QUANTIFYING THE IMPACTS OF IN-FURROW FERTILIZER APPLICATIONS IN PEANUT AND MOWING REQUIREMENTS OF NEW ZOYSIAGRASS CULTIVARS FOR THE BENEFIT OF CROP AND URBAN STAKEHOLDERS IN THE SOUTHEASTERN UNITED STATES

by

MACIE WHEELER

(Under the Direction of Walter S. Monfort and Brian M. Schwartz)

ABSTRACT

With the recommendation of at-plant in-furrow inoculant, this has opened up doors for industry to recommend other in-furrow products. Due to minimal available information on these products, research was conducted in a bare-ground greenhouse and multiple locations across the peanut belt to evaluate the effects of these newly emerging products. All fertilizer rates slowed emergence across rating dates at all locations. All rating dates of the untreated check had higher emergence compared to all treatments. The application of in-furrow products negatively impacted stand, yield, and revenue.

Overall clippings were lower and turf cover was higher for the two experimental cultivars, 09-TZ-53-20 and 09-TZ-54-9 in the zoysiagrass trial. The rate of clipping increase in weeks 2-4 was higher for ‘Zenith’ than the other three cultivars. The decrease in turf cover was more drastic in ‘Zeon’ in weeks 2-4 than for the two experimental cultivars.

INDEX WORDS: peanut, in-furrow fertilizer, emergence, zoysiagrass, mowing frequency

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DEDICATION

For my fiancé, Wesley, family and friends who have always stood by my side and never stopped encouraging me to keep going. Additionally, Dr. Wayne Hanna for encouraging, mentoring, teaching, and guiding me seamlessly into this program. Without your support I would not have taken the leap.

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LITERATURE REVIEW

Peanut

Peanut (*Arachis hypogaea* L.) is a legumes food crop that fulfills its own nitrogen requirement through symbiosis with *Bradyrhizobia* spp. Peanut uses less water, chemicals, and natural resources while being a cheap source for high levels of oil, protein, and fiber. Different ways of human consumption include peanut butter, roasted peanuts, peanut oil, and other confectionary products (Naab, et al., 2004).

Peanuts are grown around the world in warm climates of Asia, Australia, and North and South America. China and India produce 60% of the world's peanuts, while only exporting 4% (Chamberlin et al., 2014). In 2019, the United States grew 5% of the worlds crop due to higher yields per hectare while only planting 2% of the hectarages (National Peanut Board, 2020). World peanut production totals about 45 million metric tons per year (National Peanut Board, 2020). The US leads the world in peanut exports and grows all peanut market types (Chamberlin et al., 2014). U.S. peanut exports for the year 2020 totaled 669,161 metric tons valued at $759.6 million, up by 43% compared to 2019. When converted back into farmer stock equivalent, 2020 exports reached 82,5630 metric tons (American Peanut Council, 2020).

In the U.S., peanuts are grown commercially in 13 states with Georgia, Florida, Alabama, Texas, being the top producers. Georgia ranks number one in the United States with nearly 50% of the total production (National Peanut Board, 2020). In 2020, Georgia farmers produced 53% or

1.487 metric tons of the peanuts grown in the United States. Peanuts are a $2 billion industry in the state of Georgia as 76 of 159 counties in Georgia grow peanuts for human and livestock consumption. Mitchel, Worth and Decatur counties were the top three counties in Georgia to produce certified peanut hectares in 2020 (Georgia Peanut Commission, 2020).

In the United States, there are four market-types of peanut grown: Runner, Virginia, Spanish and Valencia. Each of these types are distinctive in growth habit, size, and flavor (America Peanut Council, 2020). Since the 1970's, Runner market-type cultivars have become the dominant peanut type grown in the U.S., accounting for 90% of production (American Peanut Council, 2020). 'Georgia-06G', a popular variety grown in the state of Georgia, was introduced in 2006 offering tomato spotted wilt virus (TSWV) resistance, desirable pod shape, runner seed size, testa color, growth habit, maturity, high yield, and grade characteristics (Branch, 2007). Virginia market-type cultivars, have the largest kernels and are used for roasted peanuts and eaten as inshells (American Peanut Council, 2022). Spanish-type peanuts have smaller kernels with a reddish-brown skin and a high oleic content for peanut butter and crushing. Spanish and valencia make up the remaining 5% of production in the U.S.

A healthy stand establishment and yield potential start with influencing factors such as cultivars, germination, planting date, row pattern, and in-furrow decisions (Blackstone et al., 1954) (Navarro, 1989) (Prasad, 2006) (Tubbs et al., 2016) (Grey, 2017). A uniform and healthy plant stand is critical in defending against virus, disease and insects all season long while maximizing yield and profit (Tubbs et al., 2016) (Grey, 2017). The use of susceptible cultivars, early planting dates, failure to establish satisfactory plant populations, use of single row patterns and conventional tillage are factors that favor negative yield (Sarver et al., 2016). A peanut crop begins with seeds planted approximately 5 cm deep into the soil, with optimal moisture levels (30%), favorable soil temperatures (20◦C), and favorable oxygen supply of (>2%) (Kvien, 2019) (Tubbs, 2019). When these factors are favorable, seeds begin germination with water uptake and finish with the emergence of embryonic axis. Depending on environmental conditions, the seedling should begin to break through the soil surface around 6-11 days (Boote, 1982). Successful germination is achieved when the seedling emerges through the ground and the cotyledons appear just above the soil surface (Kvien, 2019). Vigorous seedlings are crucial for a peanut crop that is of high quality to produce optimal plant stands and high yields (Hurdle et al., 2020).

Planting date is critical in order to establish ample plant populations. Peanut germination will occur when soil temperatures are in the range of 20˚C to 35˚C at a depth of 10 cm (Hurdle, et al., 2020. Optimal growing conditions occur between air temperatures of 27˚C to 32˚C. Late April and early May will bring these optimal germination conditions for southern Georgia. Cooler soil temperatures result in smaller seedlings, lower plant populations, slower emergence rates, and increased thrips (*Frankliniella fusca* Hinds) population (Hurdle et al., 2020).

Cultural practices such as seeding rate and single or double row patterns are factors that can influence stand establishment. TSWV susceptibility will be heightened due to seeding rate but can be decreased by increasing planting populations (Sarver et al., 2013). Research showed that increasing the number of plants did not decrease the number of infected plants but reduced the percentage of infected plants (Sarver et al., 2013). Growers must utilize a seeding rate of 19.7 seed/m which will obtain 13.1 plants/m, which can be very costly to a grower (Sarver et al., 2013).

At planting, if a field has been out of peanut rotation for more than five years, inoculant should be included in the in-tank mixture to aid in the conversion of atmospheric nitrogen to a form utilized by the plant (Tubbs, 2019 and Abney et al., 2023). In addition to an inoculant, insecticide such as phorate is recommended for added thrips control. Pre-plant herbicides and fungicides will aid in pre-emergence and early-season control of weeds and diseases (Abney et al., 2023). With this addition of in-furrow inoculants and insecticides, industry has begun to recommend in-furrow fertilizer products with minimal data. Therefore, research to analyze these recommendations is justified.

Turfgrass

The United States turfgrass industry makes a significant contribution to the economy with an estimated $40 billion impact and covers 20,234,282 hectares in the United States (Waltz, 2020). According to the 2022 Farm Gate Value, 103,337 hectares of Georgia are in commercial sod production with a $126,430,568 impact, suggesting that it is one of the largest agricultural commodities in the state. It is estimated that 1.25 million acres of home lawns in Georgia are the largest segment of customers to the industry (Waltz, 2020).

New turfgrass cultivars that are bred for improved quality with fewer inputs may help homeowners and turf managers reduce inputs that will benefit them economically and environmentally. Zoysiagrass (*Zoysia* spp.) is a low maintenance, warm-season perennial grass adapted to a wide range of environments that is widely used throughout the transitional and warm climatic regions of the Southeastern United States (Patton et al., 2007). It is shade tolerant, but can be prone to disease susceptibility and increased irrigation needs. *Zoysia matrella* is indigenous to the Malaysian islands that is the result of a transfer from migrating peoples (Hanna et al., 2013). *Zoysia matrella* has been cultivated in China, Japan, and Korea for centuries. *Zoysia japonica* was introduced to the United States from Japan in 1902. The earliest herbarium is of Wilcox, collected in 1907, from Washington, D.C. *Zoysia japonica*, *Zoysia matrella*, and *Zoysia pacifica* have been used in the development of zoysiagrasses for turf in the United States. Zoysiagrass rapidly gained popularity upon the release of the cultivar ‘Meyer’ in the 1950’s because of its heat, freezing, and drought tolerance in the transition zone (Grau and Radko, 1952). Its growth habit forms a uniform, dense, and high-quality turf when best management practices are used. Due to Meyer’s minimal fertility requirements and slow growth, it has become a viable option for residential lawns, commercial landscapes, and golf courses in the transition zone (Hanna et al., 2013). Though newer zoysiagrasses can tolerate a wide range of soil conditions and pH’s, they do not tolerate water logged, poorly drained soil conditions (Hanna et al., 2013). In these situations, zoysisagrass is less likely to recover from injury in addition to abiotic and biotic stressors.

Bermudagrass (*Cynodon dactylon*), a warm-season, highly favorable and commonly used cultivar has been researched extensively on mowing requirements (Dorah, 2010; Grubbs et al., 2020; Joiner et al., 1962). Bermudagrass breeding efforts have developed favorable traits such as adaptation to decreased mowing heights, increased canopy density, improved quality and color, and cold tolerance (Burton, 1966 and Hanna et al., 2006). Mowing and plant growth regulators are a large part in the overall budget of managing high quality bermudagrass in home lawns to golf courses (Johnson, 1994). Plant growth regulators can suppress vegetative growth and seed heads of bermudagrass, therefore, directly reducing the amount of mowing (Johnson, 1994). Previous research shows that maintaining a mow height of >2.54 cm can improve ball lie which is how a golf ball rests in the turf canopy following a stroke (McCalla, 2007).

Centipedegrass (*Eremochloa ophiuroides* (Munro) Hack.) is a favorable low maintenance turfgrass suitable for the southeastern United States. It is adapted to low fertility, has slow shoot growth, and frequent mowing is not needed until mid-summer (Johnson, 1993). In centipedegrass studies, researchers found that mowing alone did not suppress seed heads consistently. A lower PGR application plus occasional mowing increased seed head suppression over PGR’s alone (Johnson, 1993). Mowing interval research has been done in cool-season grasses as well but do not apply to research done in Georgia but can be useful for researchers elsewhere. Tall fescue (*Festuca arundinace* Schred.) produces rapid growth during a 6-8-week period in early spring.

Plant growth regulators (PGR) are natural or synthetic compounds used to promote or inhibit plant growth and alter undesirable physiological factors. Plant growth regulators were introduced to reduce mowing frequencies. Studies showed that tall fescue not treated with PGR’s required more mowing than those that were treated (Johnson, 1993). In turf, PGR’s are typically used as growth inhibitors (Glab et al., 2020). PGR’s are used in turfgrass to slow vertical growth and reduce mowing frequency (Glab et al., 2020). Research on PGR’s and mowing intervals in turf is very prominent due to the cultural practices by golf course superintendents. Use of these products is often limited to commercial applicators and professional turfgrass managers like golf course superintendents and sports field managers due to the difficulty of application. Contrary to home lawns there is a developed interest in highway right-of-way programs for a PGR and scheduled mowing to reduce labor. For example, bahiagrass (*Paspalum notatum*) a widely used warm-season grass developed to poor soils, low fertility, and low rainfall requires frequent mowing due to its high seed head production (Goatley et al., 1998).

