corn grain yield in this study were not consistent from year-to-year at each location; therefore, results show that planting corn in 76-cm single, 91-cm single or 91-cm twin-rows at a particular seeding rate does not provide a benefit over another. This suggests that a universal agronomic recommendation for the best row pattern, row spacing, or seeding rate to use in corn cannot be made. In Tifton, seeding rate did have an effect on vegetative biomass, where high seeding rates tend to produce plants with less biomass compared to low and medium seeding rates. However, higher seeding rates biomass did not provide any additional biomass over low seeding rates on an area basis, thus reducing seeding rate (and plant population) would reduce seed cost while supplying equal biomass per hectare, although larger individual plants would be the result. Larger plants may result in reduced palatability, fiber concentration, or digestibility of the plant by animals if the material were to be used for feed (Cusicanqui and Lauer, 1999).

Though a specific recommendation was not determined, it is indicated that corn producers in Georgia may have more abundant options for planter selection without consequence with respect to yield. Benefits to a grower may be evident when other crops that are grown in rotation with corn require different planters than what is currently being used to plant corn. By using one planter for all crops, planting logistics may become simplified and the cost of the planter will then be spread among more than one enterprise allowing for less risk and reduced overall costs. Economic and financial aspects of production are likewise important. When averaged across seeding rate, planting with a 91-cm single-row planter was the best option to maximize net income and NPV when compared to 76-cm single and 91-cm twin-rows at both locations. Since significant yield differences were not consistently observed in row type, purchasing or owning one single-row planter has the lowest annual costs. If the opportunity to reduce the number of planters currently being used across multiple crops by planting corn in twin-rows or using 76-cm versus 91-cm single-row planters presents itself, the savings in annual ownership costs could have major economic impacts.

Table 3.1. Corn planting and harvest dates for Tifton and Blairsville, GA 2012–2014.

	2012		2013		2014	
	Plant	Harvest	Plant	Harvest	Plant	Harvest
Tifton	Mar. 30	Sept. 4	Mar. 29	Aug. 27	Apr. 3	Aug. 22
Blairsville	May 8	Oct. 26	May 15	Oct. 22	May 26	Oct. 27

Table 3.2. Average temperatures[a] and rainfall[a] for Tifton and Blairsville, GA 2012–2014.

	Maximum Temperature ˚C[b]	Minimum Temperature ˚C[b]	Rainfall (cm)[c]
		2012	
Tifton	29.7	18.9	78.6
Blairsville	26.7	13.7	64.3
		2013	
Tifton	28.6	18.1	79.4
Blairsville	26.9	15.6	67.8
		2014	
Tifton	29.6	18.7	61.0
Blairsville	27.7	15.9	42.7

[a]Temperature and rainfall data from www.georgiaweather.net
[b]Average temperature for growing season of crop
[c]Cumulative sum of total rainfall for growing season of crop

Table 3.3. Analysis of variance probability values for yield and biomass at Tifton, GA 2012–2014.

Sources of Variation	df[b]	2012 Yield	2012 Biomass	2013 Yield	2013 Biomass	2014 Yield	2014 Biomass
		p-values[a]					
Row Type (Row)	2	0.0398	0.0196	ns	ns	ns	ns
Seeding Rate (SR)	2	<0.0001	0.0002	ns	0.0009	ns	0.0017
Row*SR	4	0.0187	ns[c]	ns	ns	ns	ns

[a]p-values were obtained from ANOVA table in output of SAS using PROC GLIMMIX procedure
[b]df = degrees of freedom
[c]ns = not significant

Table 3.4. Corn grain yield (kg ha^{-1}) for interaction term row type x seeding rate at Tifton, GA 2012.

Row Type[a]	Seeding Rate[a] Low	Seeding Rate[a] Medium	Seeding Rate[a] High
	kg ha^{-1}		
76-cm Single	14580 Ba	15890 Bb	17350 Aab
91-cm Single	14650 Ba	17480 Aa	18570 Aa
91-cm Twin	15790 Aa	16040 Ab	16470 Ab

[a]Data pooled over rep. Means within a row followed by same uppercase letter are not significantly different at P = 0.05. Means within a column followed by same lowercase letter are not significantly different at P = 0.05.

Table 3.5. Analysis of variance probability values for yield and biomass at Blairsville, GA 2012–2014.

Sources of Variation		2012		2013		2014	
		Yield	Biomass	Yield	Biomass	Yield	Biomass
	df[b]	p-values[a]					
Row Type (Row)	2	ns[c]	ns	ns	ns	ns	ns
Seeding Rate (SR)	2	0.0025	0.0098	ns	ns	ns	ns
Row*SR	4	ns	ns	ns	ns	ns	ns

[a]p-values were obtained from ANOVA table in output of SAS using PROC GLIMMIX procedure
[b]df = degrees of freedom
[c]ns = not significant

Table 3.6. Corn grain yield (kg ha^{-1}) for seeding rate at Blairsville, GA 2012.

Seeding Rate[a]	Yield
	kg ha^{-1}
Low (4.56 - 5.78)	15,079 B
Medium (5.61 - 7.15)	16,080 A
High (7.15 - 8.55)	16,838 A

[a]Data pooled over rep and row type. Means within a column followed by same uppercase letter are not significantly different at P = 0.05.

Table 3.7. Vegetative plant biomass for seeding rate at Tifton, GA 2012–2014.

Seeding Rate[a]	2012[b]	2013[c]	2014[c]
	Vegetative Biomass		
	g $plant^{-1}$		
Low (4.56 - 5.78)	85.8 A	167.1 A	220.9 A
Medium (5.61 - 7.15)	74.4 B	130.5 B	192.0 A
High (7.15 - 8.55)	63.7 C	113.5 B	150.7 B

[a]Data pooled over rep and row type. Means within a column followed by same uppercase letter are not significantly different at P = 0.05.
[b]Vegetative biomass was sampled at harvest in 2012 with ears removed.
[c]Vegetative biomass was sampled at mid-pollination in 2013-2014 with ear intact.

Table 3.8. Vegetative plant biomass for row type at Tifton, GA 2012.

Row Type[a]	Vegetative Biomass
	g $plant^{-1}$
76-cm Single	73.1 AB
91-cm Single	82.0 A
91-cm Twin	68.7 B

[a]Data pooled over rep and seeding rate. Means within a column followed by same uppercase letter are not significantly different at P = 0.05.

Table 3.9. Vegetative plant biomass for seeding rate at Blairsville, GA 2012.

Seeding Rate[a]	Vegetative Biomass
	——g $plant^{-1}$——
Low (4.56 - 5.78)	78.2 A
Medium (5.61 - 7.15)	75.7 A
High (7.15 - 8.55)	64.9 B

[a]Data pooled over rep and row type. Means within a column followed by same uppercase letter are not significantly different at P = 0.05.

Table 3.10. Estimated costs and average net income ($ ha^{-1}) by treatment for corn at Tifton, GA 2012–2014.

Treatment	1 Single 76-cm	2 Single 76-cm	3 Single 76-cm	4 Single 91-cm	5 Single 91-cm	6 Single 91-cm	7 Twin 91-cm	8 Twin 91-cm	9 Twin 91-cm
Seed rate	Low	Medium	High	Low	Medium	High	Low	Medium	High
VC[a]	1370.55	1418.87	1489.43	1355.68	1414.79	1458.81	1367.61	1405.58	1473.31
FC[b]	600.70	605.52	612.58	572.69	578.60	582.99	581.86	585.66	592.43
TC[cd]	1971.26	2024.41	2102.02	1928.35	1993.36	2041.80	1949.47	1991.24	2065.74
Grain Yield[e]	11,865	12,672	13,674	13,006	13,523	13,182	12,925	14,403	13,026
Net Income[f]	638.93	763.43	906.39	933.06	981.65	858.26	893.99	1177.43	800.09

[a]Total variable costs.
[b]Total fixed costs.
[c]Sum of total variable and total fixed costs.
[d]Total cost does not include land rent or ownership costs.
[e]Average grain yield from 2012–2014 in kg ha^{-1}.
[f]Determined by grain yield multiplied by $0.22 kg^{-1} grain minus TC.

Table 3.11. Estimated costs and average net income ($ ha^{-1}) by treatment for corn at Blairsville, GA 2012–2014.

Treatment	1	2	3	4	5	6	7	8	9
	Single 76-cm	Single 76-cm	Single 76-cm	Single 91-cm	Single 91-cm	Single 91-cm	Twin 91-cm	Twin 91-cm	Twin 91-cm
Seed rate	Low	Medium	High	Low	Medium	High	Low	Medium	High
VC[a]	1167.67	1217.61	1290.55	1152.82	1213.91	1259.40	1164.83	1204.08	1274.08
FC[b]	580.40	585.41	592.70	553.18	558.52	563.06	561.58	565.51	572.50
TC[cd]	1748.09	1803.03	1883.25	1705.24	1772.42	1822.44	1726.41	1769.58	1846.57
Grain Yield[e]	11,509	12,511	12,672	13,274	13,972	13,375	12,093	12,459	13,147
Net Income[f]	783.82	949.39	904.59	1215.04	1301.35	1120.13	934.12	971.33	1045.77

[a]Total variable costs.
[b]Total fixed costs.
[c]Sum of total variable and total fixed costs.
[d]Total cost does not include land rent or ownership costs.
[e]Average grain yield from 2012–2014 in kg ha^{-1}.
[f]Determined by grain yield multiplied by $0.22 kg^{-1} minus TC.

Table 3.12. Eight-row planter investment analysis based on experiments at Tifton, GA.

	Treatment								
	1	2	3	4	5	6	7	8	9
	Single 76-cm	Single 76-cm	Single 76-cm	Single 91-cm	Single 91-cm	Single 91-cm	Twin 91-cm	Twin 91-cm	Twin 91-cm
Seed rate	Low	Medium	High	Low	Medium	High	Low	Medium	High
EFC (ha hr^{-1})[a]	3.5	3.5	3.5	4.2	4.2	4.2	4.2	4.2	4.2
ha yr^{-1}[b]	275	275	275	330	330	330	330	330	330
	Investment								
Purchase Price	$42,500	$42,500	$42,500	$42,500	$42,500	$42,500	$67,500	$67,500	$67,500
Salvage Value	$11,724	$11,724	$11,724	$11,724	$11,724	$11,724	$18,620	$18,620	$18,620
Year	**Cashflow ha^{-1}**								
2012	$1828	$2120	$2431	$1890	$2572	$2810	$2168	$2195	$2234
2013	$368	$398	$267	$921	$573	$176	$461	$672	$126
2014	-$106	-$40	$160	$135	$46	-$112	$184	$644	$145
NPV[c]	$498,259	$594,395	$686,484	$842,827	$929,686	$848,466	$792,473	$981,265	$707,722
Avg. NPV[c]/ Rowtype		$593,046			$873,659			$827,153	

[a]EFC is the field capacity of the planter taking into account the efficiency of planting (65%).

[b]ha yr^{-1} was calculated using a planter life of 1500 hr and using the planter approximately 78.5 hr yr^{-1} to plant corn.

[c]NPV was calculated using a discount rate of 8%.

Table 3.13. Eight-row planter investment analysis based on experiments at Blairsville, GA.

	Treatment								
	1	2	3	4	5	6	7	8	9
	Single 76-cm	Single 76-cm	Single 76-cm	Single 91-cm	Single 91-cm	Single 91-cm	Twin 91-cm	Twin 91-cm	Twin 91-cm
Seed rate	Low	Medium	High	Low	Medium	High	Low	Medium	High
EFC (ha hr^{-1})[a]	3.5	3.5	3.5	4.2	4.2	4.2	4.2	4.2	4.2
ha yr^{-1}[b]	275	275	275	330	330	330	330	330	330
	Investment								
Purchase Price	$42,500	$42,500	$42,500	$42,500	$42,500	$42,500	$67,500	$67,500	$67,500
Salvage Value	$11,724	$11,724	$11,724	$11,724	$11,724	$11,724	$18,620	$18,620	$18,620
Year	**Cashflow ha^{-1}**								
2012	2334	2572	2755	2406	2646	2705	2420	2577	2739
2013	461	609	346	1368	1556	721	709	756	424
2014	1025	1263	1229	1565	1485	1641	1216	1170	1651
NPV[c]	$895,042	$1,042,508	$1,019,699	$1,499,900	$1,605,365	$1,428,156	$1,208,639	$1,257,845	$1,339,362
Avg. NPV[c]/ Rowtype		$985,750			$1,511,140			$1,268,616	

[a]EFC is the field capacity of the planter taking into account the efficiency of planting (65%).

[b]ha yr^{-1} was calculated using a planter life of 1500 hr and using the planter approximately 78.5 hr yr^{-1} to plant corn.

[c]NPV was calculated using a discount rate of 8%.

Table 3.14. Annual cost of eight-row planters

Planter	Annual Hours	Years of useable life	Annual Cost[a]
Eight-row Single	157	9	$15,416
Eight-row Twin	157	9	$18,926

[a]Annual cost was calculated using planter purchase price, which was based on $42,500 for a single-row and $67,500 for twin-row.

Figure 3.1. Corn leaves overlapping in-between rows in twin-row pattern.

Figure 3.2. Corn leaves with less overlapping in single-row pattern.

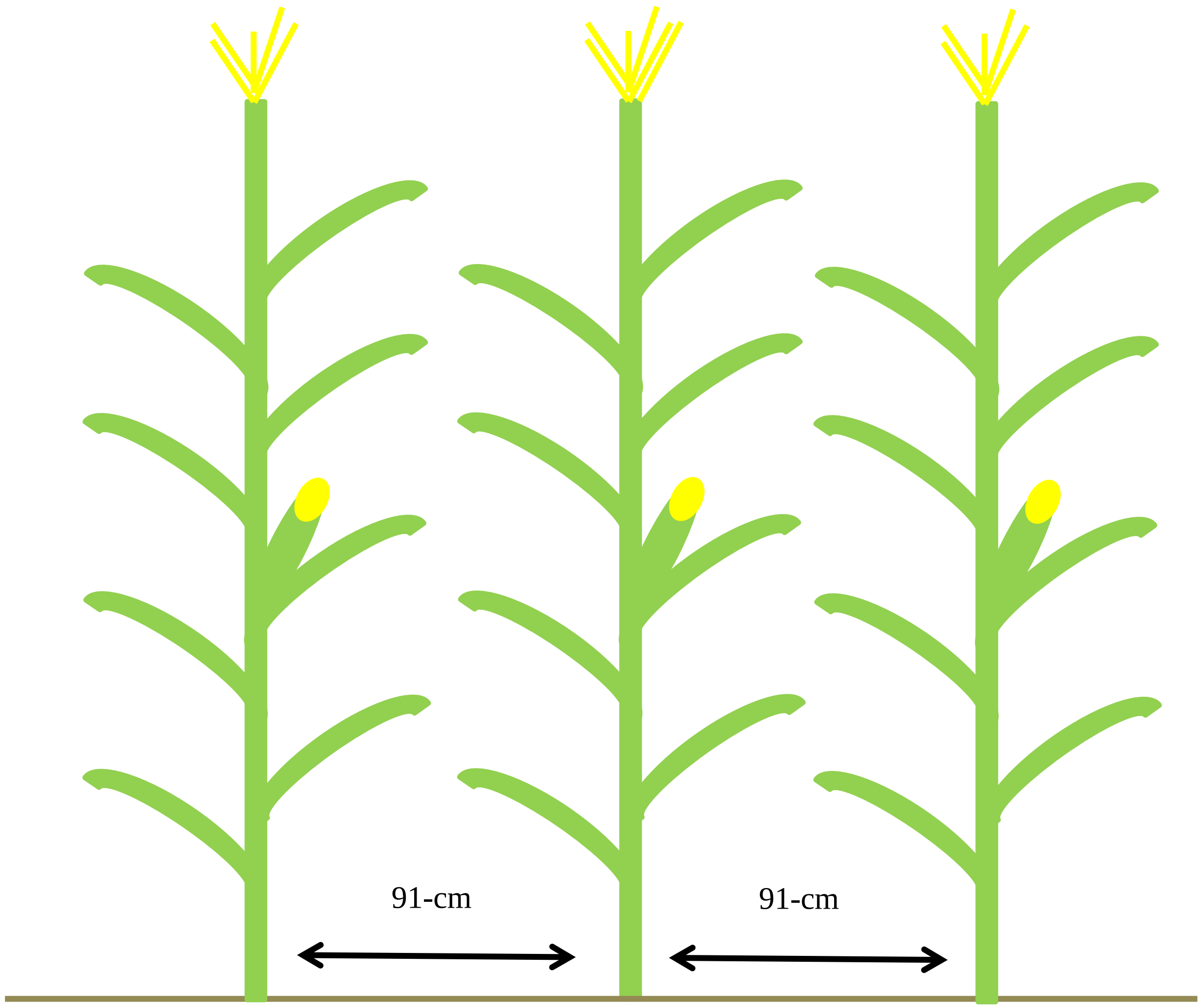


Figure 3.3. Example of corn leaf overlap in 91-cm single-rows.