Fertilizers are often applied to improve the aesthetics of turfgrass by modifying the canopy to be darker green with higher shoot density. Urban soils in homeowner yards often require additional nitrogen (N) to meet these needs (Grubbs et al., 2021). Excessive N demands can have environmental consequences such as air and ground water contamination through leaching, and emission of greenhouse and ozone depleted gasses (Grubbs et al., 2021). Homeowners would benefit from the development of new cultivars with both lower mowing and fertility input needs.

Current research methods can take many years to quantify the mowing interval frequency needed for new turfgrass cultivars. Previous research on zoysiagrass management requirements have focused on responses to different mowing heights and fertility needs (Engelke 1991 and

1992) (Schwartz et al., 2018). Law stated that most homeowners do not follow the one-third rule in mowing practices but on schedule. The one-third rule is that grass blades should be cut at a time. on Law concluded, mowing more frequently results in a higher energy requirement and financial costs (Law et al., 2016). Yue conducted a study to determine if consumers are willing to pay more for low-input turfgrasses on residential lawns. Results from this study determined that maintenance requirements of cultivars greatly impact consumer demand (Yue et al., 2012). Mowing requirements were second in importance to consumers which helps researchers develop more low-input varieties (Yue et al., 2012). This study was initiated to determine whether newly developed zoysiagrasses can maintain acceptable turf cover and decreased clipping weights with extended mowing intervals.

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CHAPTER 2

EFFECT OF IN-FURROW FERTILIZER ON PEANUT (*Arachis hypogaea* L.) STAND IN OPTIMAL CONDITIONS

[1] Macie Wheeler, W.S. Monfort, L.C. Hand, X. Luo, L. Baxter, B.M. Schwartz. To be submitted to *Peanut Science*.

ABSTRACT

Peanut (*Arachis hypogaea* L.) is a N-fixing legume through symbiosis with *Bradyrhizobium* making a naturally sustainable food and forage crop. Uniform stands are important to reduce disease risk and sustain high yield potential in peanut production. In an effort to achieve this desired start to the growing season, industry has begun recommending in-furrow fertilizers at plant with minimal research available to support their recommendations. Therefore, the objective of this research is to determine the impact of in-furrow fertilizer on stand establishment. Several in-furrow fertilizers were analyzed, IF1 (7-17-3 + micronutrients), IF2 (1-0.5-1), and IF 3 (2-6-16) products were applied in-furrow and evaluated on peanut seed emergence. Preliminary trials were done in a bare-ground greenhouse at The University of Georgia Tifton Campus. The effects of IF1, IF2, IF3 at rates of 4.7, 9.4, 18.7, 28.1 l/ha respectively and an untreated control (0.0 l/ha) were evaluated on seed emergence and stand establishment over a 14-day period. At all dates, the untreated control had statistically higher emergence than all rates of fertilizer products applied in-furrow at $\alpha = 0.05$. Both 18.7 l/ha and 28.1 l/ha rates of in-furrow fertilizer products reduced stands up to 14 days after planting. In summary, the application of in-furrow fertilizer products negatively impacted peanut emergence over time and final peanut stand at 14 days after planting (DAP).

Introduction

Peanut is an important legume crop to the southeastern U.S. that uses less resources by fulfilling its own N-requirement through symbiosis with *Bradyrhizobia* spp. (Tubbs, 2016). Georgia leads production with around 52% of peanut production in the U.S., with Mitchell, Early, and Decatur counties leading GA production in the 2020-2021 growing season (NASS, USDA, 2022). Peanut seed is one of the highest input costs of peanut production in Georgia at an estimated cost of $1.76 to $1.87/kg. In order to maintain this high production rate, growers must start the growing season off with an adequate plant population and pest free conditions. Factors such as seed quality, planting time, soil temperature, air temperature, and soil moisture are just a few factors that will determine an adequate plant population (Blackstone et al., 1954; Prasad et al., 2006; Grey et al, 2017).

When these factors are favorable, seeds begin germination with water uptake and finish with the emergence of embryonic axis (Boote, 1982). Germination is considered successful when the seedling emerges through the ground and the cotyledons appear just above the soil surface. Peanut germination will occur when soil temperatures are in the range of 20˚C to 35˚C (Abney et al., 2019). Germinated peanut seedlings emerge from the soil within 6 to 14 days after planting depending on environmental temperatures (Canavar, 2010).

Late April and early May will often bring these optimal germination conditions for southern Georgia (Hurdle et al., 2020). Research has shown that planting in cooler soil temperatures can result in lower plant populations due to slower emergence rates, and increased risk of disease infection. (Hurdle et al., 2020). With that knowledge, the University of Georgia Extension recommends planting when soil temperatures have reached 20 ˚C on average for 3 consecutive days. Growers are recommended to use a seeding rate of 19.7 seed/m in an effort to obtain 13.1 plants/m which can be very costly to a grower (Culbreath et al., 2013, Sarver et al., 2016).

At planting, growers typically apply a fungicide on the seed and/or in-furrow, an insecticide to manage thrips, and an inoculant to aide in nitrogen fixation if needed (Tubbs et al., 2016; Abney et al., 2023). A field that has been out of peanut rotation for more than five years, an inoculant is recommended and applied at plant in-furrow with the seed to aid in the conversion of atmospheric nitrogen to a form utilized by the plant (Tubbs et al., 2016; The University of Georgia Extension, 2020). Inoculant formulations utilized in peanut are most popularly applied through a dry hopper box into the root zone at planting. Similar practices are seen if inoculants are used in soybeans (*Glycine max*) (Salvagiotti et al., 2013). With new innovations liquid inoculants have started to be used as well. With the adoption of liquid inoculants in peanuts, the opportunity for industry to recommend other in-furrow liquid products including fungicides, insecticides, and fertilizers has grown. Research has been conducted on the efficacy and safety of insecticides and fungicides applied as a liquid in-furrow with the seed (Culbreth et al., 2016; Tubbs et al., 2016). However, minimal research is available on liquid fertilizer products applied in-furrow.

The placement of fertilizer products has been tested in wheat (*Triticum aestivum*), soybeans (*Glycine max*), rapeseed (*Brassica napus*) and corn (*Zea mays*) via deep-banding, granules in furrow and broadcast (Boomsma et al., 2007; Freiling et al., 2022; Hansel et al., 2018; Quinn et al., 2020). Results from Boomsma et al. (2007) showed that deep-banding of phosphorus (P) and potassium (K) will not improve corn and soybean productivity or grower profitability under all circumstances. Freiling et al., (2022), found that deep banded phosphorous applications improved yield in wheat and corn. Rapeseed responded best to a banded application and soybean responded best to a broadcast application (Freiling et al., 2022). Overall, the placement of phosphorous was heavily influenced by site, year, and crop variety (Freiling et al., 2022). Hansel et al. (2018), discovered that approximately 9.8% of the studies showed higher yields in soybean when phosphorous was banded. The remaining 85.2% showed no response to fertilizer placement and soybean yield (Hansel et al., 2018). Quinn et al. (2020), discovered that fertilizer applied sub-surface in-furrow and banded applications in corn increased yield by 5.2% (Quinn et al., 2020). Results were inconsistent on the effects of in-furrow fertilizer applications with other major row crops.

Therefore, the objective of this research was to assess response of peanut to liquid in-furrow fertilizer products. It is hypothesized that in-furrow fertilizer will improve stand establishment of peanut.

Materials and Methods

Greenhouse Experiments

Experiments were conducted in 2021 and 2022 in Tift County at The University of Georgia Tifton Campus (31.4505° N, 83.5085° W) in a bare ground greenhouse (Figure 2.1) composed of Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults). The experiment was conducted in a randomized complete block design with 8 replicates of the 8 treatments and untreated control. In 2021, GA-07W (Branch and Brenneman, 2008) was planted and in 2022 GA-06G (Branch, 2007) was planted. Peanuts used in this experiment were treated with Dynasty PD (azoxystrobin plus fludioxonil plus mefenoxam, Syngenta Crop Protection, Greensboro, NC) fungicide seed treatment. Peanuts were planted on 18 February 2021, 11 March 2021, 15 March 2022, and 29 March 2022.

Greenhouse preparations for all experiments included hand ploughing followed by levelling with rakes and thoroughly watered. Plots were 60.96 cm long by 30.48 cm wide. Seed was planted at a rate of 19.7 seed/m and at a depth of 5 cm deep. Treatments consisted of a) 4.7 b) 9.4, c) 18.7, d) 28.1 l/ha of a liquid fertilizer with a 7-17-3 formulation (IF1) (“Riser”, Nutrien Ag Solutions, Loveland, Colorado), a 1-0.5-1 formulation (IF2) (“Blastoff”, Success Nutrients, Denver, Colorado), 2-6-16 formulation (IF3) (“PlayMaker”, Nachurs Alpine Solutions, Marion, Ohio) and an untreated control (0.0 l/ha) were applied overtop of the seed prior to furrow closure (Figure 2.2). Rates were based off of industry recommendations and product label. In 2021, IF1, IF2, and an untreated control were tested. In 2022, IF1, IF3, and an untreated control were tested. Each product was tested individually of each other therefore treatments were not compared to each other in the regression analysis with an $\alpha = .05$.

The change in IF2 to IF3 in 2022 was due to the product being unavailable for peanuts, therefore a similar product was selected for evaluation. All treatments were mixed and applied with water at a carrier volume of 65 l/ha.

Treatments were applied by hand with a 5mL syringe at 1.8 mL/m calibrated based off 65.6 L/ha carrier volume. Heaters were turned onto ensure soil temperatures were above 20 ˚C which is what soil temperature is recommended for adequate germination and emergence. Plots were watered as needed to prevent wilting. Stand counts were accessed from 6 to 14 DAP. After the 14-day assessment the trial was terminated all seed and plants were exterminated. Soil was prepped and trial was repeated for a 2nd run.

Statistical Analysis

Data was analyzed in SAS version 9.4 using the PROC GLIMMIX function (SAS 9.4, SAS Institute Inc, Cary, NC) with $\alpha = 0.05$. with rate, run, and treatment by run interaction tested for each fertilizer. Run-by-treatment interactions were not significant; therefore, data were pooled across each run for the individual fertilizer products. Year-by-treatment interactions were tested and were not significant for IF1, therefore, the data were pooled for both years.

Runs and replications were considered random effects. Due to the change in availability of IF2 in 2022, all fertilizer products were analyzed individually for each year except for IF1 which was combined across years. An analysis of variance (ANOVA) was used for treatment evaluations at

6, 10, and 14 DAP for percent emerged plants. Means of significant difference were separated using Tukey Kramer least significant difference (LSD) at α = 0.05 probability level. Regression analysis was performed using SAS sigmoidal regression (SAS Institute Inc., Cary, NC) to determine if IF1, IF2, and IF3 could be described using equation,

$$y = \frac{a}{I + e\,\frac{(DAP - \ xO)}{b}}$$

In this equation, y is the percent emergence, α is the upper limit, b is the slope, and x0 is the inflection point. Data for the equations were subjected to an ANOVA using the general linear mixed model procedure with mean separation using 95% asymptotic confidence intervals. Data were then graphed in Sigmaplot 15 (Systat Software, San Jose, CA).