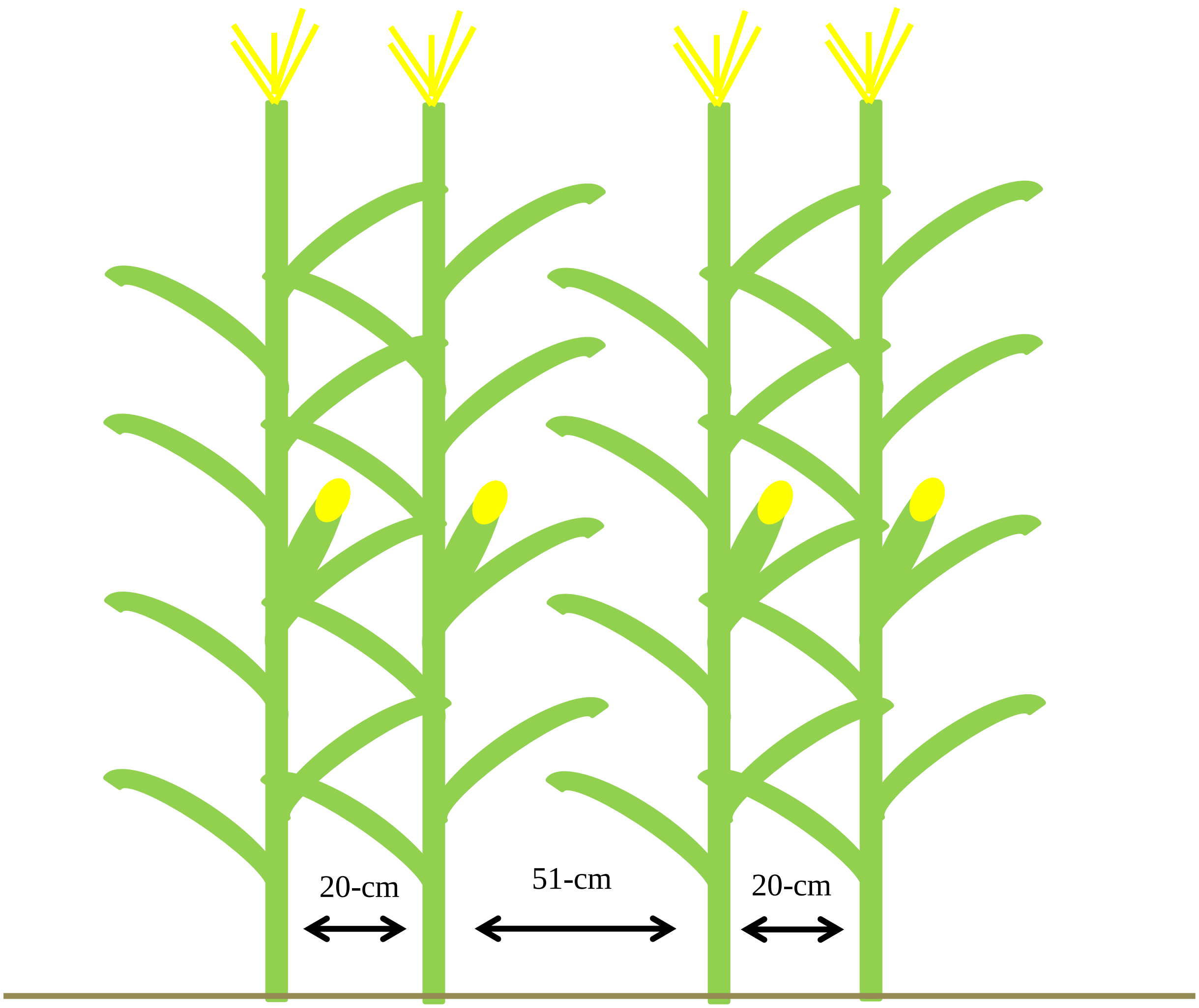


Figure 3.4. Example of corn leaf overlap in 91-cm twin-rows.

CHAPTER 4

ROW PATTERN, ROW SPACING, AND SEEDING RATE EFFECTS IN PEANUT *(Arachis hypogaea* L.)[1]

[1]Plumblee, M.T., R.S. Tubbs, N.B. Smith and E.P. Prostko. To be submitted to *Peanut Science*.

Abstract

When Tomato Spotted Wilt Virus (*Tospovirus*) (TSWV) became a major economic factor in peanut production in the mid-1990's, many peanut producers adopted twin-row patterns to maintain yield. Since then, TSWV-resistant peanut cultivars with high yield potential have been developed and widely adopted among producers. Objectives of this research are to determine if row pattern still has significant effects on yield with TSWV-resistant cultivars, to determine if small and large-seeded cultivars (Georgia Green, C-99R, and Georgia-06G) have any yield effects with varying row types, and to determine any agronomic or economic advantages to planting peanut in 76- or 91-cm single-rows or 91-cm twin-row at varying seeding rates (14, 17, 20, 23, and 26 seed/m). This test was conducted in 2008–2010 in Tifton, GA where main effects were row type and cultivar, and in 2014 in Tifton and Camilla, GA where main effects were row type and seeding rate. All trials were irrigated and set up with randomized complete block experimental design. Results in 2008–2010 showed that Georgia Green had on average 5.8% higher incidence of TSWV than C-99R in 2008 and 2010. Tomato Spotted Wilt incidence was not affected by row type or seeding rate in 2014. Planting in 76-cm single-row resulted in 12 to 30% higher yield than 91-cm single-row in 2008 and 2009. In 2014 at Tifton, yield was lowest with the low seeding density for the 76-cm single-row spacing for Georgia-06G. When comparing C-99R and Georgia Green for each row type, C-99R planted in 76-cm single-row had the highest net income ($351/ha), which was 62% higher than Georgia Green planted in 91-cm single-rows which had the lowest net income ($135/ha). In 2014, Georgia-06G planted in 91-cm single-row at 14 seed/m had 35% higher net present value (NPV) than 91-cm twin-row at 20 seed/m which was the lowest. With seeding rate averaged across row type, 91-cm single-row had 19 and 24% higher NPV than 76-cm single and 91-cm twin-rows. Cultivar selection appears to

be the most consistent way to reduce TSWV incidence in peanut. If a grower desires to invest in a new planter, 91-cm single-row is the most economical option based on this study.

Introduction

In the United States, Georgia is the largest peanut producing state, growing on average 230,000 hectares of peanut per year from 2010–2014 (NASS, 2015c). Peanut is considered a high input row crop due to seed cost and intensive pest control programs (University of Georgia [UGA], 2015b). Although input costs in peanut can be higher than other common row crops, high returns can result. As with any agricultural commodity, maximizing yield and profit is often top priority for growers. Currently approximately 75–80% of peanut production in the United States is runner type peanut. Over the last several decades, peanut production practices in the Southeast U.S. have been greatly influenced by Tomato Spotted Wilt Virus (TSWV) (*Tospovirus*), southern stem rot (*Sclerotium rolfsii* Sacc.), and early and late leaf spot (*Cercospora arachidicola* and *Cercosporidium personatum*, respectively), all of which can substantially reduce yield in peanut if not controlled. In the early to mid-1990's, TSWV became a severe threat to peanut production in the southeastern U.S. causing major economic and yield losses (Culbreath and Srinivasan, 2011; Culbreath *et al*., 2013). At that time, the most widely grown peanut cultivar was Florunner (Norden *et al.*, 1969), which did not have resistance to TSWV (Sholar *et al*., 1995; UGA, 2010). Since then, numerous agronomic cultural practices have proven to assist in the reduction of TSWV (Wells *et al*., 1992; UGA, 2010). By selecting proper row pattern, row spacing, and seeding rate, TSWV incidence in peanut can be reduced (Wells *et al*., 1992; Culbreath *et al*., 2008; Tubbs *et al*., 2011). In recent years, reduced severity of TSWV in peanut has been observed, partly from a transition to growing primarily highly TSWV-resistant cultivars, and from lower overall incidence of the virus.

Tobacco thrips (*Frankliniella fusca*) and western flower thrips (*Frankliniella occidentalis*) are the most common agricultural pest species in Georgia for vectoring TSWV (Riley *et al*., 2008). When thrips feed on plants and spread viruses, they tend to feed on plants that are surrounded by soil making a clear distinction between the soil and foliage (Brown *et al.*, 2005; UGA, 2010). In theory, faster canopy closure should result in the reduction of thrips feeding on plants and aid in the reduction of TSWV. Previous research has shown that growing peanut in a twin-row pattern reduces TSWV incidence in peanut, and allows peanut vines in twin-row pattern to cover the soil surface faster than single-row patterns (Kvien and Bergmark, 1987; Brown *et al*., 2005; Hurt *et al*., 2006). Furthermore, planting narrow single-row spacing has also shown to decrease the amount of time it takes for canopy closure (Hauser and Buchanan, 1981). Likewise, using a high versus low seeding rate can reduce TSWV incidence in peanut (Brenneman and Walcott, 2001). Because of these findings, some growers in the peanut growing regions of the United States have adopted the use of twin-row patterns and/or high seeding rates to help control TSWV in order to maintain yield in peanut. Despite the fact that eight-row twin-row planters can cost $25,000 more than eight-row single-row planters, the yield gain using this row pattern has often offset the additional expense.

Coupled with row pattern and seeding rate, another important tool to prevent yield loss to TSWV in peanut has been cultivar selection. Cultivar Georgia Green (Branch, 1996) was released by UGA in 1996 and was one of the only medium maturity runner type peanut cultivars with TSWV resistance at the time (Tillman *et al*., 2014). As a result, Georgia Green became extremely popular and replaced Florunner as the main cultivar grown in the Southeast (Brown *et al*., 2005). Since the release of Georgia Green, many other TSWV-resistant cultivars have been released, most of which have greater TSWV resistance and higher yield potential, such as cv.

Georgia-06G (Branch, 2007). Because of improved resistance and yield characteristics, Georgia-06G has surpassed Georgia Green and is currently the most widely planted runner type cultivar in Georgia (GCIA, 2012). As wear occurs and improved technologies are available in agriculture, planters reach the end of their useable lifetime and/or become obsolete. Therefore, farmers and researchers need to consistently evaluate whether twin-row planters still have significant effects on peanut yield and reduction of TSWV to offset the additional cost of the equipment.

Over the last several years, peanut seed size characteristics have tended to increase (UGA, 2015c). In peanut, seed size can have major impacts on input costs. Peanut seed is sold on a bag-weight-basis instead of on a seed-count-basis like corn (*Zea mays* L.) and soybean (*Glycine max* L. [Merr.]). For this reason, if seeding rate remains the same and seed size increases, the weight (and thus cost) of seed to plant the same area likewise increases. While large-seeded cultivars may cost more to plant, current large-seeded cultivars, such as Georgia-06G, have proven to have high yield potential. Therefore, increases in seed cost are often outweighed by yield. Yet, if seeding rate can be reduced with larger seeded cultivars while maintaining or increasing yield, increased profit margin may be the result.

The main objectives of this research were to assess the current UGA Extension recommendations of row pattern, row spacing, and seeding rate in peanut using both small-seeded (Georgia Green) and large-seeded (C-99R and Georgia-06G) cultivars with varying levels of TSWV-resistance. In this assessment variables such as yield, grade, TSWV incidence, and days to row coverage were measured. In addition to this, a secondary objective was to conduct an economic analysis to compare single (76 and 91 cm) and twin-row (91 cm) planters at varying seeding rates to determine which treatment provided the highest net income and NPV.

Materials and Methods

This experiment was conducted at the Lang-Rigdon Farm on the UGA Coastal Plain Experiment Station in Tifton, GA in 2008, 2010, and 2014. In 2009, this experiment was conducted at the USDA-ARS Belflower Farm in Tifton, GA. All trials in Tifton were conducted on Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults). In 2014, this experiment was also conducted at the UGA C.M. Stripling Irrigation Research Park in Camilla, GA on a Lucy loamy sand (Loamy, kaolinitic, thermic Arenic Kandiudults) (USDA-NRCS, 2015). Every year and location of this trial was designed using a randomized complete block, with six replications in 2008 and four replications in 2009, 2010, and 2014. In each year, all plots were approximately 4.56 m wide (six rows) for 76-cm single-row spacing treatments and 5.49 m wide (six rows) for 91-cm single and twin-row treatments. While the plot width remained constant for each respective treatment each year, the plot length fluctuated from year-to-year. Plot lengths were 15.2 m, 12.2 m, and 12.2 m, and 10.7 m long in 2008, 2009, 2010, and 2014, respectively and varied because of the size and shape of each field. In 2008–2010, trials were comprised of six treatments made up of three row types (76-cm single-row, 91-cm single-row, and 91-cm twin-row) and two cultivars (Georgia Green and C-99R [Gorbet and Shokes, 2002]). In 2014, trials had 12 treatments made up of three row types (76-cm single-row, 91-cm single-row, and 91-cm twin-row) and five seeding rates (14, 17, 20, 23, and 27 seed/m) to achieve four targeted seeding densities (151,000; 187,000; 215,000; and 246,000 seeds/ha). All plots in 2014 were planted with Georgia-06G.

Field preparation for all locations consisted of deep turning the soil with the use of a bottom/switch/moldboard plow (Harrell Ag. Products, Leesburg, GA) followed by a ripper/bedding implement (76 and 91 cm spacing) (Kelley Mfg. Co., Tifton, GA). Soil samples were taken prior to planting and maintenance fertilizers were amended to each field at each location. Gypsum ($CaSO4$) was applied as determined by UGA recommendations based on pegging zone soil samples (8 cm depth) (Plank *et al*., 2001). Liquid Boron (10% B) was applied at 0.56 kg/ha with the first fungicide application.

Peanut trials were planted on 22 May 2008, 29 May 2009, 12 May 2010, and 28 May 2014 in Tifton, and 22 May 2014 in Camilla using Monosem Single and Twin-Row Precision Vacuum Planters (Monosem Inc., Edwardsville, KS). In the 2008–2010 trials, seeding rate remained constant across all row types; therefore, peanut was planted at the UGA recommended rate of 20 seed/m (Beasley, 1997). In 2014, seeding rate varied for each row type in order to keep seeding density similar across row spacings. For 76-cm single-row, seeding rate had to be reduced to keep an equivalent seeding density to the 91-cm row spacings. Seed plate and gearing selection that was used for each treatment was in compliance with Monosem planter operators manuals.

As a result of treatments changing in 2014 from row type x cultivar to row type x seeding rate, additional seeding rates were used to achieve desired plant populations. Previous research has shown that optimum seeding rates for twin-row pattern could be higher than single-row (Tubbs *et al*., 2011). Therefore, seeding rates were selected to be higher and lower than each recommended rate for each row type (Tubbs and Beasley, 2013). In twin-row, a seeding rate of 27 seed/m was used rather than 14 seed/m to account for a possible advantage of increased seeding rate in twin-row (Tubbs *et al*., 2011). In 91-cm single-row, a seeding rate of 14 seed/m was selected over a seeding rate higher than 23 seed/m due to limitations of available seed plates and higher gear ratios on the planter.

Planter configurations were set up where in twin-rows, the two outer most row units were spaced 91-cm apart with inner most row units spaced approximately 20 cm toward the interior of the planted bed, leaving 51-cm spacing between interior twin-rows. This type of pattern was used because it is the most representative of how twin-row planters are set up in Georgia. This pattern design may also have increased compatibility with harvest operations such as digging and inverting.

Georgia Green and C-99R were used from 2008–2010 because at the time of trial initiation, Georgia Green was the industry standard, was small-seeded (375 seed/kg), and had TSWV-resistance. C-99R was selected because of its large-seed size (300 seed/kg), good yield potential according to the Georgia Statewide Variety Testing (SWVT) Program trials (UGA, 2015c), and having TSWV-resistance (Beasley, 2006). In 2014, Georgia-06G was selected because of the significant shift in hectares from Georgia Green to Georgia-06G in Georgia and much of the Southeast based off of data from The Georgia Crop Improvement Association (GCIA) based on the seed increase quantities of each cultivar annually, as well as its high yield potential and disease resistance (GCIA, 2012) .

The herbicide program utilized was representative of current production practices and followed recommendations from the Georgia Pest Management Handbook (UGA, 2014c). A protective fungicide program was also employed which followed recommendations from the Georgia Pest Management Handbook (UGA, 2014d) and the PeanutRx high-risk management program (Kemerait *et al*., 2011) to control early (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*) as well as southern stem rot (*Sclerotium rolfsii* Sacc.). Fungicides were first applied starting approximately 30 days after planting, at R1 (first bloom) growth stage

(Boote, 1982), and continued throughout the season on 14 d spray intervals. All field locations were irrigated.

Harvest determination was via the hull scrape method (Williams and Drexler, 1981). Peanut digging and inversion was done with a 2-row digger/shaker/inverter (Kelley Mfg. Co., Tifton, GA) that was set up for twin-row pattern. Once the peanuts had been dug and dried down to approximately 12–15% moisture, harvest was carried out using a 2-row KMC harvester (Kelley Mfg. Co., Tifton, GA), and yields were adjusted to 7% moisture for uniformity of comparisons. Grade (total sound mature kernels [TSMK]) was determined according to USDA-AMS grade standards (USDA-AMS, 1997).

Data collected in 2008, 2009, 2010, and 2014 included emergent stand counts (plants in 3 m of row, two locations per plot) at approximately 20 d after planting and TSWV incidence ratings prior to digging. The TSWV ratings were conducted by visual infection ratings (Culbreath *et al.*, 1997). In 2010 and 2014 in Tifton, lapping dates (the number of days from planting until 50% of peanut vines in the harvest rows had covered the row middle) were also recorded for each plot. Statistical analyses were conducted using PROC GLIMMIX in SAS version 9.3 (SAS Institute, 2010). Data were analyzed by analysis of variance (ANOVA) and differences among least square means were determined by using multiple pairwise t-tests (P = 0.10) by year and location.

Economic analyses were based on the 2015 UGA Extension irrigated peanut enterprise budget (UGA, 2015b). This budget was used as a base for expenses which were then adjusted by treatment depending on inputs used and input cost. Net income was determined for each treatment which subtracted all expenses that dealt with production excluding land rent or land ownership costs from revenue based on average price and average yields obtained. A farmer's stock peanut price of $534/tonne was assumed to calculate net income for each treatment. Equipment used for economic analysis and calculations consisted of eight-row equipment and planters (76 and 91-cm single-row and 91-cm twin-row). Equipment size changes to the equipment parameters within the budget accounted for any differences in fuel, repairs and maintenance, field efficiency, and labor costs. The results for net income were used to determine which row type and cultivar treatment from 2008–2010 and 2014 had the highest and lowest profits (accounting for differences in seed cost). To compare 2008–2010 trials with 2014, only plots with the same seeding rate were used. Net income was also analyzed at both locations (Tifton and Camilla) in 2014 to compare row type and seeding rate treatments among each other.

Net present value (Formula 4.1) was also calculated for 2008–2010 and 2014 using net income (as a cash flow from each year) to determine which planter would be the best investment for a grower. Using NPV, planter purchase price and salvage value of the planter at the end of its useable lifetime was considered. An average of 157 hr/yr was used to give the planter a total lifetime of 9 yr. Annual hours were determined by using a peanut planting window from April 15 to June 15 working 8 hr/d and 6 d/wk to calculate the number of suitable field work days for the planting window (ASABE, 2011). For this analysis it was assumed that at least half of the hours per year would be spent planting peanut (78.5 hr/yr), the remaining hours would be spent planting another crop. The effective field capacity (ha/hr) (Formula 4.2) of each planter was determined (76-cm: 275 ha/yr; 91-cm: 330 ha/yr) by using appropriate implement widths, speeds of operation, and field efficiencies from Table 3 in ASAE Standards (Barry and Ellinger, 2010; ASABE, 2011).