Results and Discussion

Visual assessments allowed the conclusion that in the untreated plots peanut seeds were seen to germinate and produce healthy seedlings at 14-days after planting (Figure 2.3) whereas, seeds with the fertilizer applied in-furrow tended to have burned or damaged seed coats on non-emerged seeds and young seedlings extracted from the soil at 14-DAP (Figure 2.4). Peanut seed has three parts testa, embryo, and endosperm (Wan et al., 2016). Rapid cotyledon growth in peanut can cause seed-coat (testa) cracking and the seed becomes more vulnerable to external factors (Wan et al., 2016). Contrary to soybean that has an outermost cuticle that protects the seed from external factors while emerging uniformly (Shao, 2007). Due to the thin seed coat on peanut, products in-furrow need to be minimally harmful to the seed.

In examining the emergence of the peanut seed over the 14-day period using the regression analysis, there was a decreasing amount of emergence with increasing amounts of fertilizer observed for all fertilizer products. Based on the data across all of the rating dates, the upper limit or maximum percent emergence for 18.7 l/ha, and 28.1 l/ha was significantly lower than the 0.0 l/ha treatments for both IF1 and IF3 (Table 2.1). IF2 significantly reduced the upper limit of percent emergence at 4.7 l/ha and 9.4 l/ha compared to the 0.0 l/ha. The higher rates of the fertilizer for IF2 were not significant due to the level of variability observed. However, the trends of lower maximum percent emergence were the same as the IF1 and IF3 (Table 2.1). The slope (rate of emergence) was not significantly different among the fertilizer rates for either product except for the 4.7 l/ha and 9.4 l/ha which was lower compared to the 0.0 l/ha for IF1 across the evaluation period.

Table 2.1 represents each fertilizer treatment: IF1 (7-17-3+micros) in 2021 and 2022, IF2 (1-0-0.5-1) 2021, and IF3 (2-6-16) in 2022 across 6, 10, and 14 DAP to show the beginning, middle, and end of stand evaluations. There were no significant differences in stand at 6 DAP for either product; although, you can see stand decreases as treatment rate increases. The two highest rates of IF1(18.7 and 28.1 l/ha) at 10 DAP, which was the suggest rate by industry, had significantly lower emerged plants than all other treatments (Table 2.2). This trend continues through 14 DAP, where 0.0 l/ha had greater emergence than 18.7 l/ha 28.1 l/ha (Table 2.1). For IF2 (1-0.5-1), trends remain similar to IF1 with all rates significantly lower in percent emergence compared to the 0.0 l/ha at 10 DAP with the 9.4, 18.7 and the 28.1 l/ha treatments being significantly lower than the 0.0 l/ha at 14 DAP (Table 2.1). IF3 (2-6-16) follows a similar trend to IF1 and IF2 although the impacts on stand were not as significant across the rating dates (Table 2.2). Though stands were not as significant at the other products, emergence still decreased as rates of IF2 increased (Table 2.2). The 28.1 l/ha was the only rate of IF3 that significantly impacted percent emerged plants compared to the 0.0 l/ha at 10 and 14 DAP (Table 2.2). At 14 DAP, the 0.0 l/ha treatment had 16.5% greater emerged plants than 28.1 l/ha treatment (Table 2.2).

In examining the regression analysis for each fertilizer product, the results showed increasing rates of IF1 (7-17-3) resulted in a decreasing level in stand establishment (Figure 2.5) from 6-14 days after planting. The results showed 0.0 l/ha had quicker initial percent emergence and reached maximum emergence all the fertilizer treatments. Around 8-10 DAP 0.0 l/ha hit its peak emergence and began to level off. The 4.7 l/ha and 9.4 l/ha treatments followed this same trend although it did take them a few days longer to initiate emergence. The 18.7 and 28.1 l/ha took longer to initiate emergence and only reached 65 and 47 percent emergence, respectively over the 14-Day evaluation period.

Regression analysis for IF2 (1-0.5-1) at 4.7, 9.4, 18.7, and 28.1 l/ha to a known untreated control (0.0 l/ha) showed increasing the rate of fertilizer from 0.0 to 28.1 l/ha resulted in a decreasing level in stand establishment from 6-14 days after planting in 2021 (Figure 2.6). The 0.0 l/ha hit its peak emergence between 8-10 DAP and plateaued to 83% emergence on the last rating date of 14 DAP. All other treatments followed this same trend but did not start emerging until 8 DAP with max emergence lagging behind the 0.0 l/ha treatment (Figure 2.6). The Upper limit or maximum percent emergence for IF2 at the 4.7 l/ha, 9.4 l/ha, 18.7 l/ha, 28.1 l/ha were 69.7, 61.1, 40.6, and 35.5, respectively.

Like with IF1 and IF2, the regression analysis for IF3 (2-6-16) showed that increasing rates of the fertilizer resulted in a decreasing level of stand establishment (Figure 2.7) from 6-14 days after planting compared to the 0.0 l/ha in 2022. Although the response to IF3 was still significant at the higher rates, it was noted there was not as drastic of differences between treatments as compared to IF1 and IF2.

Prior to planting, seed quality is an on-going issue for peanut production in Georgia. Seed quality is an issue due to the indeterminate growth habit and continuous flowering of peanut (Song et al., 2022). Plant performance throughout the growing season transfers into the plants seed production which then progresses to the next growing season (Song et al., 2022). Results from Song et al. (2022) showed that plants produced from mature seed had increased emergence than plants produced from immature seed. Offspring seed was also affected, plants produced from immature seed had 9.91% less mass and mature pods formed later in plant development (Song et al., 2022). The use of mature seeds that are of good quality will give growers a foot-forward are on factors that are present in early season production.

In peanut, a serious problem is tomato spotted wilt, caused by thrips (*Frankliniella fusca* Hinds)-vectored with tomato spotted wilt virus (Srinivasan, 2018; LaTora, 2022). Stand establishments with 13 or more plants/m of row with varieties of moderate TSWV is recommended (Culbreath et al., 2013). Growers typically plant 19 seed/m of row to achieve the goal of 13 seed/m (Culbreath et al., 2013). Reducing seeding rate would greatly benefit growers without increased TSWV incidence. Although, if a grower used a seeding rate of 19 seed/m of row with in-furrow fertilizer it could be equal to using a lower seeding rate and increasing TSWV incidence. To combat TSWV a combination of practices must be used: cultivar selection, planting date, seeding rate, and row pattern (Culbreath et al., 2016). Due to the combination of tactics that have to be used in order to control TSWV, there is room for third-parties to include products such as liquid in-furrow fertilizers into a grower’s program. From this research, these products are shown to contradict seeding rates that growers may implement by decreasing stand establishment.

Studies done by Dona et al. (2020), granular starter fertilizer was tested in-furrow on soybean, green pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.), black bean (*Phaseolus vulgaris* L.), small red lentils (*Lens culinaris* L.), and chickpea (*Cicer arietinum* L.) in trays to immolate field rows. Injury response for starter fertilizer of N, P, and S fertilizers was 1) lentil 2) pea 3) chickpea 4) soybean 5) black bean and 6) faba bean. Faba bean emergence was generally unaffected by all rates of N and showed little sensitivity to seed-row placement of fertilizer (Done et al., 2020). Though we did not test different legume crops in this experiment, this study proves that under certain conditions other legume crops will respond similarly fertilizer in seed-row to peanut.

Summary and Conclusions

The goal of this research was to evaluate the stand establishment of peanuts utilizing in-furrow fertilizer. Results from this study concluded in-furrow fertilizer was not applicable to improving peanut stand establishment. For both years across all fertilizer products, the untreated seed (0.0 l/ha treatment) reached greater than 80% emergence in 2021 and 2022 (Table 2.1). Furthermore, the untreated check had a higher percentage of emerged plants compared to a majority of the fertilizer treatments at the end of the 14-day evaluation.

Overall, all fertilizer products showed a decreasing rate and percent emergence as product rates were increased from 0.0 l/ha to 28.1 l/ha. The 18.7 l/ha and 28.1 l/ha rates of IF1, and IF2 significantly reduced final stand counts up to 14 DAP. IF3 had a similar but reduced effect on percent emergence when visually compared to IF1 and IF2. Although the regression model did not fit IF2 as it did for IF1 and IF3, the trends of reduced emergence as fertilizer rates increased remained the same.

This study indicates the application of fertilizers in-furrow with peanut seed can negatively impact their viability causing growers to have a loss of potential yield as a result of reduced plant populations and/or loss in revenue from having to replant to achieve optimum yields. Due to minimal research available on these products, growers can use these findings to determine the validity of in-furrow fertilizer in peanut.

Future research should be conducted to further determine the impact of in-furrow fertilizer on stand establishment and yield potential across the peanut growing areas. Finally, research is needed to assess if in-furrow fertilizer decreases the effectiveness of *Bradyrhizobia* spp. inoculant.

Figure 2.1. Bare-ground greenhouse immediately after closing furrows.

Figure 2.2. Furrows with 12 runner-market type peanut seed and 0.0, 4.7, 9.4, 18.7, and 28.1 l/ha of IF1 applied prior to furrow closure.

Figure 2.3. Peanut seedlings at 14 DAP from the 0.0 l/ha treatment.

Figure 2.4. Peanut seed and seedlings at 14 DAP showing damage caused by fertilizers applied in-furrow at planting.

Table 2.1. Impact of fertilizers applied in-furrow on percent emerged plants of runner market-type peanuts at 6, 10, and 14 days after planting (DAP) in Greenhouse trials in 2021 and 2022.

	IF1[1]			**IF2**[1]			**IF3**[1]		
	% Emerged Plants[2]			**% Emerged Plants**			**% Emerged Plants**		
Rate (l/ha)	6 DAP	10 DAP	14 DAP	6 DAP	10 DAP	14 DAP	6 DAP	10 DAP	14 DAP
0.0	10.4a[3]	79.9a	89.6a	2.1a	76.6a	87.0a	18.8a	89.9a	92.8a
4.7	10.9a	71.9a	84.1a	1.0a	51.8b	69.0ab	20.3a	83.9ab	92.6ab
9.4	7.6a	66.7a	80.5a	0.0a	33.1c	59.3bc	16.1a	81.7ab	86.4ab
18.7	5.5a	44.8b	62.0b	0.0a	15.7cd	43.2cd	13.0a	74.5ab	86.1ab
28.1	3.4a	27.6c	44.8c	0.0a	12.4d	29.1d	9.4a	68.3b	76.3b

Table Footnote. [1] IF1 = 7-17-3+micros (Riser, Nutrien, Loveland, CO); IF2 = 1-0.5-1 (Blastoff, Success Nutrients, Denver, CO) and IF3 = 2-6-16 (Playmaker, Nachurs Alpine Solutions, Marion, OH). [2] % emerged plants = number of peanut plants emerged out of 19.7 seed per m. [3] Means followed by the same letter in a column are not significantly different at a 0.05 probability level.

Table 2.2. Parameter estimates for peanut emergence over time in response to multiple rates of Riser, Blastoff, and Natures Playmaker applied in-furrow[a].

Rate (l/ha)	**a** **Upper Limit**	**b** **Slope**	**x^o** **Inflection Point**
		IF1[ab] (2021, 2022)	
0.0	88.134 (+/- 3.0043)	1.0116 (+/- 0.222)	7.1319 (+/- 0.2013)
4.7	85.4047 (+/- 6.3229)	1.6258 (+/- 0.5705)	7.3205 (+/- 0.4307)
9.4	82.7828 (+/- 7.64)	1.8240 (+/- 0.6753)	7.6665 (+/- 0.5003)
18.7	**64.6564 (+/- 11.9713)**	**2.2648 (+/- 1.4098)**	7.6846 (+/- 1.0202)
28.1	**46.8583 (+/- 34.3087)**	4.1830 (+/- 11.4655)	5.2541 (+/- 2.9706)
		IF2[c] (2021)	
0.0	83.5369 (+/- 3.9286)	0.8987 (+/- 2.732)	7.5655 (+/- 0.2553)
4.7	69.6882 (+/- 6.7191)	1.2762 (+/- 0.5491)	**8.4367 (+/- 0.4878)**
9.4	61.1361 (+/- 12.418)	1.6125 (+/- 0.9694)	**9.4800 (+/- 0.8922)**
18.7	**40.5905 (+/- 86.9095)**	5.7514 (+/- 46.4268)	**3.3466 (+/- 3.3858)**
28.1	35.4774 (+/- 146.6226)	7.7076 (+/- 117.7924)	0.3912 (+/- 2.8042)
		IF3[d] (2022)	
0.0	91.9869 (+/- 3.4467)	0.8926 (+/- 0.231)	6.8313 (+/- 0.2144)
4.7	92.0175 (+/- 3.6291)	1.0028 (+/- 0.2819)	6.6873 (+/- 0.2496)
9.4	87.7111 (+/- 5.8285)	1.2104 (+/- 0.5004)	6.8942 (+/- 0.4175)
18.7	84.0457 (+/- 7.1478)	**1.4467 (+/- 0.7967)**	6.6082 (+/- 0.6325)
28.1	**74.8914 (+/- 7.008)**	**1.1098 (+/- 0.7291)**	6.7616 (+/- 0.6396)

[a] Data are pooled over 2021 and 2022

[b] IF1 (7-17-3+micros) (Nutrient Ag Solutions, Loveland, CO)

[c] IF2 (1-0.5-1) (Success Nutrients, Denver, CO)

[d] IF3 (2-6-16) (Nachurs Alpine Solutions, Marion, OH)

$\pm CL_{95\%}$ confidence limit.

Where a is the upper limit, b is the slope, x^0 is the inflection point.

Values for each parameter within a column and cultivar that are bolded are significantly different from untreated control (0.0 l/ha) at $\alpha = 0.05$.

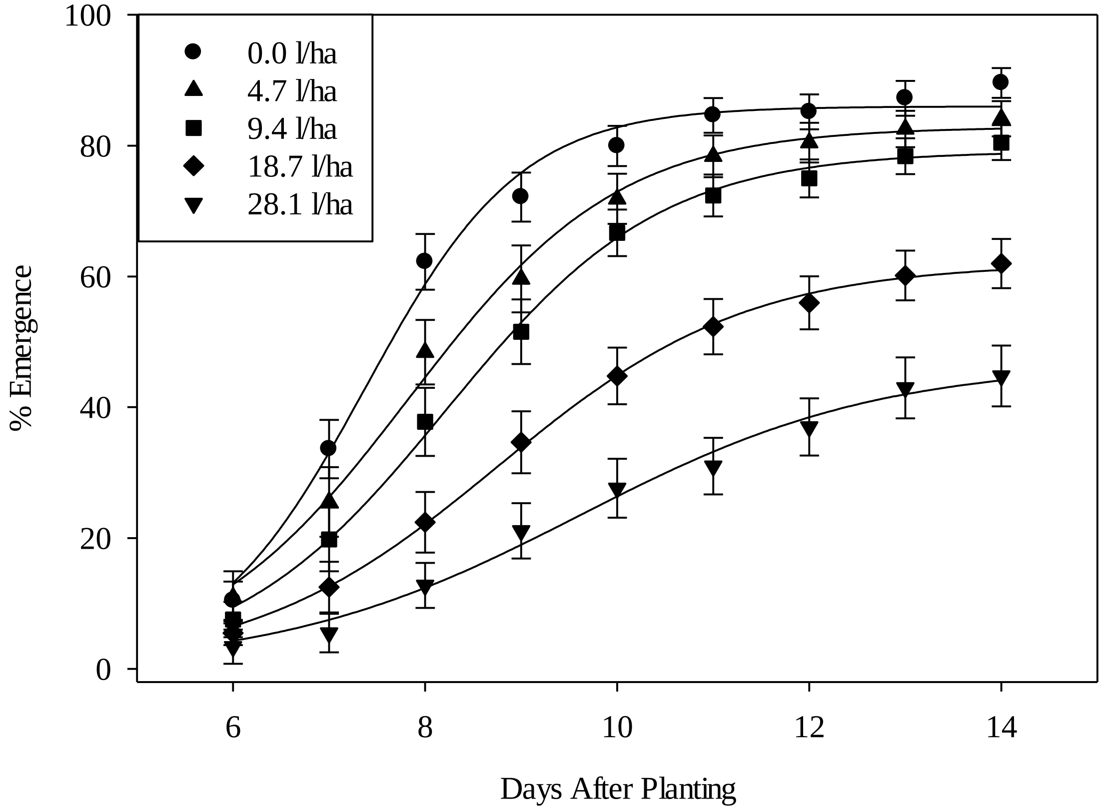

Figure 2.5. Impact of IF1 (7-17-3-micronutrients) (sold as Riser) on % Emergence in 2021 and 2022 across time by rate in Georgia using the equation

$$y = \frac{a}{I + e\frac{(DAP - xO)}{b}}$$

Sigmoidal regression was applied for days after planting. The lines represent the first-order regression equation for each treatment. Data points are the means of replications and bars indicate the SE of the mean. The models for each treatment represented are:

0.0 l/ha: $y = \frac{88.134}{I+e\frac{(DAP-7.1319)}{1.0116}}$ ($R^2 = 0.71$; $P < 0.001$)
4.7 l/ha: $y = \frac{85.4047}{I+e\frac{(DAP-7.3205)}{1.6258}}$ ($R^2 = 0.56$; $P < 0.001$)
9.4 L/ha: $y = \frac{82.7828}{I+e\frac{(DAP-7.6665)}{1.8240}}$ ($R^2 = 0.59$; $P < 0.001$)
18.7 l/ha: $y = \frac{64.6564}{I+e\frac{(DAP-7.6846)}{2.2648}}$ ($R^2 = 0.45$; $P < 0.001$)
28.1 l/ha: $y = \frac{46.8583}{I+e\frac{(DAP-5.2541)}{4.1830}}$ ($R^2 = 0.30$; $P < 0.001$)

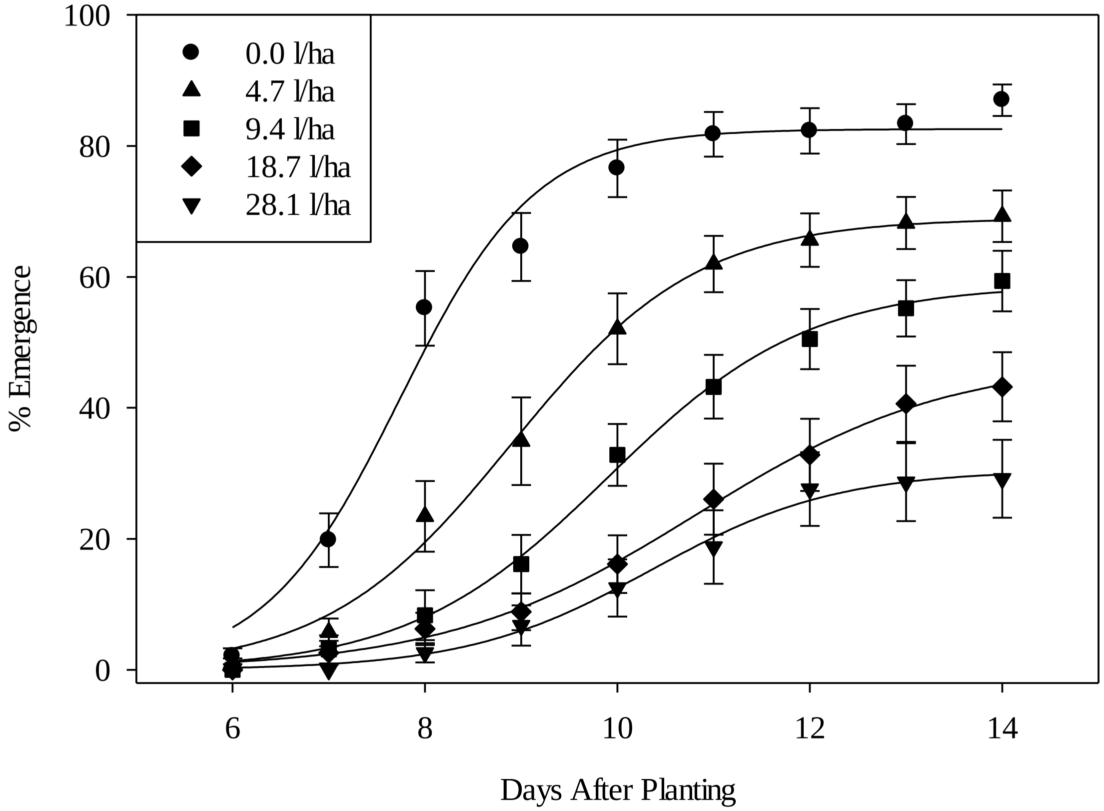

Figure 2.6. Impact of IF2 (1-0.5-1) (sold as BlastOff) on % Emergence in 2021 and 2022 across time by rate in Georgia using the equation,

$$y = \frac{a}{I + e\frac{(DAP - xO)}{b}}$$

Sigmoidal regression was applied for days after planting. The lines represent the first-order regression equation for each treatment. Data points are the means of replications and bars indicate the SE of the mean. The models for each treatment represented are:

0.0 l/ha: $y = \frac{83.5369}{I+e\frac{(DAP- 7.5655)}{0.8987}}$ ($R^2 = 0.79$; $P < 0.001$)
4.7 l/ha: $y = \frac{69.6882}{I+e\frac{(DAP- 8.4367)}{1.2762}}$ ($R^2 = 0.69$; $P < 0.001$)
9.4 l/ha: $y = \frac{61.1361}{I+e\frac{(DAP-9.4800)}{1.6125}}$ ($R^2 = 0.675$; $P < 0.001$)
18.7 l/ha: $y = \frac{40.5905}{I+e\frac{(DAP- 3.3466)}{5.7514}}$ ($R^2 = 0.44$; $P < 0.001$)
28.1 l/ha: $y = \frac{35.4774}{I+e\frac{(DAP- 0.3912)}{7.7076}}$ ($R^2 = 0.31$; $P < 0.001$)