Formula 4.1 *Net Present Value (NPV)*

$$NPV = -Investment + \frac{P_1}{1+i} + \frac{P_2}{(1+i)^2} + \cdots + \frac{P_N}{(1+i)^N} + \frac{V_N}{(1+i)^N}$$

Where,

Investment = price of planter

P_N = net cash flows

N = length of planning horizon

i = discount rate

V_N = Salvage Value at end of planning horizon

Formula 4.2 *Effective Field Capacity (ha/hr)*

$$EFC = \frac{W \times S \times FE}{10}$$

Where,

W = Width of Implement (m)

S = Speed traveled through field (km/hr)

FE = Field efficiency of operation (%)

Results and Discussion

2008–2010 Row type x Cultivar

Based on peanut yield results for each year and location of this study, no significant interactions between row type and cultivar were observed (Table 4.1). Row type was significant in 2008 and 2009 for peanut pod yield (Table 4.1). In 2008, 76-cm single-row had 11 to 12% higher yield than both 91-cm twin and single-rows, respectively (Table 4.2). In 2009, 76-cm single-row and 91-cm twin-row had 27 to 33% higher yield than 91-cm single-row, respectively (Table 4.2). Based on these results 91-cm single-row in both 2008 and 2009 had the lowest pod yield when compared to 76-cm single and 91-cm twin-rows. Similar results were observed by Hauser and Buchanan (1981), Colvin *et al*. (1985), and Jaaffar and Gardner (1988), where increased yields in narrow spaced single-rows (less than 91-cm) or twin-rows had higher yields than conventional row spacing (91-cm single-row). Yield advantages to 76-cm single or 91-cm twin-rows may have been observed because increased spacing between plants (with seeding rate held constant across row types) would occur in narrower row spacing or twin-rows and could reduce the intra-row competition for plant resources (water and nutrients), thus reducing stress and increasing yield. In 2009, cultivar was significant when averaged across row type for pod yield (Table 4.1) where C-99R had 18% higher yield than Georgia Green (Table 4.3). These results are consistent with the reports from UGA SWVT in 2008 and 2009, where C-99R had significantly higher yield than Georgia Green in 50% of the trials and Georgia Green only having higher yield than C-99R in 8% of the trials conducted across three locations and two years in irrigated and non-irrigated conditions (UGA, 2015c). It is also noted that in the SWVT non-irrigated trials, Georgia Green yields ranked among the lowest. In 2009, our experiment received some supplemental irrigation, but at a drastically lower amount than the UGA checkbook method recommendations, thus crop stress was observed and pod yield declined as a result. This may be a contributing factor for why significant cultivar yield differences were observed in 2009.

In 2008 and 2010, cultivar had significant effects on TSWV incidence (Table 4.1). In both 2008 and 2010, C-99R had 6.7 and 5.0% lower TSWV incidence than Georgia Green, respectively (Table 4.4). While the magnitude of the TSWV incidence differences was substantial between cultivars, neither cultivar (C-99R or Georgia Green) had higher than 11% incidence in either year. It can also be speculated from these results that TSWV incidence did not appear to have a direct effect on pod yield because there was only a significant difference in yield between cultivars in 2009, but TSWV incidence was equal in between cultivars in that year. In 2010, row type had a significant effect on TSWV incidence (Table 4.1), where 91-cm twin-row had less than half the incidence of 76-cm single row, and less than one-third of the infection in 91-cm single row (Table 4.5). In addition to these differences, 76-cm single-row had 3.5% less TSWV incidence than 91-cm single-row. Similar results were observed by Culbreath *et al.* (2008) and Tubbs *et al.* (2011), where twin-row pattern had less TSWV incidence than single-rows. Hauser *et al*. (1982) and Johnson *et al.* (2005) showed that narrow row spacings increased the rate of canopy closure when compared to conventional 91-cm single-rows. This experiment likewise showed earlier canopy closure with the narrower row spacing in single-rows in 2010 and 2014 (Table 4.6). By promoting faster canopy closure with row spacing, the soil surface will be covered quicker and may have some reduction of TSWV late in the growing season. Peanut grade (TSMK) was not affected by row type in 2008–2010 trials (data not shown).

2014 Row type x Seeding Rate

The 2014 trial in Tifton did not have significant interactions between row type and seeding rate, but row type averaged across seeding rate was significant (Table 4.7). Both single-row spacings had 16% higher yield than 91-cm twin-rows (Table 4.8). These results are consistent with trials conducted in 2008–2010 with respect to 76-cm single-rows having higher yield than 91-cm twin-row (Table 4.2), but were not consistent with the 91-cm single-row and 91-cm twin-row results. Although both single-row spacings had higher yield than twin-rows in Tifton 2014, high yields are still possible in twin-row peanut, and additional benefits can be observed when using twin-rows, thus twin-rows should not be completely ruled out in peanut production.

For the purpose of appropriately representing the change in seed densities from 91-cm to 76-cm row spacings as seeding rate remains constant, treatments were compared by seeding density (seeds/ha) and row type, rather than seeding rate averaged across row type. In Tifton, seeding density had a significant effect on pod yield in 2014 (Table 4.7). When peanut was planted at the lowest seeding density in 76-cm single and 91-cm twin-rows (183,200 seeds/ha), the lowest yields were observed (Table 4.9). In 76-cm single-row, seeding densities of 215,900 and 245,000 seeds/ha had on average 13.0% higher yield than 183,200 seeds/ha. When planted at 291,000 seeds/ha, an 11.0% higher yield than 183,200 seeds/ha was observed. In 91-cm twin-row, 245,000 seeds/ha had 14% higher yield than 215,900 seeds/ha. No yield differences in 91-cm single-row between seeding densities were observed.

Row type in Tifton also had a significant effect on TSWV incidence (Table 4.7), where 76-cm single-row had lower incidence than both 91-cm single and twin-rows (Table 4.8). Even though reductions in TSWV were observed with 76-cm single-rows, incidence was less than 5% across all row types. It can be speculated that differences in TSWV incidence between 76-cm and 91-cm row types had to do with thrips populations and flights that occurred during this trial for Tifton, since similar results were not observed in Camilla. This is not consistent with other results, often under heavier TSWV pressure, where twin-rows had less incidence of TSWV. (Brown *et al.*, 2005; Culbreath *et al.*, 2008; Tubbs *et al.*, 2011).

In Camilla 2014, a significant interaction between row type and seeding density was observed (Table 4.7) for yield. The 76-cm single-row had similar results to those at Tifton where the 183,200 seeds/ha density had the lowest yield compared to a higher seeding density (Table 4.10). In 91-cm twin-row, a seeding density rate of 291,000 seeds/ha had on average 12% higher yield than 183,200, 215,900, and 245,000 seeds/ha seeding densities which agrees with the findings of Monzingo and Coffelt (1984) in bunch type peanut and Tubbs *et al.* (2011) in runner type peanut planted that twin-row pattern can likely support higher seeding densities (higher than 215,900 seeds/ha), resulting in additional yield. No yield differences between seeding densities in 91-cm single-row were observed in Camilla, 2014, which could be attributed to Georgia-06G ability to compensate for reduced seeding densities in a high yielding environment (irrigated) (Tillman *et al*., 2006).

By analyzing the interaction of row type and seeding density, yield differences were observed at 245,000 and 291,000 seeds/ha (Table 4.10), where both 76 and 91-cm single-rows had 13 and 9% higher yield than 91-cm twin-row at 245,000 seeds/ha, but 91-cm twin-row had 14% higher yield than 76-cm single-row at 291,000 seeds/ha. While 76-cm single-row did have higher yield than twin-rows in Tifton at 291,000 seeds/ha (Table 4.9), in Camilla twin-rows had higher yield than 76-cm single-row. The results from both Tifton and Camilla are similar to the findings of Tubbs *et al*. (2011), that twin-row pattern can benefit from increased seeding rates or seeding densities. While an explanation cannot be made as to why 76-cm single-row had higher yield than 91-cm twin-rows in Tifton, the results from Camilla did agree with Lanier *et al.* (2004), Tillman *et al.* (2006), and Nuti *et al.* (2008), that yield advantages in twin-row over single-row pattern exist.

Based on yield results from 2008–2010 and 2014 in Tifton and Camilla, row type had significant effects on yield in multiple years (2008, 2009, and 2014) (Table 4.1 and 4.7), but determining which row type had higher yield than others was not determined because of inconsistent results. Because of these findings for row type and yield in 2014, all three row types appear to have the potential of producing high peanut yields. Low seeding density in peanut did result in lower yield than when increased seeding densities were used, and twin-row pattern had yield advantages when seeding density was increased above UGA recommendations of 215,200 seeds/ha. Cultivar and row type selection had more consistent effects on TSWV incidence than changing seeding density, but TSWV incidence did not have a direct impact on yield. It is speculated that yield was not affected by TSWV incidence because the total TSWV incidence observed was relatively low and the cultivars used in this test all had TSWV-resistance, therefore even though the plants were infected, it did not affect yield.

Rate of Canopy Closure

In 2010 and 2014, the number of days it took for 50% of peanut vines to touch in the row middles (commonly referred to as "lapping") was also observed. Row type had a significant effect on the number of days to lapping. The data revealed that with 91-cm twin-rows, lapping was faster than both 76- and 91-cm single-rows, and 76-cm single-row was faster than the 91-cm single-row (Table 4.6). These findings agree with the findings of Hauser *et al*. (1982) and Jaaffar and Gardner (1988) that twin and narrow-row (less than 91-cm) spacings allow for faster canopy closure and soil coverage. Although TSWV incidence did not appear to have a direct correlation to the rate at which peanut plants covered the soil surface as they have in previous research (Brown *et al.*, 2005), there may still be other agronomic advantages for rapid soil coverage. For example, weed suppression, soil water conservation, and soil temperature moderation are all favorable to rapid canopy closure (Hauser and Buchanan, 1981; Colvin *et al.*, 1985).

Economic Analysis

For all trials conducted in 2008–2010 and 2014, the UGA Extension irrigated peanut enterprise budget was used as a base and adjusted to account for production inputs and their costs associated with this test. From these adjustments, estimated cost budgets were derived for each individual treatment taking into account seed size, seed weights, and seed cost between Georgia Green, C-99R, and Georgia-06G at the same seed density (215,000 seeds/ha) but varying seeding rates depending upon row spacing. From the budgets, total variable costs, total fixed costs, and total cost of production were calculated over 2008–2010 and 2014, but land ownership and/or land rent costs were excluded thus, costs may be reduced compared to actual costs a grower may experience (Table 4.11 and 4.12). Variable costs were much higher (on average $265/ha more) for Georgia-06G than Georgia Green (Table 4.11), which are correlated to the difference in seed size. Yields were also substantially higher for Georgia-06G, which contributed to much larger net income on a per hectare basis, but Georgia-06G yields were based on one-year of data averaged across two locations. As a result, net income for Georgia Green and C-99R were compared together and then each cultivar was compared individually across row type. Over 2008–2010, C-99R planted in 76-cm single-row provided the highest net income (61% higher net income per ha) over Georgia Green planted in 91-cm single-row which had the lowest net income (Table 4.11). Average yield for each treatment was the largest influence on net income. Comparing each cultivar individually, Georgia Green in twin-row pattern had the highest net income ($342/ha), while both C-99R ($351/ha) and Georgia-06G ($2773/ha) had the highest net income in 76-cm single-row.

Additional budgets were constructed to represent tests in Tifton and Camilla in 2014, where treatments consisted of three row types (76 and 91-cm single-row and 91-cm twin-row) and four out of five seeding rates (depending on which row type 14, 17, 20, 23, and/or 26 seed/m) with Georgia-06G (Table 4.12). In 76-cm single-row at a high seeding rate (23 seed/m) the highest total production costs were observed, which was primarily due to higher seed, fuel, repairs and maintenance, and labor costs associated with a narrow row spacing planter; 91-cm single-row at a low seeding rate of 14 seed/m had the lowest total production cost which can be correlated to reduced seed, fuel, repairs and maintenance, and labor costs linked with low seeding rates and a wider row spacings. The highest net income came from 76-cm single-row at 20 seed/m, where net income was directly affected by average yields of each treatment. The lowest net income resulted from 91-cm twin-row at 20 seed/m, where net income was equal to $2166/ha; a 25% reduction (Table 4.12).

While high net income is desirable, knowing which row type that provided the best planter investment opportunity for a grower was considered important. Net present value (NPV) was calculated for 2008–2010 and for 2014 experiments in Tables 4.13 and 4.14. When determining NPV, planter purchase price, salvage value, and a discount rate of 8% to account for time value of money were used. Net present value based treatments in 2008–2010 revealed that Georgia Green planted in 91-cm twin-row provided a 38% higher NPV, and Georgia Green planted in 91-cm single-row which had the lowest NPV. Comparing NPV among row types within each cultivar displayed that 91-cm twin-row had the highest NPV in Georgia Green and 91-cm single-row had the highest NPV in C-99R. Assuming that either Georgia Green or C-99R was to be selected by a grower, C-99R had a 10% higher average NPV across all row types than Georgia Green, which suggests that C-99R can provide a wider range of planter row types to select from when investing in a planter than Georgia Green, while still maintaining high NPV (Table 4.13). When analyzing NPV in 2014 for row type x seeding rate, the treatment that provided the highest NPV was 91-cm single-row, at 14 seeds/m. The lowest NPV occurred at 91-cm twin-row at 20 seeds/m; a 35% reduction. With NPV averaged across seeding rate, 91-cm single-row had the highest NPV; 19% higher than 76-cm single-row and 24% higher than 91-cm twin-row (Table 4.14). From these results both trials (2008–2010 and 2014) recommend a grower interested in investing in a new planter to buy a 91-cm single-row.

Conclusion

In conclusion, both C-99R and Georgia Green performed equally in terms of yield, except in 2009 where C-99R had higher yield than Georgia Green. In 2008 and 2009, 76-cm single-row had higher yield than 91-cm single-row, while 91-cm twin-row had yields either equal to or greater than 91-cm single-row. Georgia Green had higher TSWV incidence than C-99R two out of three years. Economically, Georgia Green had lower production costs than C-99R due to smaller seed size contributing to reduced seed costs, but C-99R had the highest net income when averaged across row type. From this, C-99R would be the recommended cultivar to select over Georgia Green. Despite these cultivars no longer being commercially available, it shows that seed size can affect cost, but high-yielding cultivars can overcome the added expense of seed cost, so yield potential should be a greater factor than seed size in cultivar selection. Although 76-cm single-rows had higher yields, the yield increase did not consistently outweigh the additional production costs thus, purchasing a 91-cm single-row planter would be the more economical investment option for a grower.

The results from 2014 showed that low seeding densities would lead to lower yields in 76-cm single-row and 91-cm twin-rows. In addition to seeding rate, 91-cm twin-row on average had lower yield than both single-row treatments in Tifton, but twin-rows only had lower yield at reduced seeding rates in Camilla. From this, yield was still adequate across all row types therefore, twin-row patterns in peanut should not be completely ruled out especially if other agronomic factors associated with twin-row are desired. Seeding rate did not have any effect on TSWV incidence and row type was not consistent across locations. Overall TSWV incidence was low (less than 10%) at both locations. Economically, 76-cm single-row planted at 20 seed/m had the highest net income, but 91-cm single-row at 14 seed/m had the highest NPV. Similarly to 2008–2010 trials with NPV averaged across seeding rate, 91-cm single-row was considered to be the most economical investment option for a grower. As cultivars change over time with better TSWV resistance, different seed size, and yield potential, recommendations for row pattern, row spacing, and seeding rate will continue to change. From these results, it appears that as TSWV-resistance in cultivars improves, the effect of row pattern on TSWV incidence is subdued, suggesting that the need for twin-row planters to reduce TSWV may not provide the yield and grade benefit that they once had. Since the seed size of current cultivars is larger than previous popular runner type cultivars, maximizing yield by planting twin-row pattern at increased seeding rates may not be desirable due to increased seed cost. If small-seeded cultivars regain popularity in the future (such as Georgia-13M [Branch, 2014] and Georgia-14N [Branch and Brenneman, 2015]), advantages in twin-row may arise similar to what was observed in Georgia Green (Table 4.11) in this study. Even if yield increases with twin-row are not observed, production seed costs that are magnified in large-seeded cultivars at increased seeding densities (215,200 increased to 251,100 seeds/ha) in twin-row are not likely to have the same impact with small-seeded cultivars which may make twin-rows more appealing to growers in the future.

Table 4.1. Analysis of variance probability values determined for pod yield and tomato spotted wilt virus (TSWV) at Tifton, GA 2008–2010.

		2008		2009		2010	
	df[b]	Pod Yield	TSWV	Pod Yield	TSWV	Pod Yield	TSWV
		p-values[a]					
Row Type (Row)	2	0.0046	ns	0.0251	ns	ns	0.0013
Cultivar (Culti.)	1	ns[c]	<0.0001	0.0796	ns	ns	0.0023
Row*Culti.	2	ns	ns	ns	ns	ns	ns

[a]p-values were obtained from ANOVA table in output of SAS using PROC GLIMMIX procedure.
[b]df = degrees of freedom
[c]ns = not significant

Table 4.2. Peanut pod yield (kg/ha) for varying row types at Tifton, GA 2008–2009.

	2008	2009
Row Type[a]	Pod Yield	
	kg/ha[b]	
76-cm Single	6840 a	2550 a
91-cm Single	6040 b	1870 b
91-cm Twin	6070 b	2790 a

[a]Data pooled over rep and cultivar. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

[b]Yield adjusted to 7% moisture.

Table 4.3. Peanut pod yield (kg/ha) for cultivar at Tifton, GA 2009.

Cultivar[a]	Pod Yield
	———kg/ha[b]———
Georgia Green	2160 b
C-99R	2640 a

[a]Data pooled over rep and row type. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

[b]Yield adjusted to 7% moisture.