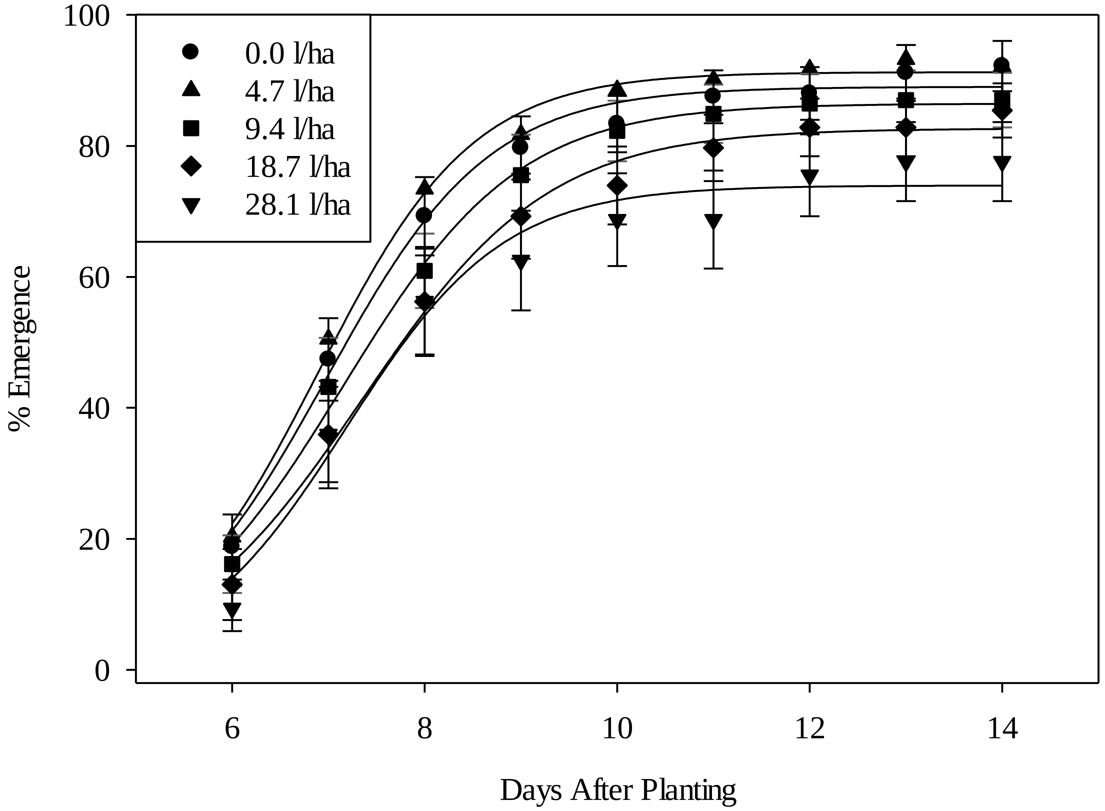

Figure 2.7. Impact of IF3 (2-6-16) (sold as Nachurs Playmaker) on % Emergence in 2021 and 2022 across time by rate in Georgia using the equation,

$$y = \frac{a}{I + e\frac{(DAP -\ xO)}{b}}$$

Sigmoidal regression was applied for days after planting. The lines represent the first-order regression equation for each treatment. Data points are the means of replications and bars indicate the SE of the mean. The models for each treatment represented are:

0.0 l/ha: $y = \frac{91.9869}{I+e^{\frac{(DAP-\ 6.8313)}{0.8926}}}$ ($R^2 = 0.71$; $P < 0.001$)
4.7 l/ha: $y = \frac{92.0175}{I+e^{\frac{(DAP-\ 6.6873)}{1.0028}}}$ ($R^2 = 0.70$; $P < 0.001$)
9.4 l/ha: $y = \frac{87.7111}{I+e^{\frac{(DAP-\ 6.8942)}{1.2104}}}$ ($R^2 = 0.57$; $P < 0.001$)
18.7 l/ha: $y = \frac{84.0457}{I+e^{\frac{(DAP-\ 6..6082)}{1.4467}}}$ ($R^2 = 0.51$; $P < 0.001$)
28.1 l/ha: $y = \frac{74.8914}{I+e^{\frac{(DAP-\ 6.7616)}{1.1098}}}$ ($R^2 = 0.40$; $P < 0.001$)

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CHAPTER 3

MULTI-STATE EXAMINATION OF STAND ESTABLISHMENT AND YIELD RESPONSE TO IN-FURROW FERTILIZER APPLICATIONS ON PEANUT (*Arachis hypogaea* L.)

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ABSTRACT

Peanut (*Arachis hypogaea* L.) is a N-fixing legume that if planted in early spring has poor seedling germination and stand establishment. Uniform stands are important to reduce disease risk and sustain high yield potential in peanut production. In an effort to achieve this desired start to the growing season, industry has begun recommending in-furrow fertilizers at plant with minimal research available to support their recommendations. Therefore, the objective of this research is to determine the impact of in-furrow fertilizer on stand establishment and yield. The liquid in-furrow products (7-17-3+micronutrients) (sold as Riser, Nutrien Ag Solutions, Loveland, CO) was applied in-furrow and was evaluated on peanut seed emergence and yield. Treatments consisted of IF1 at 4.7, 9.4, 18.7, 28.1 l/ha and an untreated control (0.0 l/ha). Trials were conducted across the peanut belt in Alabama, Arkansas, Georgia, Florida, Mississippi, New Mexico, North Carolina, South Carolina, Texas, and Virginia. Treatment responses were assessed up to five times once plants started emerging. At all dates, the untreated control had numerically higher emergence than all rates of the fertilizer. The higher rates of the fertilizer (18.7 l/ha and 28.1 l/ha) reduced final stand counts compared to the untreated control at $\alpha = 0.05$. The application of the fertilizer in-furrow at any rate did not increase yield over the untreated control. This data supports previous bare soil greenhouse research where the use of in-furrow fertilizer products delayed emergence and negatively impacted stand establishment.

Introduction

Peanut (*Arachis hypogaea L.*) is grown commercially in 13 states in the United States which includes Alabama, Arkansas, Florida, Georgia, Louisiana, Missouri, Mississippi, North Carolina, New Mexico, Oklahoma, South Carolina, Texas, and Virginia (National Peanut Board,

2022) (Anco et al., 2022; Auman et al., 2023; Balkcom et al., 2022; Balota et al., 2023; Baughman et al., 2018; Beck et ala, 2018; Burgess et al., 2019; Faske et al., 2022). In 2022, 85% of the US peanut (*Arachis hypogaea* L.) hectares were planted in the Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Texas, and Virginia (USDA, NASS). The United States accounts for 2% of hectarage of peanuts worldwide (National Peanut Board, 2022). Total U.S. production of peanuts in 2021 was, 2,902,991 metric tons from 643,450 hectares (USDA, NASS, 2021). The average yield in 2021 was 4,634 kg/ha (USDA, NASS, 2021).

There are four market-types of peanut grown in the United States: Runner, Virginia, Spanish and Valencia. Each of these types are distinctive in growth habit, size, and flavor (America Peanut Council, 2020). Since the 1970's, Runner market-type cultivars have become the dominant peanut type grown in the U.S. accounting for 85% of production (American Peanut Council, 2020). Fertility is an important component to ensure growers can achieve maximum yield potential and high-quality products. Fertilizer needs are determined by taking soil samples and having them tested by a licenced soil testing lab. Cooperating universities (Anco et al., 2022; Auman et al., 2023; Balkcom et al., 2022; Balota et al., 2023; Baughman et al., 2018; Beck et ala, 2018; Burgess et al., 2019; Faske et al., 2022) recommend the application of fertilizers as needed based on the soil sample results. In most situations, fertilizers (phosphorus and potassium) are applied to the soil prior to planting if needed.

Growers in Georgia are recommended to plant 19.7 seed/m (157 kg/ha) by UGA Extension (Abney et al., 2023) which comes out to be $1.99/kg and $275.65 per hectare. Due to the high input costs of peanut seed, decisions made at planting will be the foundation for a successful or detrimental growing season. With this in mind, peanut growers need to start the growing season with high quality seed to establish an adequate stand under pest free conditions (Boote, 1982) (Hurdle et al., 2020). Factors such as planting time, soil temperature, air temperature, and soil moisture are just a few factors that will determine an adequate stand (Boote, 1982; Prasad, 2006) (Grey, 2017; Hurdle et al, 2020). Canavar (2010), stated that adequate peanut germination will occur when soil temperatures are in the range of 20˚C to 35˚C at a depth of 10 cm for 3 consecutive days with adequate soil moisture.

The use of in-furrow fertilizers has been recommended by industry in multiple peanut producing states to enhance germination and emergence. The application of fertilizers in-furrow has not been a recommended practice by University Cooperative Extension for peanut and there is currently insufficient published research on its effects on the claimed improved emergence.

Studies have been done on the placement of fertilizer products in wheat (*Triticum aestivum*), soybeans (*Glycine max*), rapeseed (*Brassica napus*) and corn (*Zea mays*), green pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.), black bean (*Phaseolus vulgaris* L.), small red lentils (*Lens culinaris* L.), and chickpea (*Cicer arietinum* L.) via banding, deep-banding, granules in furrow and broadcast (Boomsma et al., 2007; Dona et al. 2020; Freiling et al., 2022; Hansel et al., 2018; Quinn et al., 2020). Banded applications are 5cm to the side and 5 cm below the seed before or at planting (Boomsma et al., 2007). Deep banded applications are utilized more in strip-till operations where fertilizer is placed 15 cm to the side and 15 cm below the seed (Boomsma et al., 2007). Broadcast fertilization is a widely used and cost-efficient practice that is widely used for high seeding and fertilization rates (Boomsma et al., 2007).

There is minimal research available on liquid in-furrow applications in peanut as well as other crops. One study by Dona et al., (2020), done in trays to mirror seed rows discovered that

Faba bean emergence was unaffected by all rates of N application and was not sensitive to fertilizer placement. In contrary, soybean and black bean emergence were the most responsive to fertilization and placement (Dona et al., 2020). Results from the following studies (Boomsma et al., 2007; Freiling et al., 2022; Hansel et al., 2018; Quinn et al., 2020) concluded that different fertilizer application practices should be utilized depending on crop, variety, tillage, location, and soil type. Across the peanut belt, there will be changes in all of these factors and growers should be prepared to make a sound decision based off their conditions.

In a recent study by Wheeler et al., (*to be published in Peanut Science*), the application of fertilizers in-furrow resulted in reduced peanut emergence. This study provided the first evidence that fertilizer can damage peanut seed when applied directly on the seed. Therefore, research was conducted in a multi-state field trial to further quantify the impacts of fertilizers applied in-furrow on stand establishment and determine yield response across the peanut belt.

Materials and Methods

Field Experiments

Experiments were conducted in 2021 and 2022 in dryland and/or irrigated fields in Alabama, Arkansas, Georgia, Florida, Mississippi, New Mexico, North Carolina, South Carolina, Texas and Virginia (Table 3.1) to evaluate stand establishment and yield response to the fertilizer 7-17-3+micronutrients (IF1) sold as Riser (Nutrien Ag Solutions, Colorado). Experimental design and university cooperation were similar to Studstill et al. (2020).

Small plot dimensions were 1.8 m wide and 7.1 to 9.1 m long. All experiments were randomized complete block design with 4 to 9 replicates. Fertilizer treatments were applied in a carrier volume of 93.5 l/ha. Treatments consisted of a) 0.0, b) 4.7, c) 9.4, d) 18.7, e) 28.1 l/ha of the liquid fertilizer, IF1. Treatments were applied on top of the seed prior to furrow closure. Peanut production management decisions were made based on individual University Cooperative Extension Service recommendations for the respective state (Anco et al., 2022; Auman et al., 2023; Balkcom et al., 2022; Balota et al., 2023; Baughman et al., 2018; Beck et ala, 2018; Burgess et al., 2019; Faske et al., 2022). Planting dates ranged from 21 April to 7 June (Table 3.1). Seed was planted at a depth of 5 cm and a seeding rate of 19.7 seed/m. Manual stand counts were collected in the field for one 6m section of the plot.

Locations collected manual stand counts once they began to observe initial plant emergence. Manual stand counts were assessed up to 5 times after initial emergence was observed. Emergence was likely delayed due to weather at some locations. Stand counts were converted to a percent emergence based on the number of seeds planted. Yield was collected at a majority of the locations between 18 September to 4 November (Table 3.1). These locations were Alabama, Arkansas, Florida (2022 only), Georgia, Mississippi, North Carolina, New Mexico, South Carolina, and Virginia. Peanuts were dug and inverted using the maturity profile board method (Williams and Drexler, 1981). Once inverted, plants were dried in windrows until 12-15% pod moisture was reached. Plots were harvested using a commercial peanut combine. Pod yield was adjusted to 7% moisture.

Gross and net values were calculated to determine the estimated economic impact of using IF1 (7-17-3+micros). Gross value refers to the pre-input cost deduction received, while the net value refers to the amount that remains after deductions have been made. Gross value was calculated by yield*market loan value of $321.985 per mt. Net value was determined by gross value (kg/ha) minus cost of product for each treatment.

Statistical analysis

Analysis of variance was conducted using the GLIMMIX procedure within SAS version 9.4 (SAS Institute, Cary, NC). Location (Table 3.1) was treated as a random effect in the statistical analysis to account for variability among locations and market-types grown. Repeated measures analysis was conducted for percent plant stand emergence. One-way ANOVA was conducted for yield and economic analysis. Appropriate means were separated with Tukey-Kramer's least square means test at $\alpha = 0.05$.

Results and Discussion

Stand establishment

Planting dates began to average across the peanut belt between 4 May and 26 May. According to Cooperative University Extension Production Guides, planting dates are recommended at all locations within this time frame. In examining the treatment effects of IF1 (7-17-3+micronutrients), 0.0 l/ha had the highest percent emergence rate across all rating dates (Table 3.2). Reduced rates of IF1 (7-7-3+micronutrients) at 4.7 l/ha and 9.4 l/ha slowed down emergence up to time 1 and time 2 (Table 3.2). The highest rates of IF1 (7-17-3+micronutrients), 18.7 and 28.1 l/ha, slowed emergence throughout all rating dates (Table 3.2).

At initial stand counts or time 1, 0.0 l/ha was greater than all other rates of IF1 (Table 3.2). All rates separated significantly at time 2, 0.0 l/ha remains at the highest rate of emergence while 28.1 l/ha remains the lowest (Table 3.2). These trends continue for time 3 (Table 3.2). At time 4, 4.7 l/ha and 9.4 l/ha begin to catch up with 0.0 l/ha though emergence is still less than (Table 3.2). 18.7 and 28.1 l/ha are significantly different from all other treatments at time 4 (Table 3.2). This trend continues to time 5, which is the final rating date (Table 3.2). At time 5, 4.7, 9.4, 18.7. and

28.1 l/ha are 1.1%, 4.1%, 12.5%, and 15.6% lower than 0.0 l/ha which is at 54.6% emergence (Table 3.2).

Yield, Gross Value, Net Value

The results showed the yield response from utilizing the fertilizer to increase stand establishment and yield was no different from the untreated control at the $\alpha = 0.05$ (Table 3.3). In examining the treatment effects of IF1 (7-17-3+micronutrients), the rate of 9.4 l/ha had the highest yield kg/ha but was not significantly different from 0.0 l/ha (Table 3.3). 28.1 l/ha rate of IF1 was the only rate that was significantly different from 0.0 l/ha (Table 3.2).

Gross value was highest at 4.7 l/ha but was only $1 higher than 0.0 L/ha (Table 3.3). Gross value went down as each rate increased, 28.1 l/ha was significantly different than all other rates of IF1 (7-17-3+micros) (Table 3.3). Trends are the same for net value where net value decreases as rate increases, except 0.0 and 4.7 l/ha are equal.

Physiologically peanuts are made up of three parts, testa, embryo, and endosperm (Wan et al., 2016). Rapid cotyledon growth in peanut can cause seed-coat (testa) cracking and the seed becomes more vulnerable to external factors (Wan et al., 2016). Other legume crops like soybean have a cuticle outer shell that protect it from external factors (Shao, 2007). Like peanut (Tubbs et al., 2016), soybeans also have to be inoculated to improve nodule formation (Salvagiotti et al., 2013). Salvagiotti et al. (2013), discovered that fertilizer applications in close contact with soybean seeds during planting could cause phytotoxicity.

Across the southeast it takes the integration of multiple factors to reach adequate stand establishment. Starting with seed maturity from the previous growing season, peanut has an indeterminate growth habit and continuously flowers (Song et al., 2022). The results of varying maturity cause a range of immature and mature seed that will be harvested. Results from Song et al. (2022) suggest that plants produced from seeds had higher emergence and canopy coverage throughout the growing season. It is crucial for growers across the peanut belt to have access to mature and viable seed from the beginning of the growing season that will then affect the next years seed.

Current recommendations for seeding rate are 19.7 seed/m row to achieve 13.3 seed/m row (Culbreath et al., 2013). With increased seeding rate, peanut seedling is less vulnerable to the infection of tomato spotted wilt virus (Culbreath et al., 2013 and 2016). Tomato spotted wilt is caused by tomato spotted wilt virus that is vectored by tobacco thrips (*Frankliniella fusca*) and is a major problem in peanut production causing concentric ringspots, various patterns of chlorosis, and stunting of all above ground plant matter (Culbreath et al., 2013; LaTora, 2022; Srinivasan, 2018). The increase of tomato spotted wilt virus in peanut production is cause by early planting dates, poor stand establishment, the use of single row pattern, and conventional tillage (Culbreath et al., 2013). To combat the impact of tobacco thrips and tomato spotted wilt virus, phorate in-furrow is recommended at plant (Culbreath et al., 2016). With this recommendation, in-furrow products from herbicides, insecticides, and fungicides are more readily available within the industry and has opened up doors for other products with minimal research such as in-furrow fertilizers to be recommended. Considering all of these factors without the addition of in-furrow fertilizers make peanut production difficult enough. The addition of in-furrow fertilizers under ideal planting dates, temperatures, no thrips pressure, twin row pattern, and strip tillage would still decrease the seeding rate below 19.7 seed/m row to increase the risk of tomato spotted wilt virus.

Summary and Conclusions

The goal of this research was to evaluate the stand establishment of a peanut crop utilizing in-furrow fertilizer. For both years at all locations, the untreated seed at 0.0 l/ha rate of IF1 reached

54.6% emergence (Table 3.2). Overall, this multistate research confirms that IF1 showed a decreasing rate and level of emergence as rates increased from 0.0 l/ha to 28.1 l/ha. Gross value is the total dollar amount received prior to costs. Net value is yield minus the cost of the product to determine if the cost of product is worth the potential yield boost or decline. In this case, the gross value and net value decreased with the increased rate of Riser (7-17-3+micronutrients).

In the future, based on these experiments each location should be analyzed separately to account for microclimate and seed quality differences. Additionally, variety and cultivar were not considered in this research which could be a factor in emergence and yield differences. Finally, research needs to be assessed on tank mix compatibility and effectiveness of *Bradyrhizobia* inoculant when paired with in-furrow fertilizer products.

Table 3.1. Experiment number, state, year, planting date, market-type, planting date, and harvest dates used in in-furrow fertilizer field experiments.

Experiment	State	Year	Market-Type	Planting Date	Harvest Date
1	Alabama	2021	Runner	June 3	October 19
2	Alabama	2022	Runner	June 3	October 24
3	Arkansas	2022	Runner	May 31	October 24
4	Florida	2021	Runner	April 30	-
5	Florida	2022	Runner	June 7	October 21
6	Georgia	2021	Runner	April 30, May14	September 28, October 4
7	Georgia	2022	Runner	April 29, May 26	September 22, October 28
8	Mississippi	2022	Runner	May 12	October 7
9	New Mexico	2022	Valencia	May 5	September 18
10	North Carolina	2021	Virginia	May 17	October 3
11	North Carolina	2022	Virginia	May 8	September 28
12	South Carolina	2021	Runner	May 6	September 23
13	South Carolina	2022	Runner	April 21	September 20
14	Texas	2022	Runner	May 10	-
15	Virginia	2021	Virginia	May 18	November 11
16	Virginia	2022	Virginia	May 4	November 4

Table 3.2. Impact of 7-17-3+micros fertilizer in field studies on peanut plant emergence across Alabama, Arkansas, Florida, Georgia, Mississippi, New Mexico, North Carolina, South Carolina, Texas, and Virginia.

	% Plant Emergence				
Rate (l/ha)	**Stand Count 1 (initial)[2]**	**Stand Count 2**	**Stand Count 3**	**Stand Count 4**	**Stand Count 5 (final)**
0.0	19.9a	35.8a	44.1a	47.8a	54.6a
4.7	13.3b	29.7b	39.2b	45.3a	53.5a
9.4	11.7bc	23.9c	35.1b	44.2a	50.5a
18.7	6.4c	16.6d	27.2c	37.1b	42.1b
28.1	6.2c	15.1d	25.6c	33.1b	39.0b

Table footnote. [1]% Emergence was assessed at initial emergence and then every 2 days for up to 4 additional assessments. [2]Means for each parameter within a column that are followed by the same letter are not significantly different at 0.05 probability level.

Table 3.3. Yield (kg/ha) response of peanut to applications of 7-17-3+micros fertilizer applied at different rates in-furrow in field studies in Alabama, Arkansas, Florida, Georgia, Mississippi, North Carolina, New Mexico, South Carolina, and Virginia.

Fertilizer Rate l/ha	Yield kg/ha[1]	Gross Value[2]	Net Value[3]
0.0	5522a[4]	$1778a	$1778a
4.7	5424a	$1779a	$1778a
9.4	5493a	$1769a	$1767a
18.7	5225ab	$1683ab	$1678ab
28.1	4873b	$1569b	$1563b

Table footnote. [1]Yield (kg/ha) at 7% moisture, [2]Gross Value = yield*market loan value of #321.985 per mt, [3]Net Value = gross value (kg/ha) minus cost of product for each treatment, [4]Means for each parameter within a column that are followed by the same letter are not significantly different at 0.05 probability level.