Table 4.4. Tomato spotted wilt virus (TSWV) incidence (%) for cultivar at Tifton, GA 2008 and 2010.

	——2008——	——2010——
Cultivar[a]	TSWV	
	———% Incidence[b]———	
Georgia Green	10.7 a	9.6 a
C-99R	4.0 b	4.6 b

[a]Data pooled over rep and row type. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

[b]Yield adjusted to 7% moisture.

Table 4.5. Tomato spotted wilt virus (TSWV) incidence (%) for varying row types at Tifton, GA 2010.

Row Type[a]	TSWV
	—% Incidence[b]—
76-cm Single	7.4 b
91-cm Single	10.9 a
91-cm Twin	3.1 c

[a]Data pooled over rep and cultivar. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

[b]Yield adjusted to 7% moisture.

Table 4.6. Days to 50% row coverage for varying row types at Tifton, GA in 2010 and 2014.

	Years	
Row Type[a]	2010	2014
	days	
76-cm Single	63 b	56 b
91-cm Single	69 a	62 a
91-cm Twin	59 c	45 c

[a]Data pooled over rep and cultivar. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

Table 4.7. Analysis of variance probability values determined for pod yield and tomato spotted wilt virus (TSWV) at Tifton and Camilla, GA 2014.

		Tifton		Camilla	
	df[b]	Pod Yield	TSWV	Pod Yield	TSWV
		p-values[a]			
Row Type (Row)	2	0.0002	0.0334	ns	ns
Seeding Rate (SR)	3	0.0612	ns	ns	ns
Row*SR	6	ns[c]	ns	0.0412	ns

[a]p-values were obtained from ANOVA table in output of SAS using PROC GLIMMIX procedure.
[b]df = degrees of freedom
[c]ns = not significant

Table 4.8. Peanut pod yield (kg/ha) and tomato spotted wilt virus (TSWV) incidence (%) for varying row types at Tifton, GA 2014.

Row Type[a]	Pod Yield	TSWV
	——kg/ha[b]——	—% Incidence[c]—
76-cm Single	8430 a	2.7 b
91-cm Single	8450 a	4.8 a
91-cm Twin	7050 b	4.4 a

[a]Data pooled over rep and seeding rate. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.
[b]Yield adjusted to 7% moisture.
[c]Percentage of incidence per plot.

Table 4.9. Peanut pod yield (kg/ha) for seed densities across varying row types for Tifton, GA 2014.

	——Seeding Density (seeds/ha)——				
Row Type[a]	156,400	183,200	215,900	245,000	291,000
	——kg/ha——				
76-cm Single	--	7370 Cab	8480 Ba	8490 Ba	9640 Aa
91-cm Single	8000 A	8380 Aa	8510 Aa	8130 Aa	--
91-cm Twin	--	7050 ABb	6560 Ba	7630 Ab	7420 ABb

[a]Data pooled over rep. Means within a row followed by same uppercase letter are not significantly different at P = 0.10. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.
[b]Yield adjusted to 7% moisture.

Table 4.10. Peanut pod yield (kg/ha) for interaction term row type x seeding density for Camilla, GA 2014.

	——Seeding Density (seeds/ha)——				
Row Type[a]	156,400	183,200	215,900	245,000	291,000
	——kg/ha[b]——				
76-cm Single	--	7550 Ba	8030 ABa	8320 Aa	7280 Bb
91-cm Single	8200 A	7860 Aa	7690 Aa	8020 Aa	--
91-cm Twin	--	7620 Ba	7550 Ba	7250 Bb	8460 Aa

[a]Data pooled over rep. Means within a row followed by same uppercase letter are not significantly different at P = 0.10. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.
[b]Yield adjusted to 7% moisture.

Table 4.11. Estimated costs with average net income ($/ha) row type x cultivar for peanut at Tifton and Camilla, GA 2008–2010, 2014.

Treatment	1 Single 76-cm GA Green	2 Single 91-cm GA Green	3 Twin 91-cm GA Green	4 Single 76-cm C-99R	5 Single 91-cm C-99R	6 Twin 91-cm C-99R	7 Single 76-cm GA-06G	8 Single 91-cm GA-06G	9 Twin 91-cm GA-06G
VC[a]	1231.04	1209.58	1227.95	1293.88	1277.87	1272.70	1492.89	1475.51	1429.48
FC[b]	398.81	389.94	391.78	405.09	396.77	396.25	424.99	416.53	411.93
TC[cd]	1629.85	1599.52	1619.72	1698.97	1674.64	1668.95	1917.89	1892.04	1841.41
Pod Yield[e]	3495	3250	3675	3840	3685	3530	8785	8595	7450
Net Income[f]	235.48	135.98	342.73	351.59	293.15	216.07	2773.30	2697.69	2136.89

[a]Total variable costs.
[b]Total fixed costs.
[c]Sum of total variable and total fixed costs.
[d]Total costs do not include land rent or ownership costs.
eAverage pod yield from 2008–2010,2014 in kg/ha.
[f]Determined by pod yield multiplied by $534/tonne minus TC.

Table 4.12. Estimated costs with average net income ($/ha) row type x seeding rate for peanut at Tifton and Camilla, GA 2014.

Treatment	1 Single 76-cm	2 Single 76-cm	3 Single 76-cm	4 Single 76-cm	5 Single 91-cm	6 Single 91-cm	7 Single 91-cm	8 Single 91-cm	9 Twin 91-cm	10 Twin 91-cm	11 Twin 91-cm	12 Twin 91-cm
seed/m	14	17	20	23	14	17	20	23	17	20	23	27
VC[a]	1095.70	1133.34	1166.80	1233.72	1049.65	1081.02	1124.94	1164.68	1081.02	1124.94	1164.68	1216.95
FC[b]	694.02	697.78	701.11	707.80	682.71	685.85	690.21	694.19	685.85	690.21	694.19	699.43
TC[cd]	1789.71	1831.11	1867.91	1941.52	1732.36	1766.87	1815.15	1858.87	1766.87	1815.15	1858.87	1916.37
Pod Yield[e]	7906	8767	8914	9040	8582	8624	8607	8564	7760	7447	7896	8384
Net Income[f]	2437.33	2856.08	2897.92	2891.79	2855.98	2843.86	2786.34	2719.75	2382.19	2166.57	2362.85	2565.89

[a]Total variable costs.

[b]Total fixed costs.

[c]Sum of total variable and total fixed costs.

[d]Total costs do not include land rent or ownership costs.

[e]Average pod yield from 2008–2010,2014 in kg/ha.

[f]Determined by pod yield multiplied by $534/tonne minus TC.

Table 4.13. Eight-row planter row type x cultivar investment analysis 2008–2010.

	Treatment					
	1	2	3	4	5	6
	Single 76-cm	Single 91-cm	Twin 91-cm	Single 76-cm	Single 91-cm	Twin 91-cm
Cultivar	GA Green	GA Green	GA Green	C-99R	C-99R	C-99R
EFC (ha/hr)[a]	3.5	4.2	4.2	3.5	4.2	4.2
ha/yr[b]	275	330	330	275	330	330
			Investment			
Purchase Price	$42,500	$42,500	$67,500	$42,500	$42,500	$67,500
Salvage Value	$11,724	$11,724	$18,620	$11,724	$11,724	$18,620
Year			**Cash flow/hectare**			
2008	2052	1610	1686	1911	1559	1511
2009	-536	-709	-137	-73	-563	-181
2010	-141	134	185	-49	585	-1
NPV	$334,200	$295,504	$475,469	$427,516	$439,160	$361,032
Avg. NPV/cultivar		$368,391			$409,236	

[a]EFC is the field capacity of the planter taking into account the efficiency of planting (65%).

[b]ha/yr was calculated using a planter life of 1500 hr and using the planter approximately 78.5 hr/yr to plant peanut.

Table 4.14. Eight-row planter row type x seeding rate investment analysis 2014.

	Treatment											
	1 Single 76-cm	2 Single 76-cm	3 Single 76-cm	4 Single 76-cm	5 Single 91-cm	6 Single 91-cm	7 Single 91-cm	8 Single 91-cm	9 Twin 91-cm	10 Twin 91-cm	11 Twin 91-cm	12 Twin 91-cm
seed/m	14	17	20	23	14	17	20	23	17	20	23	27
EFC (ha/hr)[a]	3.5	3.5	3.5	3.5	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
ha/yr[b]	275	275	275	275	330	330	330	330	330	330	330	330
	Investment											
Purchase Price	$42,500	$42,500	$42,500	$42,500	$42,500	$42,500	$42,500	$42,500	$67,500	$67,500	$67,500	$67,500
Salvage Value	$11,724	$11,724	$11,724	$11,724	$11,724	$11,724	$11,724	$11,724	$18,620	$18,620	$18,620	$18,620
Year	**Cash flow/hectare**											
2014 Tifton	$1,446	$1,887	$1,854	$2,285	$1,775	$1,907	$1,911	$1,706	$1,324	$1,061	$1,486	$1,337
2014 Camilla	$1,163	$1,313	$1,387	$908	$1,477	$1,309	$1,194	$1,279	$1,216	$1,138	$976	$1,392
NPV	610,939	758,418	767,588	764,295	928,656	921,399	890,376	851,541	699,071	596,581	680,793	752,718
Avg. NPV/Row Type	$725,310				$897,993				$682,291			

[a]EFC is the field capacity of the planter taking into account the efficiency of planting (65%).

[b]ha/yr was calculated using a planter life of 1500 hr and using the planter approximately 78.5 hr/yr to plant peanut.

CHAPTER 5

EVALUATION OF 76-CM PEANUT (*Arachis hypogaea* L.) ACROSS MULTIPLE SEEDING RATES AND CULTIVARS[1]

[1]Plumblee, M.T., R.S. Tubbs, N.B. Smith, and E.P. Prostko. To be submitted to *Peanut Science*.

Abstract

Standard row spacing for peanut (*Arachis hypogaea* L.) is 91-cm in single row pattern. Narrower row spacings are often used in common rotational crops with peanut, so converting peanut to narrower row spacing may be easier and beneficial to some growers if cultivars and seeding rates can be identified without yield reduction. Therefore, the objectives of this research were to evaluate cultivars and seeding rates for peanut planted in 76-cm single rows in terms of yield, grade, and TSWV incidence. Experiments were conducted in 2008, 2010, and 2014 in Tifton, GA and in 2014 at Camilla, GA. Treatments were comprised of three cultivars (varying each year) and three seeding rates (14, 17, and 19 seed/m). Results revealed that neither pod yield, grade, nor TSWV incidence were affected by seeding rate within any cultivar, any year, or location. 'Georgia-06G' consistently had 13% higher yield on average than other cultivars. Cultivar also had an effect on TSWV, where 'Georgia Green' and 'TUFRunner™ '511' had on consistently higher TSWV incidence than other cultivars. Seeding rate did not affect the rate of canopy closure, but 'Georgia-12Y' and TUFRunner™ '511' both had faster canopy closure than Georgia-06G. Peanut grade (total sound mature kernels) (TSMK) was not effected by varying seeding rates, but did differ between cultivars. From these results it can be concluded that 76-cm single-row can provide adequate yield across multiple seeding rates, allowing for reduced seeding rates to be used, decreasing seed costs. In addition to this, cultivar selection is the primary means for reducing TSWV incidence and altering grade in 76-cm peanut.

Introduction

In the United States, Georgia is the largest peanut producing state, planting 230,000 ha of peanut from 2010–2014 per year (NASS, 2015c), and contributing to a $507 million economic impact in Georgia in 2013 (University of Georgia [UGA], 2014a). Row spacing experiments as early as the 1930s were conducted (McClelland, 1931) with the goal of improving yield. Thus, the idea of growing peanut in varying row spacing including narrow rows is not new. Numerous researchers have conducted experiments planting peanut in narrow row spacings over the last 50 years and the results have varied (Duke and Alexander, 1964; Cox and Reid, 1965; Harrison, 1970; Hauser and Buchanan, 1981; Monzingo and Coffelt, 1984; Kirby and Kitbamroong, 1986). From this research, conclusions have been that narrow row spacing in runner type peanut does not have the same yield advantage as peanut with bunch or erect growth habit. It has also been demonstrated that narrow row peanut can produce higher yield than conventional (91-cm) row spacings, and narrow row peanut can have yield benefits in high weed pressure scenarios (Hauser *et al.*, 1982; Johnson *et al*., 2005). Although there were no reports suggesting yield disadvantages to planting peanut in narrow row spacing, many producers have not adopted this planting configuration because of cultivation and harvest equipment operations and concerns about improper inversion at digging. Since Tomato Spotted Wilt Virus (*Tospovirus*) (TSWV) had a large economic impact on peanut in the mid-1990s, twin-row pattern has been adopted by some farmers across the peanut belt (Brown *et al*,. 2005). Since then, the peanut quota system has ended and commodity prices in many crops have drastically changed causing crop acreage shifts from year to year, including increased peanut production and newly developing peanut producing regions (Dohlman and Livezey, 2005; Chapin *et al*., 2010). In response to the negative yield impacts of TSWV incidence in peanut, cultural practices and use of TSWV-resistant cultivars have been widely adopted by the peanut industry. With new cultivars, appealing commodity markets, reduced tillage practices, and higher investment prices for twin-row planters, planting in 76-cm single-row configuration has become a topic of interest. If peanut can increase or maintain yield, grade, and provide any other agronomic advantages, growers may have the option of sharing planting equipment across other currently planted commodities in their rotations that show benefit to narrow row spacings. By utilizing one planter for multiple crops, the ability to change annual crop production to follow the price market is easier, at least from a logistical stand point.

With the adoption of any new cultural practices in agriculture, research is often the basis of extension recommendations. The current UGA Extension recommendations for seeding rate in peanut is 20 seed/m (215,200 seeds/ha) for both 91-cm single and 91-cm twin-row patterns (Beasley, 1997). Previous research by Henning *et al*. (1979) and Kemerait *et al*. (2011) has shown that final plant stands in peanut of 13 seed/m are key to ensure optimum yield achieved. As row spacing deviates from 91-cm, seeding rates (seed/m) must also change in order to keep the seed density (seed/ha) similar to what is recommended for 91-cm spacing. If seeding rate remained at 20 seed/m in 76-cm spacing, it would result in 258,200 seed/ha to be planted, so a reduction in seeding rate to 17 seed/m would be required to keep the equivalent seed density of 215,200 for the UGA recommended rate of 20 seed/m in 91-cm row spacing. Although adequate yields have been obtained in 76-cm single-row using seeding rates that provide populations comparable to 91-cm row spacings, further investigations of 76-cm single row seeding rates are needed to further support extension recommendations.

The main objective in this test was to compare multiple cultivars at varying seeding rates in a 76-cm row spacing in peanut for yield, grade, and TSWV incidence. These results can be directly applicable to many peanut producers across the U.S., including those who currently own a 76-cm planter for other crops, growers in newly expanded peanut regions that may have to purchase a planter for peanut or use an existing planter that they already own, or peanut producers who want to see if 76-cm row peanut can provide agronomic advantages such as reduced TSWV incidence and faster canopy closure.

Materials and Methods

This experiment was conducted at the Lang-Rigdon Farm of The UGA Coastal Plain Experiment Station in Tifton, GA in 2008, 2010, and 2014 on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2015). In 2014, this test was also conducted at the UGA C.M. Stripling Irrigation Research Park in Camilla, GA on a Lucy loamy sand (Loamy, kaolinitic, thermic Arenic Kandiudults) (USDA-NRCS, 2015). For the duration of this trial, a split-plot design consisting of nine treatments and four replications was utilized. Each plot was made up of one bed (two rows) that was approximately 1.52 m wide and 15.2, 21.3, 12.2, and 9.1 m long in 2008, 2010, and 2014 in Tifton and 2014 in Camilla, respectively as a result of the shape and size of the field each year. The treatments were comprised of three cultivars as main-plot treatment factors, and three seeding rates as sub-plot effects.

All treatments were planted with a Monosem Precision Vacuum Planter (Monosem, Inc. Edwardsville, KS) and were planted 22 May 2008, 13 May 2010, and 28 May 2014 in Tifton and 22 May 2014 in Camilla. Seeding rates of 14, 17, and 19 seed/m were selected to establish targeted seed density of 183,300, 223,000, and 249,300 seeds/ha.

Cultivars that were used varied from year-to-year, but were reflective of popular runner market type cultivars planted at the time of the test. In 2008, cultivars Georgia Green (Branch, 1996), Georgia-06G (Branch, 2007), and AP-3 (Gorbet, 2007) were selected; in 2010, Georgia Green, Georgia-06G, and AP-4 (Tillman and Gorbet, 2008) were selected; and in 2014 Georgia-06G, Georgia-12Y (Branch, 2013), and TUFRunner™ '511' were selected.

The herbicide program utilized was representative of current production practices and followed recommendations from the Georgia Pest Management Handbook (UGA, 2014c). A protective fungicide program was also employed which followed recommendations from the Georgia Pest Management Handbook (UGA, 2014d) and the PeanutRx high-risk management program (Kemerait *et al*., 2011) to control early (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*) as well as southern stem rot (*Sclerotium rolfsii* Sacc.). Fungicides were first applied starting approximately 30 days after planting, at R1 (first bloom) growth stage (Boote, 1982), and continued throughout the season on 14 d spray intervals. All field study locations were irrigated on an as-needed-basis in correlation with the UGA Peanut Production Guide Checkbook method (Beasley, 2007; Beasley *et al*., 2013).

Harvest determination consisted of using the hull scrape method (Williams and Drexler, 1981). Narrow row peanut has been associated with digging losses and inversion issues because of digger width set up. For this experiment, peanut digging and inversion was done with a 2-row digger/shaker/inverter (Kelley Mfg. Co., Tifton, GA) that was set up for twin-row pattern which altered blade angle and had longer blades in hopes to prevent harvest losses. Once peanut had been dug and dried down to approximately 12–15% moisture harvest began and consisted of using a 2-row KMC harvester (Kelley Mfg. Co., Tifton, GA); yields were adjusted to 7% moisture for uniformity of comparisons. Grade (the percentage of total sound mature kernels [TSMK]) was determined according to USDA-AMS grade standards (USDA-AMS, 1997).

Data collection throughout the growing season differed between years and locations due to logistics and labor. Data collected in 2008, 2010, and 2014 included emergent stand counts at approximately 20 d after planting to ensure that adequate differences between seeding rates were attained, and TSWV incidence was determined with visual ratings (Rodriguez-Kabana *et* *al.*,1975; Culbreath *et al.*, 1997). In 2014 in Tifton, lapping dates (the number of days from planting until 50% of peanut vines in the harvest rows had covered the row middle) were also recorded for each plot. Statistical analyses were conducted using PROC GLIMMIX in SAS version 9.3 (SAS Institute, 2010). Data were analyzed by analysis of variance (ANOVA) and differences among least square means were determined by using multiple pairwise t-tests (P = 0.10) by year and location.

Results and Discussion

In 2008 Tifton and 2014 Camilla, cultivar had significant effects on pod yield (Table 5.1). In 2008, Georgia-06G had 15 and 13% higher yield than Georgia Green and AP-3 (Table 5.2). In 2014, Georgia-06G and TUFRunner™ '511' had 9 and 13% higher yield than Georgia-12Y, respectively (Table 5.3). Georgia-06 had higher or equal yield than the other cultivars planted in 76-cm single-rows in all years. Seeding rate did not have any effect on yield for any cultivar in any year of this study which was similar to the findings of Tubbs *et al*. (2011), where single-row peanut yield was not significantly affected by seeding rate. The ability of Georgia-06G to adapt to different environments, narrow or wide rows, or across a range of seeding rates may be one of the factors contributing to why this cultivar is very popular throughout the southeastern U.S. Although significant differences were observed in this study between cultivars, all that were used resulted in higher yields than the current state average for peanut in Georgia (4400 kg/ha) (NASS, 2015d), suggesting that 76-cm peanut can produce similar yields to other row spacings and could be another option for producers in the future.

In addition to yield, TSWV incidence results show that cultivar had significant effects on TSWV incidence every year at Tifton and Camilla (Table 5.1). No differences in TSWV incidence between seeding rates were observed which does not agree with what Brenneman and

Walcott (2001) reported, where high seeding rates had less TSWV incidence than low seeding rates in 91-cm single-row. In 2008, Georgia Green had 2.6 and 3.1% higher TSWV incidence than Georgia-06G and AP-3, respectively (Table 5.2). In 2010, Georgia-06G had 4.5 and 4.4% higher TSWV incidence than Georgia Green and AP-4, respectively (Table 5.4). In 2014 at both locations, TUFRunner™ '511' had 4.5 and 11.1% higher TSWV incidence than Georgia-06G and 8.1 to 15.4% higher TSWV incidences than Georgia-12Y (Table 5.3). As a result, cultivar selection was the only significant effect on TSWV incidence in 76-cm single-rows in this study. AP-3 and AP-4 had equal or lower TSWV incidence than both Georgia Green and Georgia-06G. TUFRunner™ '511' consistently had higher TSWV incidence than both Georgia-06G and Georgia-12Y. It is speculated that the genetic TSWV-resistance of each cultivar may have contributed to varying levels of TSWV incidence observed (Brown *et al.*, 2005). In 2010, a significant interaction between cultivar and seeding rate was observed for TSWV incidence (Table 5.1). Georgia-06G had 2.0% less TSWV incidence when planted at high (19 seed/m) seeding rate rather than low (14 seed/m) (Table 5.5) which agrees with findings from Brenneman and Walcott (2001). Georgia Green had 3.5 and 2.9% less TSWV incidence when planted at low seeding rate than high or medium seeding rates, respectively which agreed with the findings from Branch *et al*. (2003), where Georgia Green at low seeding rate (low < 20 seed/m in 91-cm single-rows) had increased TSWV incidence. Averaged across all seeding rates Georgia Green had on average 4.3% higher TSWV incidence than Georgia-06G and AP-4.

In 2014 at Tifton, lapping dates (the number of days from planting until 50% of peanut vines in the harvest rows had covered the row middle) were also recorded for each plot (Table 5.3). Seeding rate did not have an effect on the number of days it took for peanut vines to cover the row middles, but cultivar did have an effect. Both Georgia-12Y and TUFRunner™ '511' covered the row middles faster than Georgia-06G. These findings agree with what was to be expected based on the growth type characteristics assigned to each cultivar from the breeding programs, where Georgia-06G is considered to have a decumbent or intermediate growth habit. Both Georgia-12Y and TUFRunner™ '511' are considered to have a prostrate growth habit meaning that the vine growth stays low to the soil surface and tends to grow laterally across the soil surface. By selecting cultivars with faster row coverage, agronomic advantages may become evident such as increased weed suppression or soil temperature moderation during reproductive growth stages (R1-R8) (Hauser *et al*., 1982; Boote, 1982). Based on findings in this study, rate of canopy closure and TSWV incidence did not have any correlation which could suggest that TSWV incidence is not directly influenced by canopy closure or row spacing, but by other factors such as thrips populations, flight patterns, or timing of feeding (often occurs early in the season prior to canopy closure).

Grade (TSMK) was also measured and seeding rate had no significant effect, but significant differences between cultivars were observed (data no shown). Grade (TSMK) was likely different between cultivars due to genetic differences within the plant causing variations in grade to be observed.

Conclusion

Seeding rate did not consistently affect pod yield or TSWV incidence in 76-cm single-rows within any cultivar. As a result, increased flexibility in selecting seeding rates can be utilized, therefore by reducing seeding rate, seed cost can also be reduced when planting in 76-cm single-row, which can have major impact on production economics especially with large-seeded cultivars. Cultivar selection seems to be the best strategy for reducing TSWV incidence in narrow 76-cm single row peanut production, where using cultivars other than Georgia Green and TUFRunner™ ‘511’ could result in less TSWV incidence. Although TSWV incidence did differ between cultivars in one year, it did not seem to have a direct effect on pod yield. Overall, 76-cm single-row can provide competitive pod yields in comparison to other peanut planting configurations with current runner type peanut cultivars being planted. Utilizing other proven cultural control methods for reducing the risk for TSWV incidence would still be encouraged for 76-cm row spacings (Kemerait *et al.*, 2011), but further research is needed to confirm whether some of those practices are adequate with narrower row spacing.

Table 5.1 Analysis of variance probability values for cultivar x seeding rate for 2008–2010, 2014 Tifton and 2014 Camilla, GA

		Tifton						Camilla	
		2008		2010		2014		2014	
	df[b]	Yield	TSWV	Yield	TSWV	Yield	TSWV	Yield	TSWV
		p-values[a]							
Cultivar	2	0.0312	<0.0001	ns	<0.0001	ns	<0.0001	0.0292	0.0125
Seeding Rate (SR)	2	ns[c]	ns	ns	ns	ns	ns	ns	ns
Cultivar*SR	4	ns	ns	ns	0.0353	ns	ns	ns	ns

[a]p-values were obtained from ANOVA table in output of SAS using PROC GLIMMIX procedure.

[b]df = degrees of freedom

[c]ns = not significant

Table 5.2. Peanut pod yield (kg/ha) and tomato spotted wilt virus (TSWV) incidence (%) for varying cultivars in Tifton, GA 2008.

Cultivar[a]	Pod Yield	TSWV
	——kg/ha[b]——	——% Incidence——
Georgia Green	4800 B	3.6 A
Georgia-06G	5680 A	1.0 B
AP-3	4930 B	0.5 B

[a]Data pooled over rep and seeding rate. Means within a column followed by same uppercase letter are not significantly different at P = 0.10.
[b]Yield adjusted to 7% moisture.

Table 5.3. Peanut pod yield (kg/ha), tomato spotted wilt virus (TSWV) incidence (%), and days to 50% canopy closure for varying cultivars in Tifton and Camilla, GA 2014.

	2014 Camilla	2014 Tifton	2014 Camilla	2014 Tifton
Cultivar[a]	Pod Yield	TSWV	TSWV	Canopy Closure
	—kg/ha[b]—	———% Incidence———		—days—
Georgia-12Y	7720 B	3.6 C	2.0 B	51 B
Georgia-06G	8550 A	7.9 B	5.6 B	55 A
TUFRunner™ ‘511’	8900 A	19.0 A	10.1 A	50 B

[a]Data pooled over rep and seeding rate. Means within a column followed by same uppercase letter are not significantly different at P = 0.10.
[b]Yield adjusted to 7% moisture.

Table 5.4. Tomato spotted wilt virus (TSWV) incidence (%) for varying cultivars in Tifton, GA 2010.

Cultivar[a]	TSWV
	————% Incidence————
Georgia Green	2.3 B
Georgia-06G	6.8 A
AP-4	2.4 B

[a]Data pooled over rep and seeding rate. Means within a column followed by same uppercase letter are not significantly different at P = 0.10.

Table 5.5 Tomato spotted wilt virus (TSWV) incidence (%) for interaction effect cultivar x seeding rate in Tifton, GA 2010.

	Seeding Rate		
Cultivar[a]	Low (14 seed/m)	Medium (17 seed/m)	High (19 seed/m)
	% Incidence		
Georgia 06G	3.3 Aab	2.2 ABb	1.3 Bb
Georgia Green	4.6 Ba	7.5 Aa	8.1 Aa
AP-4	2.4 Ab	2.9 Ab	2.1 Ab

[a]Data pooled over rep. Means within a row followed by same uppercase letter are not significantly different at P = 0.10. Means within a column followed by same lowercase letter are not significantly different at P = 0.10.

CHAPTER 6

CONCLUSION

The need for continued agronomic research in corn and peanut will still be crucial to agriculture in the future as production practices adapt to new technologies, cultivar characteristics improve, and new pest issues arise. These results showed there were no yield advantages in twin-row for corn, and the benefits of twin-row for yield, grade, and TSWV in peanut are subdued with newer, improved cultivars compared to previous research on less resistant cultivars with lower total yield potential. In corn, differences between row pattern, row type, and seeding rate were observed within each year throughout the duration of this test, but the lack of consistent results prevented the recommendation of one particular treatment from being determined. Based on yield alone, planting corn in 76-cm single-row, 91-cm single-row, or 91-cm twin-rows can produce high yield, therefore the decision for planter selection based on yield is left to grower preference. When taking into account production economics, yield, and planter purchase price, 91-cm single-row planter was determined the best investment option in this study for corn.

In peanut, similar to corn, one particular row type did not consistently produce better than another in yield or offer any added advantages in grade or TSWV reduction. The 91-cm single-row tended to have lower yield than 76-cm single and 91-cm twin-row in Georgia Green and C-99R cultivars. Row type did not have a consistent yield advantage in 2014 between locations using Georgia-06G. Seeding density/seeding rate at extension recommendations in 76-cm single-row tended to provide the highest pod yield. In 91-cm twin-row, higher than recommended seeding density did show some yield advantages and agreed with previous research findings by UGA. Seeding rate did not affect TSWV incidence but cultivar selection did have significant effects on TSWV incidence. Economically, 91-cm single-row was the best investment option when planting C-99R or Georgia-06G even though 91-cm single-row did not always provide the highest yield, reduced production costs and purchase price associated with 91-cm single-row planter made this option appealing. With this being said, if a producer is growing both corn and peanut, the best suggestion based on these results would be to purchase a 91-cm single-row planter and use it to plant both crops in order to reduce equipment investment costs, simplify planting operations, and maintain adequate yield.

In the event that advantages to 76-cm single-rows in rotational crops with peanut arise, growing peanut in 76-cm single-rows can produce adequate yield and offer some agronomic advantages. With the use of 76-cm single rows, soil coverage can occur faster than 91-cm single-rows which may provide agronomic benefits. Various seeding rates (14, 17, and 19 seed/m) can also be utilized and not affect yield or TSWV incidence, but could allow for reduced seeding rates to be used, thus reducing seed costs. Overall, cultivar was one of the most influential and significant tools in 76-cm single-row. Cultivar selection can alter canopy closure and TSWV incidence.

REFERENCES

Abendroth, L.J., R.W. Elmore, M.J. Boyer, and S.K. Marlay. 2011. Corn growth and development. PMR 1009. Iowa State Univ. Extension, Ames, IA.

ASABE. 2011. ASAE Standard D497.7: Agricultural machinery management data. ASABE, St. Joesph, MI.

Baldwin, J. A., J. P. Beasley Jr., A. K. Culbreath, and S. L. Brown. 1997. Twin versus single-row patterns for peanut production. Proc. Am. Peanut Res. and Ed. Soc. 29:20.

Baldwin, J.A., J.P. Beasley, Jr., S. L. Brown, J.W., Todd, and A.K. Culbreath. 1998. Yield, grade, and tomato spotted wilt virus incidence of four peanut cultivars in response to twin versus single-row planting patterns. Proc. Amer. Peanut Res. Educ. Soc. 30:51.

Baldwin, J.A., J.W. Todd, J.R. Weeks, D.W. Gorbet, A. K. Culbreath, A.S. Luke-Morgan, S.M. Fletcher, and S.L. Brown. 2001. A regional study to evaluate tillage, row patterns, in-furrow insecticide, and planting date on the yield, grade, and tomato spotted wilt virus incidence of the Georgia Green peanut Cultivar. Proc. Annu. South. Conserv. Tillage Conf. Sustain. Agric. 25:152-160. [Online]. Available at http://www.ag.auburn.edu/auxiliary/nsdl/scasc/Proceedings/2001/Baldwin.pdf (verified 18 Apr. 2015).

Balkcom, K.S., J. Arriaga, K.B. Balkcom, and D.L. Boykin. 2010. Single- and twin- row peanut production within narrow and wide strip tillage systems. Agron. J. 102:507–512.

Barry, P. and P. Ellinger. 2010. Investment analysis, net present value. In: Financial Management in Agriculture. 7th Edition. Prentice Hall. Upper Saddle River, NJ. 157–177.

Beasley, J.P. 1997. Peanut production field guide. Coop. Ext. Serv. Bull. 1146:20. Univ. of Georgia, Athens, GA.

Beasley, J.P., Jr. 2006. Peanut cultivars: making sense of all the options. [Online]. Available at www.georgiacropconsultants.org/Beasley_2006.ppt (verified 3 Mar. 2015).

Beasley, J.P., Jr. 2007. Irrigation strategies. in: E.P. Prostko. 2007 Peanut Update. Univ. of Georgia, Tifton, GA. [Online]. Available at http://www.caes.uga.edu/commodities/fieldcrops/peanuts/2007peanutupdate/irrig.html. (verified 10 Oct. 2014). Univ. of Georgia, Tifton, GA.

Beasley, J.P., G. Hawkins, and C. Perry. 2013. Irrigation. In: E.P. Prostko, 2013 Peanut Update. Univ. of Georgia, Tifton, GA. 78–82.

Bitzer, M. and J. Herbek. 2000. Effect of row width and plant population on corn yields. p. 7. *In* Abstracts of technical papers, 2000 annu. meet., S. Branch of ASA, 27th, Lexington, KY. 30-31 Jan. 2000. ASA, Madison, WI.

Black, M.C., H. Tewolde, C.J. Fernandez, and A.M. Schubert. 2001. Seeding rate, irrigation, and cultivar effects on tomato spotted wilt, rust, and southern blight diseases in peanut. Peanut Sci. 28:1–4.

Boote, K.J. 1982. Growth stages of peanut (*Arachis hypogaea* L.) Peanut Sci. 9:35–40.

Branch, W.D. 1996. Registration of 'Georgia Green' Peanut. Crop Sci. 36:806.

Branch, W.D., J.A. Baldwin, and A.K. Culbreath. 2003. Genotype x seeding rate interaction among TSWV-resistant, runner-type peanut cultivars. Peanut Sci. 30(2):108–111.

Branch, W.D. 2007. Registration of 'Georgia-06G' Peanut. J. Plant Reg. 1:120.

Branch, W.D. 2013. Registration of 'Georgia-12Y' Peanut. J. Plant Reg. 7:151–153.

Branch, W.D. 2014. Registration of 'Georgia-13M' Peanut. J. Plant Reg. 8:253–256.

Branch, W.D. and T.B. Brenneman. 2015. Registration of 'Georgia-14N' Peanut. J. Plant Reg. 9:159–161.

Brecke, B.J. 1995. Management of weeds. In: H.A. Melouk and F.M. Shokes, Peanut Health Management. Am. Phytopathological Soc. St. Paul, MN. 43-49.

Brenneman, T., and R. Walcott. 2001. Defining the relationship between plant stand, tomato spotted wilt , and pod yield from peanut seed treatment trials. Proc. Am. Peanut Res. Edu. Soc. 33:21–22.

Brown, R.H., E.R. Beaty, W.J. Ethredge, and D.D. Hayes. 1970. Influence of row width and plant population on yield of two varieties of corn (Zea mays L.). Agron. J. 62:767–770.

Brown, S, J. Todd, A. Culbreath, J. Baldwin, J. Beasley, R. Kemerait, and E. Prostko. 2003. Minimizing spotted wilt of peanut. Univ. of Georgia, Coop. Ext. Serv. Bull. 1165.

Brown, S.L., A.K. Culbreath, J.W. Todd, D.W. Gorbet, J.A. Baldwin, and J.P. Beasley, Jr. 2005. Development of a method of risk assessment to facilitate integrated management of spotted wilt of peanut. Plant Disease 89(4):348–356.

Bruns, H.A., M.W. Ebelhar, and H.K. Abbas. 2012. Comparing single-row and twin-row corn production in the mid-south. Crop Manage. doi:10.1094/CM-2012-0404-01-RS

Butzen S. and S. Paszkiewicz. 2008. Narrow-row corn production - when does it increase yields? Crop Insights 18(15) [Online]. Available at www.pioneer.com/home/site/us/agronomy/library/ (verified 5 Jan. 2015) Pioneer Hi-Bred, Johnston, IA.

Casper, B.B. and R.B. Jackson. 1997. Plant competition underground. Annu. Rev. Ecol. Syst. 28:545-570.

Chapin, J.W., J.S. Thomas, T.G. Isleib, F.M. Shokes, W.D. Branch, and B.L. Tillman. 2010. Field evaluation of Virginia-type peanut cultivars for resistance to tomato spotted wilt virus, late leaf spot, and stem rot. Peanut Sci. 37:63–69.