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CHAPTER 4

CLIPPING WEIGHTS AND TURF COVERAGE OF EXPERIMENTAL ZOYSIAGRASSES UNDER THREE MOWING INTERVALS

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Abstract

The time and mowing frequencies needed to maintain a lawn often limit homeowners because of their intensity. Therefore, the objectives of this research were to determine the (i) mower clipping yields of Zoysiagrass cultivars 09-TZ-53-20 and 09-TZ-54-9 as compared to market-types ‘Zeon’ and Zenith during mowing intervals from 2-8 weeks, 2-4 weeks, and 4-8 weeks; (ii) turf cover left after mowing on 09-TZ-53-20 and 09-TZ-54-9 as compared to market-types ‘Zeon’ and ‘Zenith’ from 2-8 weeks, 2-4 weeks, and 4-8 weeks. Clipping yields and percent green turf cover were evaluated on the four different genotypes in Tifton, GA from 2018 to 2021. Cultural management treatments included 2-week, 4-week, and 8-week mowing intervals on 09-TZ-53-20, 09-TZ-54-9, ‘Zenith’, and ‘Zeon’. Results from the study showed that overall clippings were lower and turf cover was higher for 09-TZ-54-9 and 09-TZ-53-20 compared to ‘Zeon’ and ‘Zenith’. The rate of ‘Zenith’ clipping accumulation increased in the 2-4-week rating period compared to the other three cultivars. ‘Zeon’ showed a decrease in turf cover that was more drastic in the 2-4-week rating period than for 09-TZ-54-9 and 09-TZ-53-20. In conclusion, these results support 09-TZ-53-20 and 09-TZ-54-9 as lower mowing requirement cultivars that should be investigated further.

Introduction

Zoysiagrass (*Zoysia* spp.) is a low maintenance, slow-growing, warm-season perennial grass adapted to a wide range of environments that is used throughout the transitional and warm climatic regions of the Southeastern United States (Patton and Reicher, 2006). Mowing can be a time-consuming task for homeowners and if not done within a time frame could lead to the degradation of the grass. Overall, reducing the interval between mowing could aid in the conservation of energy and resources. New turfgrass cultivars that are bred for improved quality with less inputs may help homeowners and turf managers reduce inputs that will benefit them economically and environmentally. Zoysiagrass is shade tolerant, but can be prone to disease susceptibility and increased irrigation needs (Patton et al., 2017). Zoysiagrass rapidly gained popularity upon the release of the cultivar ‘Meyer’ in the 1950’s because of its heat, freezing, and drought tolerance in the transition zone (Grau and Radko, 1951). Its growth habit forms a uniform, dense, and high-quality turf when best management practices are used. Due to Meyer’s minimal fertility requirements and slow growth, it has become a viable option for residential lawns, commercial landscapes, and golf courses in the transition zone (Hanna et al., 2013). Though newer zoysiagrasses can tolerate a wide range of soil conditions and pH, they do not tolerate water logged, poorly drained soil conditions (Hanna et al., 2013). In these situations, zoysisagrass is less likely to recover from injury in addition to abiotic and biotic stressors.

Zoysiagrass characteristics of being highly competitive under low maintenance with minimal inputs such as fertilizer and water make it a suitable option for homeowners (Engelke et. Al, 1992). A properly defined management program is required to optimize zoysiagrasses capabilities. Excessive N demands can have environmental consequences such as air and ground water contamination through leaching, and emission of greenhouse and ozone depleted gasses (Grubbs et al., 2021). Homeowners would benefit from the development of new cultivars with both lower mowing and fertility input needs.

Current research methods can take many years to quantify the mowing interval frequency needed for new turfgrass cultivars. Previous research on zoysiagrass management requirements have focused on responses to different mowing heights and fertility requirements (Engelke, 1991, 1992, and Schwartz, et al. 2018). Joiner et al., (1962), initiated a study to quantify the effects of four cutting heights and three nitrogen levels on bermudagrass (*Cynodon dactylon*), zoysiagrass (*Zoysia* spp.), and St. Augustinegrass (*Stenotaphrum secundatum-*). A study by Yue et al., (2012) indicated that consumers are more likely to utilize low input turfgrasses to reduce energy expenditures such as mowing. Results additionally indicated that there is market potential for turfgrass cultivars that can provide acceptable quality when mowed on a monthly basis (Yue et al., 2012). Joiner et al., (1991) discovered that neither nitrogen levels or height of cut produced any effects on the root growth of zoysiagrass due to its slow growing habits (Joiner et al., 1991).

The objectives of this research were to determine (i) clipping weights of 09-TZ-53-20 and 09-TZ-54-9 as compared to market-types ‘Zeon’ and ‘Zenith’ from 2-8 weeks, 2-4 weeks, and 4-8 weeks; (ii) turf cover left after mowing on 09-TZ-53-20 and 09-TZ-54-9 as compared to market-types ‘Zeon’ and ‘Zenith’ from 2-8 weeks, 2-4 weeks, and 4-8 weeks. This study was initiated to determine whether newly developed zoysiagrasses can maintain acceptable turf cover and decreased clipping weights with extended mowing intervals.

MATERIALS AND METHODS

Field experiments were conducted in plots located in Tifton, Georgia (31.4505° N, 83.5085° W) planted in June 2018 and studied through November 2021. Soil at this experimental location was Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) (USDA-NRCS, 2022), the soil pH was 6.2, and no appearance of seasonal flooding or drastic differences in slope. There was an at plant fertilization of 16-4-8 followed up as needed annually by soil test recommendations. All cultivars were planted by sod in the summer of 2018. All plots were established by the spring of 2018. Irrigation was applied as needed to maintain moisture and prevent drought stress. Herbicides and fungicides were applied preventatively to reduce disease and weed pressure per standards for turfgrass management in South Georgia (*Georgia Pest Management Handbook*, 2021).

Experimental Design, Description and Timing of Treatment Applications

The experiment was arranged in a split-plot design with 4 replications. The whole plot factor was cultivar, with cultivars of 09-TZ-53-20, 09-TZ-54-9, 'Zeon', and 'Zenith'. Subplot treatments were a cultural management mowing practice, which consisted of three treatments replicated four times (1) 2-week mowing, (2) 4-week mowing, (3) 8-week mowing. All cultural management practice treatments were applied with a Toro Greensmaster 1000 walk-behind greens reel mower (The Toro Company, Bloomington, MN) at 1.27 cm mowing height and clippings were collected to be dried and weighted. In year one, treatments were initiated on 6 May 2019 and were terminated on 2 December 2019. In year two, treatments were initiated on 6 April 2020 and were terminated on 2 November 2020. In year three, treatments were initiated on 5 April 2021 and were terminated on 1 November 2021. All treatments were applied in the same plots throughout the 3-year study.

All mower clippings from each plot were placed in brown paper bags that were then oven dried in a Watlow Series 942 at 60 ◦C for 7-14 days. After the drying interval, bags were weighed and recorded in grams to get clipping yield by weighing each treatment.

After mowing, turf coverage was quantified using digital image analysis with a Canon PowerShot G5 (Canon, Tokyo, Japan) digital camera mounted to an enclosed photo box (0.31 m^2) with four 9-W compact fluorescent lamps (TCP; Lighthouse Supply, Bristol, VA). Each image was analyzed for green turf coverage using SigmaScan Pro 5 (Systat Software Inc., Richmond, CA) under the macro "Turf Analysis" for turf coverage (0% to 100%) (Karcher & Richardson, 2005) using a hue range from 55 to 120 and a saturation range from 10 to 100.

Statistical Analysis

Data was analyzed over year and season because they were considered random effects. They were treated as random effects due to the environmental variations that did and can occur over the years and seasons of this trial.

The MIXED procedure in SAS 9.3 (SAS Institute, Cary, NC) was used to analyze multiple comparisons that were computed with least square means for a given effect was significant at the α= 0.05 level. Numerous high-order interactions were statistically significant, but from a practical standpoint, they were not meaningful. Interactions were shown to be not significant because an analysis of variance was applied to each data set combined over experimental units and experimental replication in time.

The minimum and maximum clipping weight and turf cover were determined independently because of the differing slope directions on each mowing interval. A separate curve was fit for each cultivar, the 95% confidence limits of the parameter were used to determine statistical differences in the two model parameters (β_o and β_1). A combined regression was performed to see the response to treatments over the 2 to 8-week period. A modified regression was initiated used due to preliminary testing indicating that there were differences in each mowing interval. The modified regression was tested for the 2-4-week interval and the other modified regression was tested for the 4-8 week mowing intervals. This was done to further investigate trends shown over the 2 to 8-week period.

Results and Discussion

Mean clipping weight showed that there was no significant interaction between genotype and mowing frequency (Table 4.1). Turf cover showed that there was no significant interaction between genotype and mowing frequency (Table 4.1). Therefore, each testing factor had to be investigated by genotype and mowing frequency separately. Once separated, mean clipping weight was significantly affected ($p \leq .0001$) by mowing frequency and genotype (Table 4.1). Turf cover was significantly affected ($p \leq .0001$) by mowing frequency and genotype (Table 4.1).

Clipping Sum

Experimental cultivar, 09-TZ-53-20, had the lowest clipping weight out of all cultivars but was statistically the same as 09-TZ-54-9 (Table 4.2). 'Zeon' separated significantly from the experimental cultivars but remained similar to 'Zenith' which had the numerically highest clipping weight out of all the cultivars (Table 4.2). This data supports that the two experimental cultivars 09-TZ-53-20 and 09-TZ-54-9 may be a more suitable option for consumers that want to mow less often because they are slower growing. At the 2-week mowing interval, average clipping weights over all four genotypes remained the lowest, although similar to the 4-week mowing interval clipping weights (Table 4.2). At the 8-week mowing interval, clipping weights were the highest and were significantly different from the 2- and 4-week intervals (Table 4.2).

2-8 Week Combined Regression

From the model, the intercept (β_0) was greatest for 'Zenith' and lowest for 09-TZ-53-20, and the two experimental cultivars were significantly different from the two market cultivars (Table 4.3). The slope (β_1) was the steepest for 'Zeon' but there was no significant difference between cultivars (Table 4.3).

In the 2-8-week regression (Figure 4.1), 'Zenith' and 'Zeon' slopes were similar but overall Zenith had a higher clipping sum average (Figure 4.1). Slopes were similar for 09-TZ-53-20 and 09-TZ-54-9 but overall 09-TZ-53-20 had the lowest clipping sum average (Figure 4.1). In Figure 4.1, all genotypes are separated and follow the same slope across all mowing intervals at 2, 4, and 8 weeks. Because no significant differences in slope were found over the entire 2-8-week regression cycle, we determined it was important to explore whether there were different trends in the accumulation of clippings between the first four weeks and last four weeks of the 8-week mowing cycle.

2-4 Week Modified Regression

From the model, the intercept (β_0) was greatest for 'Zenith' and lowest for 09-TZ-53-20 (Table 4.3). 'Zenith' was significantly different from experimental genotypes (Table 4.3). The slope (β_1) was the similar for 'Zenith' and 'Zeon' (Figure 4.3), but 'Zenith' separated significantly from 09-TZ-53-20 and 09-TZ-54-9 (Table 4.3).