Colvin, D.L., R.H. Walker, M.G. Patterson, G. Wehtje, and J.A. McGuire. 1985. Row pattern and weed management effects on peanut production. Peanut Sci. 12:22–27.

Cox, F.R. and P.H. Reid. 1965. Interaction of plant population factors and level of production on the yield and grade of peanuts. Agron. J. 57:455–457.

Cox, W.J. and D.J.R. Cherney. 2001. Row spacing, plant density, and nitrogen effects on corn silage. Agron. J. 93(3):597–602.

Culbreath, A.K., J.W. Todd, D.W. Gorbet, F.M. Shokes, and H.R. Pappu. 1997. Field response of new cultivar UF 91108 to tomato spotted wilt virus. J. Plant Dis. 81(12):1410–1415.

Culbreath, A.K., B.L. Tillman, D.W. Gorbet, C.C. Holbrook, and C. Nischwitz. 2008. Response of new field-resistant peanut cultivars to twin-row pattern or in-furrow applications of phorate for management of spotted wilt. Am. Phytopathological Soc. 92:1307–1312.

Culbreath, A.K. and R. Srinivasan. 2011. Epidemiology of spotted wilt disease of peanut caused by Tomato spotted wilt virus in southeastern U.S. J. Virus Research 159:101-109. doi: 10.1016/j.virusres2011.04.014

Culbreath, A.K., W. D. Branch, J. P. Beasley, R. S. Tubbs, and C. C. Holbrook. 2012 peanut genotype and seeding rate effects on spotted wilt. Online. Plant Health Progress. doi:10.1094/PHP-2012-0227-03-RS.

Culbreath, A.K., R.S. Tubbs, B.L. Tillman, J.P. Beasley Jr., W.D. Branch, C.C. Holbrook, A.R. Smith, and N.B. Smith. 2013. Effects of seeding rate and cultivar on tomato spotted wilt of peanut. Crop Prot. 53:118–124.

Cusicanqui, J.A. and J.G. Lauer. 1999. Plant density and hybrid influence on corn forage yield and quality. Agron. J. 91:911–915.

Dohlman, E. and J. Livezey. 2005. Peanut backgrounder. [Online]. Available at www.ers.usda.gov/media/864326/ocs05i01_002.pdf (verified 24 Apr. 2015) United States Department of Agriculture, USDA, Washington, D.C. pp. 1–30.

Duke, G.B. and M. Alexander. 1964. Effects of close row spacing on peanut production requirements. USDA Prod. Res. Bull. 77. 14 pp.

Dwivedi, S.L., R. Jambunathan, S.N. Nigam, K. Raghunath, K. R. Shankar, and G.V.S. Nagabhushanarn. 1990. Relationship of seed mass to oil and protein contents in peanut (*Arachis hypogaea* L.). Peanut Sci. 17:48-52.

Dwyer, L.M., D.W. Stewart, and M. Tollenaar. 1991. Changes in plant density dependence of leaf photosynthesis of maize (*Zea mays* L.) hybrids, 1959 to 1988. Canadian J. of Plant Sci. 71(1):1–11.

Farnham, D.E. 2001 Row spacing, plant density, and hybrid effects on corn grain yield and moisture. Agron. J. 93:1049–1053.

Fernandez-Cornejo, J., C. Hallahan, R. Nehring, and S. Wechsler. 2012. Conservation tillage, herbicide use, and genetically engineered crops in the United States: The case of soybeans. AgBioForum 15(3):231-241.

Fernandez-Cornejo, Jorge, Seth Wechsler, Mike Livingston, and Lorraine Mitchell. Genetically engineered crops in the United States, ERR-162 U.S. Department of Agriculture, Economic Research Service, February 2014

Ferreira, G., M. Alfonso, S. Depino, and E. Alessandri. 2014. Effect of planting density on nutritional quality of green-chopped corn for silage. J. Dairy Sci. 97(9):5918–5921.

Fulton, J.M. 1970. Relationships among soil moisture, stress, plant population, row spacing, and yield of corn. Canadian J. of Plant Sci. 50(1):31–38.

[GCIA] Georgia Crop Improvement Association. 2012. Peanut cultivar seed increase quantities. Athens, GA. [Online]. Available at www.georgiacrop.com (verified 21 Apr. 2015).

Givens, W.A., D.R. Shaw, G.R. Kruger, W.G. Johnson, S.C. Weiler, B.G. Young, R. G. Wilson, M.D.K. Owen, and D. Jordan. 2009. Survey of tillage trends following the adoption of glyphosate-resistant crops. Weed Technology 23: 150-155. doi: 10.1614/WT-08038.1

Gorbet, D.W., and F.M. Shokes. 2002. Registration of 'C-99R' Peanut. Crop Sci. 42:2207.

Gorbet, D.W. 2007. Registration of 'AP-3' Peanut. J. Plant Reg. 1:126–127.

Haferkamp, M. R. 1988. Environmental factors affecting plant productivity. [Online]. Available at www.oreganstate.edu/dept/eoarc/sites/default/files/publication/328.pdf (verified 18 Apr. 2015) Montana Agr. Exp. Sta., Bozeman.

Hallman, A. and J. Lowenberg-DeBoer. 1999. Cost, average returns, and risk of switching to narrow row corn. J. of Production Agric. 12(4):685-691.

Harris, G.H., Jr. 2013. Fertilization. In: R.D. Lee, A Guide to Corn Production in Georgia 2013. Univ. of Georgia, Tifton, GA. 9–12.

Harrison, A. L. 1970. The effect of seed rates and multiple rows per bed under irrigation. Proc. Amer. Peanut Res. & Educ. Assoc. 2:47–50.

Harrison, K. and D. Lee. 2013. Scheduling and management corn irrigation. In: R.D. Lee, A Guide to Corn Production in Georgia 2013. Univ. of Georgia, Tifton, GA. 13–21.

Hauser, E.W. and G.A. Buchanan. 1981. Influence of row spacing, seeding rates, and herbicide systems on the competitiveness and yield of peanuts. Peanut Sci. 8:74–81.

Hauser, E.W., G.A. Buchanan, R.L. Nichols, and R.M. Patterson. 1982. Effects of Florida Beggarweed (*Desmodium tortusum*) and Sicklepod (*Cassia obtusifolia*) on peanut (*Arachis hypogaea*) yield. Weed Sci. 30:602–604.

Henning, R.J., J.F. McGill, L.E. Samples, C.W. Swann, S.S. Thompson, and H. Womack. 1979. Growing peanuts in Georgia: A package approach. Bull. 640, Univ. of Ga. 46 pp.

Henning, R.J.,A.H. Allison, and L.D. Tripp. 1982. Peanut science and technology. In: H.E. Pattee and C.T. Young. Am. Peanut Res. and Educ. Soc. Inc., Yoakum, TX. 123–138.

Houck, M. J. 2009. Understanding seeding rates, recommended planting rates, and pure live seed. Plant Materials Technical Note: 11. [Online]. Available at http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/lapmctn9045.pdf

Humphrey, L.D. and E.W. Schupp. 2000. Alternate yield-density models for the study of plant competition. In Proc 85th Ann. Meet. Ecol. Soc. Amer. Snowbird, UT. 6-10 Aug. 1999. Ecol. Soc. Amer., Washington, D.C.

Hurt, C.A., R.L. Brandenburg, D.L. Jordan, B.M. Royals, and P.D. Johnson. 2006. Interactions of Tillage with Management Practices Designed to Minimize Tomato Spotted Wilt of Peanut (*Arachis hypogaea* L.). Peanut Sci. 33:83–89.

Jaaffar, Z., and F.P. Gardner. 1988. Canopy development, yield, and market quality in peanut as affected by genotype and planting pattern. Crop Sci. 28:299–305.

Johnson, W.C., III, J.P. Beasley Jr., S.S. Thompson, H. Womack, C.W. Swann, and L.E. Samples. 1987. Georgia peanut production guide. Ga. Coop. Ext. Serv. Publ. SB23.

Johnson, W.C. III, E.P. Prostko, and B.G. Mullinix Jr. 2005. Improving the management of dicot weeds in peanut with narrow row spacings and residual herbicides. Agron. J. 97:85–88.

Karlen, D.L. and C.R. Camp. 1985. Row spacing, plant population, and water management effects on corn in the Atlantic coastal plain. Agron. J. 77(3):393–398.

Kemerait, R., A. Culbreath, J. Beasley, E. Prostko, T. Brenneman, N. Smith, S. Tubbs, R. Olantinwo, R. Srinivasan, M. Boudreau, B. Tillman, D. Rowland, N. Dufault, A. Hagan, and W. Faircloth. 2011. Peanut Rx, minimizing diseases of peanut in the southeastern United States - the 2011 version of the Peanut Disease Risk Index. Univ. of Georgia Coop. Ext. Serv., Athens, GA:100–116.

Kirby, J.S. and C. Kitbamroong. 1986. Peanut cultivar response to row spacing and plant density. Proc. Amer. Peanut Res. Educ. Soc. 18:48 (Abstr.).

Kvien, C.S. and C.L. Bergmark. 1987. Growth and development of the Florunner peanut cultivar as influenced by population, planting date, and water availability. Peanut Sci. 14:11–16.

Kvien, C.S. 1995. Physiological and environmental disorders of peanut. In: H.A. Melouk and F.M. Shokes, Peanut Health Management. Am. Phytopathological Soc. St. Paul, MN. 33-42.

Lanier, J.E., D.L. Jordan, J.F. Spears, R. Wells, P.D. Johnson, J.S. Barnes, C.A. Hurt, R.L. Brandenburg, and J.E. Bailey. 2004. Peanut response to planting pattern, row spacing, and irrigation. Agron. J. 96:1066–1072.

Lauer, J.G. and M. Rankin. 2004. Corn response to within row plant spacing variation. Agron. J. 96:1464–1468.

Lee, R. D. 2013. Agronomic practices for corn. In: R.D. Lee, A Guide to Corn Production in Georgia 2013. Univ. of Georgia, Tifton, GA. 3–8.

Leonard, B.J., D.B. Myers, N.R. Kitchen, and K.A. Sudduth. 2014. Physiological responses of corn to variable seeding rates in landscape-scale strip trials. Int. Soc. of Precision Agric. (Abstr.) [Online]. Available at www.ispag.org/icpa/Proceedings (verified 20 Apr. 2015)

Lutz, J.A., H.M. Camper, and G.D. Jones. 1971. Row spacing and population effects on corn yields. Agron. J. 63(1):12–14.

McClelland, C.K. 1931. The peanut crop in Arkansas. Bull. 263, Ark. Exp. Sta.

Minton, N.A. and A.S. Csinos. 1986. Effects of row spacings and seeding rates of peanut on nematodes and incidence of southern stem rot. Nematropica 16:167-176.

Monsanto. 2015. agSeedSelect. [Online]. Available at www.agseedselect.com (verified 10 Dec. 2014) Monsanto, St. Louis, MO.

Monzingo, R.W. and T.A. Coffelt. 1984. Row pattern and seeding rate effects on value of virginia-type peanut. Agron. J. 76:460–462.

[NASS] USDA National Agricultural Statistics Service. 2015a. Quick stats corn acres planted [Online]. Available at http://quickstats.nass.usda.gov/ (verified 22 Feb. 2015). USDA-NASS, Washington, D.C.

[NASS] USDA National Agricultural Statistics Service. 2015b. Quick stats corn price by year [Online]. Available at http://quickstats.nass.usda.gov/ (verified 22 Feb. 2015). USDA-NASS, Washington, D.C.

[NASS] USDA National Agricultural Statistics Service. 2015c. Quick stats peanut planted acreage [Online]. Available at http://quickstats.nass.usda.gov/ (verified 9 Mar. 2015). USDA-NASS, Washington, D.C.

[NASS] USDA National Agricultural Statistics Service. 2015d. Quick stats peanut yield in lbs./ac [Online]. Available at http://quickstats.nass.usda.gov/ (verified 9 Mar. 2015). USDA-NASS, Washington, D.C.

Nelson, K.A. and R.L. Smoot. 2009. Twin- and single-row corn production in northeast Missouri. Online. Crop Manage. doi:10.1094/CM-2009-0130-01-RS

Norden, A.J., R.W. Lipscomb, and W.A. Carver. 1969. Registration of Florunner peanut. Crop Sci. 9:850.

Norden, A.J. and R.W. Lipscomb. 1974. Influence of plant growth habit on peanut production in narrow rows. Crop Sci. 14:454–457.

Nuti, R.C., W.H. Faircloth, M.C. Lamb, R.B. Sorensen, J.I. Davidson, and T.B. Brenneman. 2008. Disease management and variable planting patterns in peanut. Peanut Sci. 35:11–17.

Pioneer Hi-Bred International. 2011. Optimizing corn seeding rates (eastern corn belt and northeast)[Online]. Available at https://www.pioneer.com/home/site/us/template.PAGE/agronomy/library (verified 22 Feb. 2015) Crop Insights. Pioneer Hi-Bred Int. Johnston, IA.

Plank, C.O., G.H. Harris, and R. Hitchcock. 2001. UGFertex - A windows based expert system for formulating prescription lime and nutrient guidelines for agronomic crops. Univ. of Georgia Coop. Ext. Serv., Athens, GA.

Porter, P.M., D.R. Hicks, W.E. Lueshcen, J.H. Ford, D.D. Warnes, and T.R. Hoverstad. 1997. Corn response to row width and plant density in the northern corn belt. J. Prod. Agric. 10:293–300.

Reeves, G.W. and W.J. Cox. 2013. Inconsistent responses of corn to seeding rates in field-scale studies. Agron. J. 105:693–704.

Riley, D., R. McPherson, and L. Wells. 2008. Tospoviruses in solanaceae and other crops in the coastal plain of Georgia. [Online]. Available at http://www.caes.uga.edu/topics/diseases/tswv/vegcrops/tospoviruses/thripsvectors.html (verified 12 Mar. 2015). Univ. of Georgia, Athens, GA.

Ritchie, S.W., J.J. Hanway, and G.O. Benson. 1996. How a corn plant develops. Spec. Re. 48. Rev. ed. Iowa State Univ. Coop. Ext. Serv. Ames, IA.

Robles, M., I.A. Ciampitti,and T. J. Vyn. 2012. Responses of maize hybrids to twin-row spatial arrangement at multiple plant densities. Agron. J. 104:1747–1756.

Rodriguez-Kabana, R., P. A. Backman, and J.C. Williams. 1975. Determination of yield losses to *Sclerotium rolfsii* in peanut fields. Plant Dis. Rep. 59:855–858.

SAS Institute. 2010. The SAS system for Windows. v. 9.3. SAS Inst., Cary, NC.

Sconyers, L.E., T.B. Brenneman, and K.L. Stevenson. 2007. Effects of row pattern, seeding rate, and inoculation date of fungicide efficacy and development of peanut stem rot. Plant Dis. J. 91:273–278.

Sholar, J.R., R.W. Monzingo, and J.P. Beasley Jr.1995. Peanut cultural practices. In: H.E. Pattee and H.T. Stalker, Advances in Peanut Science. Am. Peanut Res. and Educ. Soc. Inc., Stillwater, OK. 354–382.

Smith, C.W. 1995. Corn. Crop Production Evolution, History, and Technology. John Wiley and Sons, Inc., New York. 1–56.

Snider, J.L. R.L. Raper, and E.B. Schwab. 2012. The effect of row spacing and seeding rate on biomass production and plant stand characteristics of non-irrigated photoperiod-sensitive sorghum (*Sorghum bicolor* (L.) Moench) Publications from USDA-ARS/UNL Faculty Paper 876 [Online]. Available at http://digitalcommons.unl.edu/usdaarsfacpub/876 (verified 20 Apr. 2015)

Sorensen, R.B., L.E. Sconyers, M.C. Lamb, and D.A. Sternitzke. 2004. Row orientation and seeding rate on yield, grade, and stem rot incidence of peanut with subsurface drip. Peanut Sci. 31(1):54–58.

Sorensen, R.B., M.C. Lamb, C.L. Butts. 2006. Row pattern, plant density, and nitrogen rate effects on corn yield in the southeastern US.[Online]. Crop Management. doi:10.1094/CM-2006-1211-01-RS.

Sorensen, R.B., M. C. Lamb, and C. L. Butts. 2007. Peanut response to row pattern and seed density when irrigated with subsurface drip irrigation. Peanut Sci. 34:27–31.

Stephenson, D.O. IV, and B.J. Brecke. 2011. Weed management in evenly-spaced 38- vs. 76-cm row peanut (*Arachis hypogaea).* Peanut Sci. 38:66–72.

Sturkie, D.G. and G.A. Buchanan. 1973. Cultural practices. Peanuts: Culture and Uses. Am. Peanut Res. Educ. Soc., Stillwater, OK. 299-326.

Sullivan, G.A. 1991. Cultivar response to twin-row planting. Proc. Amer. Peanut Res. Educ. Soc. 23:26 (Abstr.).

Tillman, B.L., D. W. Gorbet, A.K. Culbreath, and J.W. Todd. 2006. Response of peanut cultivars to seeding density and row patterns. Crop Manage. 5 doi:10.1094/CM-2206-0711-01-RS

Tillman, B.L. and D.W. Gorbet. 2008. Registration of 'AP-4' Peanut. J. Plant Reg. 3:138–142.

Tillman, B., M. Gomillion, J. McKinney, and G. Pearson. 2014. Peanut variety performance in Florida, 2011–2014. Research Report 15-P1. Univ. of Florida, NFREC, Marianna, FL. 1–7.

Tubbs, R.S., J. P. Beasley, A. K . Culbreath, R. C. Kemerait, N. B. Smith, and A. R. Smith. 2011. Row pattern and seeding rate effects on agronomic, disease, and economic factrors in large-seeded runner peanut. Peanut Sci. 38(2):93–100.

Tubbs, R.S., and J.P. Beasley. 2013. Update on seeding rates for twin-row pattern. In: E. P. Prostko, 2013 Peanut Production Update. Univ. of Georgia, Tifton, GA. 57–61.

United States Census Bureau. 2014. Population clock. [Online]. Available at https://www.census.gov/popclock/ (verified 20 Jan. 2015). U.S. Department of Commerce, Washington, D.C.

University of Georgia. 2010. Tomato spotted wilt virus in peanut. [Online]. Available at http://www.caes.uga.edu/topics/diseases/tswv/peanut/ (verified 2 Feb. 2015). Univ. of Georgia College of Agric. and Environ. Sci., Tifton, GA.

University of Georgia. 2014a. 2013 Georgia farm gate value report. [Online]. Available at http:// www. caes.uga.edu/center/caed/documents/GeorgiaFGVR2013_FINAL.pdf (verified 18 Apr. 2015). Univ. of Georgia. The Center for Agribusiness and Economic Development. AR-14-01

University of Georgia. 2014b. Field corn weed control. In: E.P. Prostko, Georgia Pest Management Handbook. [Online]. Available at www.ent.uga.edu/pest-management/Commerical-Field-Corn.pdf (verified 19 Apr. 2015) Univ. of Georgia Coop. Ext. Serv. Tifton, GA. 139-157

University of Georgia. 2014c. Peanut weed control. In: Kemerait, R.C., T.B. Brenneman, and A.K. Culbreath, Georgia Pest Management Handbook. [Online]. Available at www.ent.uga.edu/pest-management/Commerical-Peanut_2015.pdf (verified 19 Apr. 2015) Univ. of Georgia Coop. Ext. Serv. Tifton, GA. 495-514

University of Georgia. 2014d. Peanut disease control. In: E.P. Prostko, Georgia Pest Management Handbook. [Online]. Available at www.ent.uga.edu/pest-management/Commerical-Peanut_2015.pdf (verified 19 Apr. 2015) Univ. of Georgia Coop. Ext. Serv. Tifton, GA. 489-493

University of Georgia. 2015a. Farm gate value reports. [Online]. Available at www.caes.uga.edu/center/caed/ (verified 18 Apr. 2015) Center for Agribusiness and Economic Development, Athens, GA.

University of Georgia. 2015b. Row crop enterprise budgets. [Online]. Available at www.agecon.uga.edu/extension/budgets/index.html (verified 19 Apr. 2015).

University of Georgia. 2015c. Statewide Variety Testing. [Online]. Available at www.swvt.uga.edu (verified 22 Apr. 2015).

USDA-AMS. 1997. United States standards for grades of shelled runner type peanuts. Available at www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050496 (verified 22 Apr. 2015). USDA Agric. Marketing Serv., Washington, D.C.

USDA. 2015. Corn background. Econ. Res. Serv. [Online]. Available at http://www.ers.usda.gov/topics/crops/corn/background.aspx (verified 22 Feb. 2015). USDA, United States Department of Agriculture, Washington, D.C.

USDA-NRCS. 2015, Official soil series descriptions [Online]. Available at http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/class/ (verified 22 Feb. 2015). USDA Natural Resources Conversation Serv., Washington, D.C.

Vencill, W.K., R.L. Nichols, T.M. Webster, J.K. Soteres, C. Mallory-Smith, N.R. Burgos, W.G. Johnson, and M. R. McClelland. 2012. Herbicide Resistance: Toward an understanding of resistance development and the impact of herbicide-resistant crops. Weed Sci. 60 Special Issue 1-30. doi: 10.1614/WS-D-11-00206.1

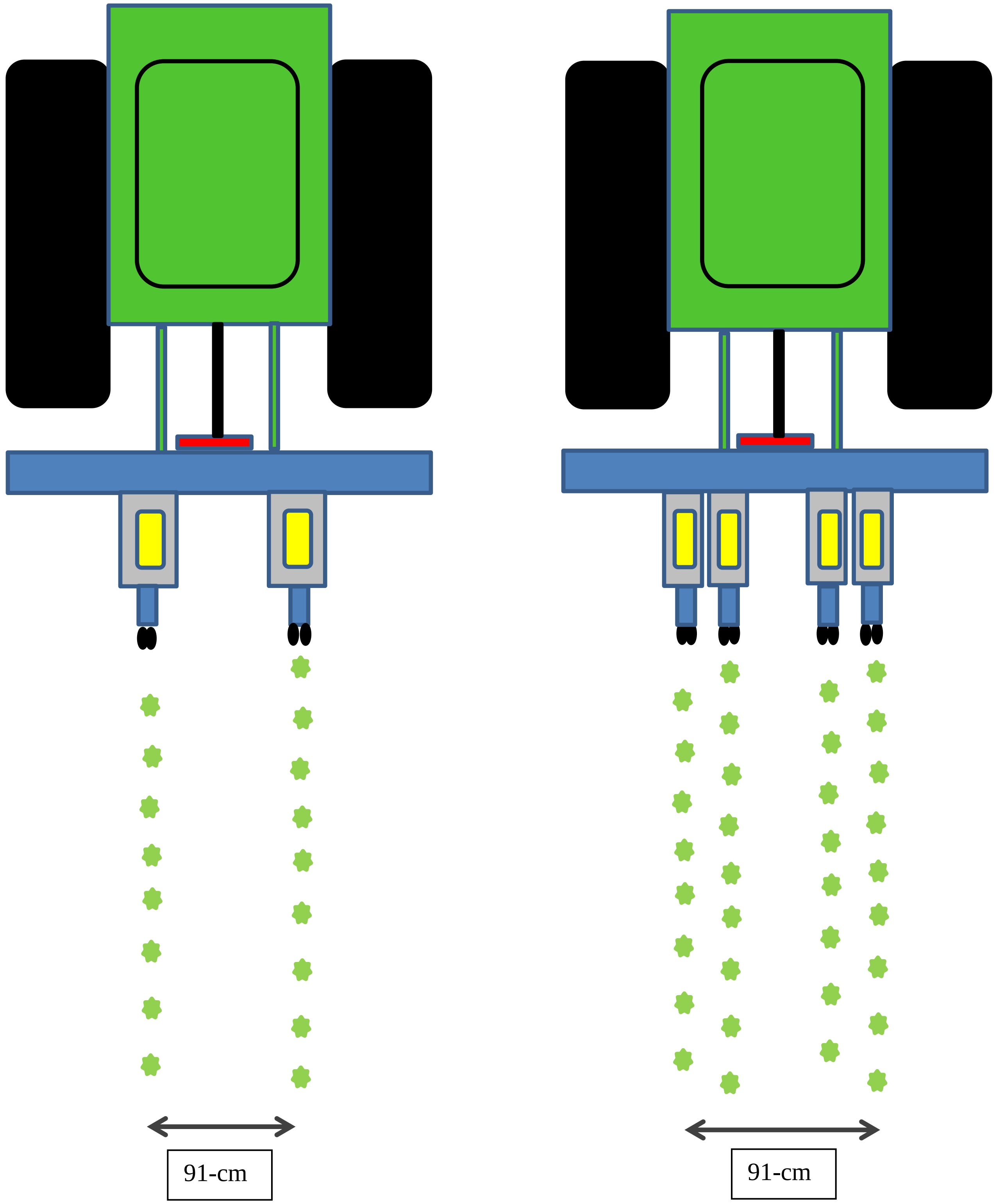
Wehtje, G., R. Weeks, M. West, L. Wells, and P. Pace. 1994. Influence of planter type and seeding rate on yield and disease incidence in peanut. Peanut Sci. 21:16–19.

Wells, L., R. Weeks, and G. Wehtje. 1992. Performance of peanuts (Arachis hypogaea L.) as influenced by seeding rate and planter. Proc. Amer. Peanut Res. Educ. Soc. 24:60 (Abstr.).

Williams, E.J., and J. S. Drexler. 1981. A non-destructive method for determining pod maturity. Peanut Sci. 8:134–141.

APPENDICES

A. SCHEMATIC OF PLANTER CONFIGURATIONS AND MEASUREMENTS



B. BASE UNIVERSITY OF GEORGIA (UGA) CONVENTIONAL IRRIGATED CORN ENTERPRISE BUDGET[1]

Irrigated Corn
South Georgia, 2015

Estimated Costs and Returns

Expected Yield: **200** bushel

Variable Costs	**Unit**	**Amount**	**$/Unit**	**Cost/Acre**	**$/bushel**
Seed	thousand	32	$ 2.95	$ 94.40	$ 0.47
Lime	ton	0.5	$ 44.00	$ 22.00	$ 0.11
Fertilizer					
Nitrogen	pounds	240	$ 0.62	$ 148.80	$ 0.74
Phosphate	pounds	100	$ 0.43	$ 43.00	$ 0.22
Potash	pounds	200	$ 0.41	$ 82.00	$ 0.41
Weed Control	acre	1	$ 14.20	$ 14.20	$ 0.07
Insect Control	acre	1	$ -	$ -	$ -
Disease Control	acre	1	$ 22.56	$ 22.56	$ 0.11
Preharvest Machinery					
Fuel	gallon	4.7	$ 2.90	$ 13.69	$ 0.07
Repairs and Maintenance	acre	1	$ 10.66	$ 10.66	$ 0.05
Harvest Machinery					
Fuel	gallon	2.5	$ 2.90	$ 7.34	$ 0.04
Repairs and Maintenance	acre	1	$ 7.49	$ 7.49	$ 0.04
Labor	hours	1.0	$ 12.00	$ 12.11	$ 0.06
Irrigation	applications	8	$ 10.35	$ 82.80	$ 0.41
Crop Insurance	acre	1	$ 14.00	$ 14.00	$ 0.07
Land Rent	acre	1	$ -	$ -	$ -
Interest on Operating Capital	percent	$ 287.52	6.5%	$ 18.69	$ 0.09
Drying - 8 Points	bushel	220	$ 0.28	$ 61.46	$ 0.31
Total Variable Costs:				**$ 655.20**	**$ 3.28**

[1]Smith, N.B. 2015. www.agecon.uga.edu/extension/budgets/index.html

Fixed Costs

	Machinery Depreciation, Taxes, Insurance and Housing					
Preharvest Machinery	acre		1	$ 29.48	$ 29.48	$ 0.15
Harvest Machinery	acre		1	$ 36.46	$ 36.46	$ 0.18
Irrigation	acre		1	$ 125.00	$ 125.00	$ 0.63
General Overhead	% of VC	$ 655.20		5%	$ 32.76	$ 0.16
Management	% of VC	$ 655.20		5%	$ 32.76	$ 0.16
Owned Land Cost, Taxes, Cash Payment, etc.	acre		1	$ -	$ -	$ -
Other ___________________	acre		1	$ -	$ -	$ -
Total Fixed Costs					**$ 256.47**	**$ 1.28**
Total Costs Excluding Land					**$ 911.67**	**$ 4.56**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Heavy Disk 27' with Tractor (180-199 hp) MFWD 190	13.2	2	0.19	1.48	$ 3.62	$ 10.51
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.60	$ 4.64
Bed-Disk (Hipper) 6R-36 with Tractor (180-199 hp) MFWD 190	9.6	1	0.13	1.02	$ 1.59	$ 4.91
Plant - Rigid 6R-36 with Tractor (120-139 hp) 2WD 130	9.5	1	0.13	0.70	$ 1.72	$ 4.81
Fert Appl (Liquid) 6R-36 with Tractor (120-139 hp) 2WD 130	9.2	1	0.14	0.73	$ 1.81	$ 3.83
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	1	0.04	0.19	$ 0.33	$ 0.79
Total Preharvest Values			0.70	4.72	$ 10.66	$ 29.48

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header - Corn 6R-36 with Combine (200-249 hp) 240 hp	6.5	1	0.19	1.90	$ 6.22	$ 33.03
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.28	$ 3.43
Total Harvest Values			0.31	2.53	$ 7.49	$ 36.46

C. Adjustment to base UGA corn budget by row type and seeding rate 2012-2014 Tifton, GA for the study “ROW PATTERN, ROW SPACING, AND SEEDING RATE IN FIELD CORN (*Zea mays* L.)”

Treatment	1 Single 76-cm Low	2 Single 76-cm Medium	3 Single 76-cm High	4 Single 91-cm Low	5 Single 91-cm Medium	6 Single 91-cm High	7 Twin 91-cm Low	8 Twin 91-cm Medium	9 Twin 91-cm High
Preharvest									
Seed Cost	-12.60	6.32	33.97	-10.58	12.58	29.82	-7.87	7.00	33.53
Fertilizer	30.56	30.56	30.56	30.56	30.56	30.56	30.56	30.56	30.56
Weeds	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24
Fuel	-2.23	-2.23	-2.23	-4.00	-4.00	-4.00	-3.46	-3.46	-3.46
R&M	-1.93	-1.93	-1.93	-3.52	-3.52	-3.52	-2.46	-2.46	-2.46
Fixed Costs	-6.27	-6.27	-6.27	-10.54	-10.54	-10.54	-7.31	-7.31	-7.31
Harvest									
Fuel	-1.15	-1.15	-1.15	-2.18	-2.18	-2.18	-2.18	-2.18	-2.18
R&M	-0.09	-0.09	-0.09	-1.27	-1.27	-1.27	-1.27	-1.27	-1.27
Fixed Costs	3.04	3.04	3.04	-3.43	-3.43	-3.43	-3.43	-3.43	-3.43
Labor	-0.75	-0.75	-0.75	-2.50	-2.50	-2.50	-2.19	-2.19	-2.19
VC	-100.32	-80.76	-52.19	-106.34	-82.41	-64.59	-101.51	-86.14	-58.72
FC	-13.27	-11.32	-8.46	-24.61	-22.22	-20.44	-20.90	-19.36	-16.62

Note: Input costs were averaged over 2012, 2013, and 2014.

D. BASE UNIVERSITY OF GEORGIA (UGA) CONVENTIONAL NON-IRRIGATED CORN ENTERPRISE BUDGET[1]

Non-Irrigated Corn
Georgia, 2015

Estimated Costs and Returns

Expected Yield: **85** bushel

Variable Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel
Seed	thousand	20	$ 2.55	$ 51.00	$ 0.60
Lime	ton	0.25	$ 44.00	$ 11.00	$ 0.13
Fertilizer					
Nitrogen	pounds	100	$ 0.62	$ 62.00	$ 0.73
Phosphate	pounds	40	$ 0.43	$ 17.20	$ 0.20
Potash	pounds	60	$ 0.41	$ 24.60	$ 0.29
Weed Control	acre	1	$ 14.20	$ 14.20	$ 0.17
Insect Control	acre	1	$ -	$ -	$ -
Disease Control	acre	1	$ 22.56	$ 22.56	$ 0.27
Preharvest Machinery					
Fuel	gallon	4.7	$ 2.90	$ 13.69	$ 0.16
Repairs and Maintenance	acre	1	$ 10.66	$ 10.66	$ 0.13
Harvest Machinery					
Fuel	gallon	2.5	$ 2.90	$ 7.34	$ 0.09
Repairs and Maintenance	acre	1	$ 7.49	$ 7.49	$ 0.09
Labor	hours	1.0	$ 12.00	$ 12.11	$ 0.14
Crop Insurance	acre	1	$ 23.00	$ 23.00	$ 0.27
Land Rent	acre	1	$ -	$ -	$ -
Interest on Operating Capital	percent	$ 138.42	6.5%	$ 9.00	$ 0.11
Drying - 8 Points	bushel	93	$ 0.28	$ 26.12	$ 0.31
Total Variable Costs:				**$ 311.97**	**$ 3.67**

[1]Smith, N.B. 2015. www.agecon.uga.edu/extension/budgets/index.html

Fixed Costs

		Machinery Depreciation, Taxes, Insurance and Housing				
Preharvest Machinery	acre		1	$ 29.48	$ 29.48	$ 0.35
Harvest Machinery	acre		1	$ 36.46	$ 36.46	$ 0.43
General Overhead	% of VC	$ 311.97		5%	$ 15.60	$ 0.18
Management	% of VC	$ 311.97		5%	$ 15.60	$ 0.18
Owned Land Cost, Taxes, Cash Payment, etc.	acre		1	$ -	$ -	$ -
Other ____________________	acre		1	$ -	$ -	$ -
Total Fixed Costs					**$ 97.15**	**$ 1.14**
Total Costs Excluding Land					**$ 409.11**	**$ 4.81**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Heavy Disk 27' with Tractor (180-199 hp) MFWD 190	13.2	2	0.19	1.48	$ 3.62	$ 10.51
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.60	$ 4.64
Bed-Disk (Hipper) 6R-36 with Tractor (180-199 hp) MFWD 190	9.6	1	0.13	1.02	$ 1.59	$ 4.91
Plant - Rigid 6R-36 with Tractor (120-139 hp) 2WD 130	9.5	1	0.13	0.70	$ 1.72	$ 4.81
Fert Appl (Liquid) 6R-36 with Tractor (120-139 hp) 2WD 130	9.2	1	0.14	0.73	$ 1.81	$ 3.83
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	1	0.04	0.19	$ 0.33	$ 0.79
Total Preharvest Values			0.70	4.72	$ 10.66	$ 29.48

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header - Corn 6R-36 with Combine (200-249 hp) 240 hp	6.5	1	0.19	1.90	$ 6.22	$ 33.03
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.28	$ 3.43
Total Harvest Values			0.31	2.53	$ 7.49	$ 36.46

E. Adjustment to base UGA corn budget by row type and seeding rate 2012-2014 Blairsville, GA for the study "ROW PATTERN, ROW SPACING, AND SEEDING RATE IN FIELD CORN (*Zea mays* L.)"

Treatment	1 Single 76-cm Low	2 Single 76-cm Medium	3 Single 76-cm High	4 Single 91-cm Low	5 Single 91-cm Medium	6 Single 91-cm High	7 Twin 91-cm Low	8 Twin 91-cm Medium	9 Twin 91-cm High
Preharvest									
Seed Cost	30.80	49.72	77.37	32.82	55.98	73.22	35.53	50.40	76.93
Fertilizer	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33	58.33
Weeds	13.13	13.13	13.13	13.13	13.13	13.13	13.13	13.13	13.13
Fuel	-2.23	-2.23	-2.23	-4.00	-4.00	-4.00	-3.46	-3.46	-3.46
R&M	-1.93	-1.93	-1.93	-3.52	-3.52	-3.52	-2.46	-2.46	-2.46
Fixed Costs	-6.27	-6.27	-6.27	-10.54	-10.54	-10.54	-7.31	-7.31	-7.31
Harvest									
Fuel	-1.15	-1.15	-1.15	-2.18	-2.18	-2.18	-2.18	-2.18	-2.18
R&M	-0.09	-0.09	-0.09	-1.27	-1.27	-1.27	-1.27	-1.27	-1.27
Fixed Costs	3.04	3.04	3.04	-3.43	-3.43	-3.43	-3.43	-3.43	-3.43
Labor	-0.75	-0.75	-0.75	-2.50	-2.50	-2.50	-2.19	-2.19	-2.19
VC	160.77	180.99	210.52	154.76	179.49	197.91	159.62	175.51	203.85
FC	137.83	139.86	142.81	126.49	128.97	130.81	130.21	131.80	134.63

Note: Input costs were averaged over 2012, 2013, and 2014

F. REFERENCE FOR CALCULATING FIELD EFFICIENCY OF OPERATIONS

Table 3 – Field efficiency, field speed, and repair and maintenance cost parameters - part of http://ag.arizona.edu/crops/equipment/agmachinerymgt.html

	Field efficiency		Field speed				Estimated life	Total life R&M cost
Machine	Range %	Typical %	Range mph	Typical mph	Range km/h	Typical km/h	h	% of list price
TRACTORS								
2 wheel drive & stationary							12 000	100
4 wheel drive & crawler							16 000	80
TILLAGE & PLANTING								
Moldboard plow	70–90	85	3.0–6.0	4.5	5.0–10.0	7.0	2 000	100
Heavy-duty disk	70–90	85	3.5–6.0	4.5	5.5–10.0	7.0	2 000	60
Tandem disk harrow	70–90	80	4.0–7.0	6.0	6.5–11.0	10.0	2 000	60
(Coulter) chisel plow	70–90	85	4.0–6.5	5.0	6.5–10.5	8.0	2 000	75
Field cultivator	70–90	85	5.0–8.0	7.0	8.0–13.0	11.0	2 000	70
Spring tooth harrow	70–90	85	5.0–8.0	7.0	8.0–13.0	11.0	2 000	70
Roller-packer	70–90	85	4.5–7.5	6.0	7.0–12.0	10.0	2 000	40
Mulcher-packer	70–90	80	4.0–7.0	5.0	6.5–11.0	8.0	2 000	40
Rotary hoe	70–85	80	8.0–14.0	12.0	13.–22.5	19.0	2 000	60
Row crop cultivator	70–90	80	3.0–7.0	5.0	5.0–11.0	8.0	2 000	80
Rotary tiller	70–90	85	1.0–4.5	3.0	2.0–7.0	5.0	1 500	80
Row crop planter	50–75	65	4.0–7.0	5.5	6.5–11.0	9.0	1 500	75
Grain drill	55–80	70	4.0–7.0	5.0	6.5–11.0	8.0	1 500	75
HARVESTING								
Corn picker sheller	60–75	65	2.0–4.0	2.5	3.0–6.5	4.0	2 000	70
Combine	60–75	65	2.0–5.0	3.0	3.0–6.5	5.0	2 000	60
Combine (SP)[1)]	65–80	70	2.0–5.0	3.0	3.0–6.5	5.0	3 000	40
Mower	75–85	80	3.0–6.0	5.0	5.0–10.0	8.0	2 000	150
Mower (rotary)	75–90	80	5.0–12.0	7.0	8.0–19.0	11.0	2 000	175
Mower-conditioner	75–85	80	3.0–6.0	5.0	5.0–10.0	8.0	2 500	80
Mower-conditioner (rotary)	75–90	80	5.0–12.0	7.0	8.0–19.0	11.0	2 500	100
Windrower (SP)	70–85	80	3.0–8.0	5.0	5.0–13.0	8.0	3 000	55
Side delivery rake	70–90	80	4.0–8.0	6.0	6.5–13.0	10.0	2 500	60
Rectangular baler	60–85	75	2.5–6.0	4.0	4.0–10.0	6.5	2 000	80
Large rectangular baler	70–90	80	4.0–8.0	5.0	6.5–13.0	8.0	3 000	75
Large round baler	55–75	65	3.0–8.0	5.0	5.0–13.0	8.0	1 500	90
Forage harvester	60–85	70	1.5–5.0	3.0	2.5–8.0	5.0	2 500	65
Forage harvester (SP)	60–85	70	1.5–6.0	3.5	2.5–10.0	5.5	4 000	50
Sugar beet harvester	50–70	60	4.0–6.0	5.0	6.5–10.0	8.0	1 500	100
Potato harvester	55–70	60	1.5–4.0	2.5	2.5–6.5	4.0	2 500	70
Cotton picker (SP)	60–75	70	2.0–4.0	3.0	3.0–6.0	4.5	3 000	80
MISCELLANEOUS								
Fertilizer spreader	60–80	70	5.0–10.0	7.0	8.0–16.0	11.0	1 200	80
Boom-type sprayer	50–80	65	3.0–7.0	6.5	5.0–11.5	10.5	1 500	70
Air-carrier sprayer	55–70	60	2.0–5.0	3.0	3.0–8.0	5.0	2 000	60
Bean puller-windrower	70–90	80	4.0–7.0	5.0	6.5–11.5	8.0	2 000	60
Beet topper/stalk chopper	70–90	80	4.0–7.0	5.0	6.5–11.5	8.0	1 200	35
Forage blower							1 500	45
Forage wagon							2 000	50
Wagon							3 000	80

[1)] SP indicates self-propelled machine.

G. EIGHT-ROW SINGLE-ROW PLANTER AVERAGE ANNUAL OWNERSHIP COSTS

8 Row Single			
2015 Value	42500.00	$	
Fuel Cost	3.5	$/gal	
Ins. Coverage	0.8		
Ins. Premium	0.005		
Interest	0.07		
Labor	12	$/hr	
X (Depreciation Coefficent)	1.2		
Mechanical Lifetime	1500	hrs	
Annual Hours	157	hrs/yr	
Mechanical Lifetime	9.00	yrs	
Power Requirement as PTO	187	hp	
Tractor Used as PTO	190	hp	
% Loading	98.4		
Fuel Efficency	14.94	hp-hr/gal	
SFC	0.067	gal/hp-hr	
Fuel Consumption Rate	12.517	gal/hr	
Annual Fuel	1965.20	gal/yr	
RF1	0.32		
RF2	2.1		

End of Year	Remaining Value	Depreciation	Interest	Shelter	Insurance	Fuel	Lube	AccHrs	AccRepair	Annual Repairs	Labor	Total Annual Costs
0	42,500.00											
1	36,833.33	5666.67	396.67	637.50	170.00	6878.21	687.82	157	278.57	278.57	1884	16,599.44
2	31,922.22	4911.11	343.78	552.50	147.33	6878.21	687.82	314	1194.24	915.67	1884	16,320.43
3	27,665.93	4256.30	297.94	478.83	127.69	6878.21	687.82	471	2798.23	1603.99	1884	16,214.78
4	23,977.14	3688.79	258.22	414.99	110.66	6878.21	687.82	628	5119.81	2321.59	1884	16,244.28
5	20,780.18	3196.95	223.79	359.66	95.91	6878.21	687.82	785	8180.22	3060.41	1884	16,386.75
6	18,009.49	2770.69	193.95	311.70	83.12	6878.21	687.82	942	11996.26	3816.03	1884	16,625.53
7	15,608.23	2401.27	168.09	270.14	72.04	6878.21	687.82	1099	16581.89	4585.63	1884	16,947.20
8	13,527.13	2081.10	145.68	234.12	62.43	6878.21	687.82	1256	21949.12	5367.23	1884	17,340.60
9	11,723.51	1803.62	126.25	202.91	54.11	6878.21	687.82	1413	28108.49	6159.36	1884	17,796.29
										Total Costs Over Lifetime		$150,475.30
										Salvage Value at End of Life		$11,723.51
										Total Costs Less Salvage		$138,751.78
										Average Annual Cost		$15,416.86

H. EIGHT-ROW TWIN-ROW PLANTER AVERAGE ANNUAL OWNERSHIP COSTS

8 Row Twin			
2015 Value	67500.00	$	
Fuel Cost	3.5	$/gal	
Ins. Coverage	0.8		
Ins. Premium	0.005		
Interest	0.07		
Labor	12	$/hr	
X (Depreciation Coefficent)	1.2		
Mechanical Lifetime	1500	hrs	
Annual Hours	157	hrs/yr	
Mechanical Lifetime	9.00	yrs	
Power Requirement as PTO	187	hp	
Tractor Used as PTO	190	hp	
% Loading	98.4		
Fuel Efficency	14.94	hp-hr/gal	
SFC	0.067	gal/hp-hr	
Fuel Consumption Rate	12.517	gal/hr	
Annual Fuel	1965.20	gal/yr	
RF1	0.32		
RF2	2.1		

End of Year	Remain. Value	Depreciation	Interest	Shelter	Insurance	Fuel	Lube	AccHrs	AccRepair	Annual Repairs	Labor	Total Annual Costs
0	67,500.00											
1	58,500.00	9000.00	630.00	1012.0	270.00	6878.2	687.82	157	442.43	442.43	1884	20,804.96
2	50,700.00	7800.00	546.00	877.50	234.00	6878.2	687.82	314	1896.73	1454.30	1884	20,361.84
3	43,940.00	6760.00	473.20	760.50	202.80	6878.2	687.82	471	4444.24	2547.51	1884	20,194.05
4	38,081.33	5858.67	410.11	659.10	175.76	6878.2	687.82	628	8131.47	3687.23	1884	20,240.90
5	33,003.82	5077.51	355.43	571.22	152.33	6878.2	687.82	785	12992.12	4860.65	1884	20,467.17
6	28,603.31	4400.51	308.04	495.06	132.02	6878.2	687.82	942	19052.88	6060.76	1884	20,846.41
7	24,789.54	3813.78	266.96	429.05	114.41	6878.2	687.82	1099	26335.94	7283.06	1884	21,357.30
8	21,484.27	3305.27	231.37	371.84	99.16	6878.2	687.82	1256	34860.37	8524.43	1884	21,982.10
9	18,619.70	2864.57	200.52	322.26	85.94	6878.2	687.82	1413	44642.89	9782.52	1884	22,705.84
										Total Costs Over Lifetime		$188,960.58
										Salvage Value at End of Life		$18,619.70
										Total Costs Less Salvage		$170,340.88
										Average Annual Cost		$18,926.76

I. BASE UGA CONVENTIONAL IRRIGATED PEANUT ENTERPRISE BUDGET[1]

Irrigated Peanut
6-Row Equipment
South Georgia, 2015

Estimated Costs and Returns

Variable Costs	Unit	Amount	$/Unit	Cost/Acre	$/ton
Seed	pounds	150	$ 0.70	$ 105.00	$ 44.68
Inoculant	pounds	5	$ 1.60	$ 8.00	$ 3.40
Lime/Gypsum	ton	0.5	$ 104.00	$ 52.00	$ 22.13
Fertilizer					
Boron	pounds	0.5	$ 4.50	$ 2.25	$ 0.96
Phosphate	pounds	0	$ 0.43	$ -	$ -
Potash	pounds	0	$ 0.41	$ -	$ -
Weed Control	acre	1	$ 44.30	$ 44.30	$ 18.85
Handweeding	acre	1	$ 7.50	$ 7.50	$ 3.19
Insect Control	acre	1	$ 46.20	$ 46.20	$ 19.66
Scouting	acre	1	$ 10.00	$ 10.00	$ 4.26
Disease Control	acre	1	$ 74.67	$ 74.67	$ 31.77
Preharvest Machinery					
Fuel	gallon	9.2	$ 2.90	$ 26.77	$ 11.39
Repairs and Maintenance	acre	1	$ 18.72	$ 18.72	$ 7.97
Harvest Machinery					
Fuel	gallon	7.9	$ 2.90	$ 22.87	$ 9.73
Repairs and Maintenance	acre	1	$ 26.22	$ 26.22	$ 11.16
Labor	hours	2.5	$ 12.00	$ 30.16	$ 12.83
Irrigation	applications	6	$ 10.35	$ 62.10	$ 26.43
Crop Insurance	acre	1	$ 21.00	$ 21.00	$ 8.94
Land Rent	acre	1	$ -	$ -	$ -
Interest on Operating Capital	percent	$ 278.88	6.5%	$ 18.13	$ 7.71
Cleaning	ton	0.8	$ 20.00	$ 15.51	$ 6.60
Drying	ton	1.6	$ 30.00	$ 47.24	$ 20.10
Marketing	ton	2.4	$ 3.00	$ 7.05	$ 3.00
NPB Checkoff	dollars	$ 0.01	834	$ 8.34	$ 3.55
Total Variable Costs:				**$ 654.03**	**$ 278.31**

[1]Smith, N.B. 2015. www.agecon.uga.edu/extension/budgets/index.html

Fixed Costs

	Machinery Depreciation, Taxes, Insurance and Housing								
Preharvest Machinery	acre		1	$	54.18	$	54.18	$	23.06
Harvest Machinery	acre		1	$	79.62	$	79.62	$	33.88
Irrigation	acre		1	$	125.00	$	125.00	$	53.19
General Overhead	% of VC	$ 654.03			5%	$	32.70	$	13.92
Management	% of VC	$ 654.03			5%	$	32.70	$	13.92
Owned Land Cost, Taxes, Cash Payment, etc.	acre		1	$	-	$	-	$	-
Other ___________________	acre		1	$	-	$	-	$	-
Total Fixed Costs						**$**	**324.20**	**$**	**137.96**
Total Costs Excluding Land						**$**	**978.23**	**$**	**416.27**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Heavy Disk 27' with Tractor (180-199 hp) MFWD 190	13.2	2	0.19	1.48	$ 3.62	$ 10.51
Plow 4 Bottom Switch with Tractor (180-199 hp) MFWD 190	2.3	1	0.54	4.20	$ 7.17	$ 21.63
Field Cultivate Fld 32' with Tractor (180-199 hp) MFWD 190	21.4	1	0.06	0.46	$ 0.99	$ 4.14
Plant & Pre-Rigid 6R-36 with Tractor (120-139 hp) 2WD 130	8.9	1	0.14	0.75	$ 2.10	$ 5.85
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	9	0.32	1.70	$ 2.94	$ 7.08
Total Preharvest Values			1.24	8.59	$ 16.82	$ 49.21

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Peanut Dig/Inverter 6R-36 with Tractor (180-199 hp) MFWD 190	5.3	1	0.23	1.83	$ 7.02	$ 16.05
Pull-type Peanut Combine 6R-36 with Tractor (180-199 hp) MFWD 190	3.3	1	0.38	2.99	$ 14.64	$ 51.49
Peanut Wagon 21' with Tractor (120-139 hp) 2WD 130	2.2	1	0.57	3.07	$ 4.56	$ 12.08
Total Harvest Values			1.19	7.88	$ 26.22	$ 79.62

J. Adjustment to base UGA peanut budget by row type and cultivar 2008–2010 for the study “ROW PATTERN, ROW SPACING, AND SEEDING RATE IN PEANUT (*Arachis hypogaea* L.)”

Treatment	1 Single 76-cm GA Green	2 Single 91-cm GA Green	3 Twin 91-cm GA Green	4 Single 76-cm C-99R	5 Single 91-cm C-99R	6 Twin 91-cm C-99R
Preharvest						
Seed Cost	-58.98	-60.62	-60.62	-39.30	-40.12	-40.12
Fertilizer	0	0	0	0	0	0
Weeds	46.62	46.62	46.62	46.62	46.62	46.62
Fuel	-11.24	-12.23	-12.23	-11.24	-12.23	-12.23
R&M	-7.83	-8.69	-8.69	-7.83	-8.69	-8.69
Fixed Costs	-22.18	-24.20	-24.20	-22.18	-24.20	-24.20
Harvest						
Fuel	0	0	0	0	0	0
R&M	0	0	0	0	0	0
Fixed Costs	0	0	0	0	0	0
Labor	-5.38	-6.01	-6.01	-5.38	-6.01	-6.01
VC	-36.81	-40.93	-40.93	-17.13	-20.43	-20.43
FC	-22.18	-24.20	-24.20	-22.18	-24.20	-24.20

Note: Input costs were averaged over 2008–2010.

K. Adjustment to base UGA peanut budget by row type and seeding rate 2014 for the study "ROW PATTERN, ROW SPACING, AND SEEDING RATE IN PEANUT (*Arachis hypogaea* L.)"

Treatment	1	2	3	4	5	6	7	8	9	10	11	12
	Single	Single	Single	Single	Single	Single	Single	Single	Twin	Twin	Twin	Twin
	76-cm	76-cm	76-cm	76-cm	91-cm	91-cm	91-cm	91-cm	91-cm	91-cm	91-cm	91-cm
	14	17	20	23	14	17	20	23	17	20	23	27
Preharvest												
Seed Cost	-55.76	-40.84	-27.87	-1.72	-71.46	-59.04	-41.92	-26.43	-58.86	-41.92	-26.43	-5.90
Fertilizer	0	0	0	0	0	0	0	0	0	0	0	0
Weeds	46.62	46.62	46.62	46.62	46.62	46.62	46.62	46.62	46.62	46.62	46.62	46.62
Fuel	-11.24	-11.24	-11.24	-11.24	-12.23	-12.23	-12.23	-12.23	-12.23	-12.23	-12.23	-12.23
R&M	-7.83	-7.83	-7.83	-7.83	-8.69	-8.69	-8.69	-8.69	-8.69	-8.69	-8.69	-8.69
Fixed Costs	-22.18	-22.18	-22.18	-22.18	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90
Harvest												
Fuel	0	0	0	0	0	0	0	0	0	0	0	0
R&M	0	0	0	0	0	0	0	0	0	0	0	0
Fixed Costs	0	0	0	0	0	0	0	0	0	0	0	0
Labor	-5.38	-5.38	-5.38	-5.38	-6.01	-6.01	-6.01	-6.01	-6.01	-6.01	-6.01	-6.01
VC	-33.59	-18.67	-5.70	20.45	-51.77	-39.35	-22.23	-6.74	-39.17	-22.23	-6.74	13.79
FC	-22.18	-22.18	-22.18	-22.18	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90	-24.90

Note: Input costs were averaged over 2014.