Trendlines are similar for 09-TZ-53-20 and 09-TZ-54-9 over the 4-week mowing interval, but the flat trendline for 09-TZ-53-20 indicates that there could have been a growth plateau between weeks 2-4 for this genotype (Figure 4.3).

4-8 Week Modified Regression

From the model, intercept (β_0) was significantly higher for 'Zenith' than either of the experimental genotypes 09-TZ-53-20 and 09-TZ-54-9 (Table 4.3). The slope (β_1) was the least steep for 'Zenith', but all cultivars were statistically similar (Table 4.3).

In Figure 4.4, 09-TZ-53-20 trendline starts to increase between the 4-8 mowing interval. This suggests that the later 4-week mowing interval promoted growth in this genotype. 'Zenith' and 'Zeon' have the two highest clipping sums and trendlines remain consistent from the 2-4 week mowing intervals into the 4-8 mowing intervals (Figure 4.4).

Turf Cover

09-TZ-54-9 and 09-TZ-53-20 had significantly higher turf cover over the 8-week mowing cycle than the two market cultivars (Table 4.2). 'Zeon' had a moderate turf cover and was significantly different from the two experimental cultivars and 'Zenith'. 'Zenith' had the lowest turf cover compared to all other cultivars in the experiment (Table 4.2). This suggests that ‘Zenith’ cannot withstand increased mowing intervals due to the possibility that it will scalp after mowing. Additionally, ‘Zenith’ may not have the genetic potential to have a high turf coverage due to its wide leaf blade. At the 2-week mowing interval, turf cover was significantly different than the other mowing intervals and was at the highest which proves that scalping does not typically occur when mowing this frequent (Table 4.2). At the 4-week mowing interval turf cover was moderate and was significantly different than the 2 and 8-week mowing intervals (Table 4.2). Turf cover was the lowest at the 8-week interval and was significantly different than the 2 and 4-week interval which indicates that scalping will increase with time between mows (Table 4.2).

2-8 Week Combined Regression

From the model, intercept (β_0) was greatest for 09-TZ-53-20 and lowest for ‘Zenith’, whereas ‘Zenith’ was the only cultivar that was significantly different from the other cultivars (Table 4.3). The slope (β_1) was steepest for ‘Zeon’ and it was the only cultivar significantly different from the experimental genotypes (Table 4.3).

In Figure 4.2, 09-TZ-53-20 and 09-TZ-54-9 follow the same trendline. ‘Zeon’ and ‘Zenith’ follow the same trend line and begin to trend downward at the 4-week mowing interval. Turf cover in ‘Zenith’ decreases at the same rate over the 8-week period as the experimental genotypes but it is significantly lower.

2-4 Week Modified Regression

From the model, the intercept (β_0) was greatest for ‘Zeon’ and lowest for ‘Zenith’, while ‘Zenith’ was the only cultivar that was significantly different from the others (Table 4.3). The slope (β_1) was steepest for ‘Zeon’ was significantly different from all other cultivars (Table 4.3).

During the 4-8 week mowing interval all genotype trendlines are similar to the 2-4 week modified regression and were not any different at the 4-8-week mowing interval (Figure 4.5). Although 09-TZ-53-20 and 09-TZ-54-9 trended downward over all eight weeks (Figure 4.4), they appeared to plateau during the 2-4 week mowing interval (Figure 4.5).

4-8 Week Modified Regression

From the model, intercept (β_0) was greatest for 09-TZ-53-20 and lowest for ‘Zenith’, where ‘Zenith’ was significantly different than 09-TZ-53-20 and 09-TZ-54-9 (Table 4.3). The slope (β_1) was steepest for ‘Zeon’ but there were not statistical differences between cultivars (Table 4.3).

In Figure 4.6, 09-TZ-53-20 and 09-TZ-54-9 follow the same trendline which was consistent from the 2-4 week mowing interval. The downward trend in turf cover of ‘Zeon’ in the 2-4-week mowing interval began to level out between weeks 4 and 8 (Figure 4.6).

The effects of mowing intervals on two experimental cultivars and two market cultivars were assessed in this research. Mowing intervals primarily affected turf cover due to increased scalping with extended mowing intervals. Cultivar did have a significant effect on clipping weight but is to be expected with slower growing selections.

In Table 4.1, the results from the combined means table for clip sum and turf cover were run at $\alpha = 0.05$. In turf cover, genotype*mowing frequency the significance was 0.065. Therefore, if $\alpha = 0.05$ would have been set at $\alpha = 0.1$ for this analysis then genotype x mowing frequency would have been significant. It was predicted that 09-TZ-53-20 and 09-TZ-54-9 were going to stay consistent in clip sum and turf cover across the 2-8 week mowing intervals while ‘Zeon’ and ‘Zenith’ were predicted to decrease. Therefore, running the data at $\alpha = 0.1$ could have picked up on these changes within the data and genotypes.

Joiner et al. (1961) found that neither nitrogen levels or mowing height had any effects on the root growth of zoysiagrass, due to their slow growing habits. Engelke et al., (1991) studied nitrogen fertilization on mowing height effects on zoysiagrass performance. They demonstrated that mowing treatments and fertility did not affect winter green color retention, however genotypes mowed at 0.63 cm resulted in a higher percentage of green canopy cover. A similar study (Engelke et al., 1992) was done and showed no interaction between fertilizer level and mowing treatments in zoysiagrass. Mowing height had no significant effect on any cultivars in this experiment and were not significantly different from one another (Engelke et al., 1992). Schwartz et. al. (2018) discovered that the effects of mowing height was only significant during spring green up. If the data were to be broken out by season, this research could aid in determine mowing intervals during different seasons of the year.

Summary and Conclusions

In conclusion, 09-TZ-54-9, 09-TZ-53-20, 'Zeon', and 'Zenith' were evaluated from 2018 to 2021 at 2, 4, and 8 week mowing intervals to determine their clipping weight and turf cover after mowing instances. 09-TZ-53-20 and 09-TZ-54-9 performed similarly in producing less clipping weight for the 2, 4, and 8 week mowing intervals. 'Zenith' and 'Zeon' both performed similarly at the 2, 4, and 8 week mowing intervals. 'Zenith' and 'Zeon' both decreased turf cover which correlates to scalping instances after mowing. Data will be useful in improving cultivar selection and ultimately availability for homeowners to reduce inputs.

Additional research should include disease ratings, turf quality, spring green up, winter color retention, fertility requirements and add a mowing interval of 6-weeks. This research shows that a longer interval between mowing is an option for the two experimental varieties, but the addition of a 6-week mowing interval could have assisted in describing the relationship of clipping yield and turf cover. This research would be justified due to the initiation of the modified regression where there were differences between the 2-4 week mowing intervals and the 4-8 week mowing intervals.

Table 4.1. Results from means combined for clip sum and turf cover. Mean clipping weight and turf cover as influenced by an interaction among genotype and mowing frequency on Zoysiagrass in Tifton, GA from 2018 to 2021.

Effect	Num DF	Den DF	F Value	Pr > F
	---------------------------Clipping Sum-------------------------------			
Geno	3	138	40.81	<.0001
Mow Frequency	2	138	12.49	<.0001
Geno*Mow Frequency	6	138	0.23	0.9672
	------------------------------Turf Cover------------------------			
Geno	3	246	96.45	<.0001
Mow Frequency	2	246	17.92	<.0001
Geno*Mow Frequency	6	246	2.01	0.0655

[a]**Table footnote.** α = 0.05.

Table 4.2. Results from analyses of variance for mean clipping sum and turf cover on 09-TZ-53-20, 09-TZ-54-9, 'Zeon', and 'Zenith' in Tifton, GA from 2018 to 2021.

Effect	Geno	Mowing Frequency	Estimate	Standard Error
--------Clipping Sum--------				
Geno	**09-TZ-53-20**		42.4a	29.1
Geno	**09-TZ-54-9**		63.5a	29.1
Geno	**'Zeon'**		118.6b	29.1
Geno	**'Zenith'**		134.1b	29.1
Mow Frequency		**2wk**	72.0a	28.9
Mow Frequency		**4wk**	84.2a	28.9
Mow Frequency		**8wk**	112.8b	28.9
--------Turf Cover--------				
Geno	**09-TZ-53-20**		78.4a	4.6
Geno	**09-TZ-54-9**		78.7a	4.6
Geno	**'Zeon'**		67.9b	4.6
Geno	**'Zenith'**		55.6c	4.6
Mow Frequency		**2wk**	74.0a	4.8
Mow Frequency		**4wk**	70.6b	4.8
Mow Frequency		**8wk**	65.9c	4.8

Table footnote. Means of separation by type 3 fixed effects test. Values for each parameter within a column followed by the same letter are not significantly different at a $\alpha = 0.05$.

Table 4.3. Clipping sum and turf cover parameter estimate for 09-TZ-53-20, -09-TZ-54-9, 'Zeon', and ''Zenith' in Tifton, GA from 2018 to 2021.

	Clip Sum						**Turf Cover**					
	2-8 Week Regression		**2-4 Week Regression**		**4-8 Week Regression**		**2-8 Week Regression**		**2-4 Week Regression**		**4-8 Week Regression**	
	β0						**β0**					
	β0	**CL$_{95\%}$**	**β0**	**CL$_{95\%}$**	**β0**	**CL$_{95\%}$**	**β0**	**CL$_{95\%}$**	**β0**	**CL$_{95\%}$**	**β0**	**CL$_{95\%}$**
09-TZ-53-20	18.3a	6.9	33.4a	9.5	3.8a	13.9	83.8a	2.5	83.0a	3.7	83.8a	4.9
09-TZ-54-9	32.0a	9.8	38.6ab	13.5	25.4a	20.3	82.3a	2.8	81.0a	4.9	83.6a	5.2
'Zeon'	79.4b	19.6	79.4bc	29.3	79.4ab	40.6	79.4a	3.9	85.0a	6.2	73.9ab	8.0
'Zenith'	98.8b	17.6	85.8c	26.9	111.9b	36.8	62.3b	3.8	62.9b	7.1	61.8b	6.7
	β1						**β1**					
	β1	**CL$_{95\%}$**	**β1**	**CL$_{95\%}$**	**β1**	**CL$_{95\%}$**	**β1**	**CL$_{95\%}$**	**β1**	**CL$_{95\%}$**	**β1**	**CL$_{95\%}$**
09-TZ-53-20	5.4ns	1.3	0.0a	3.0	7.5ns	2.2	-1.0a	0.5	-0.8a	1.2	-1.0ns	0.8
09-TZ-54-9	7.0ns	1.9	4.7a	4.3	8.0ns	3.2	-0.7a	0.5	-0.2a	1.5	-0.9ns	0.8
'Zeon'	7.6ns	3.7	7.7ab	9.3	7.6ns	6.4	-2.7b	0.7	-4.6b	1.9	-1.9ns	1.3
'Zenith'	7.0ns	3.3	12.4b	8.5	5.9ns	5.8	-1.4ab	0.7	-1.6ab	2.2	-1.4ns	1.1

Table Footnote. ±CL$_{95\%}$ confidence limit.
± Parameter estimates calculated by linear regression equation: $y = mX + b$
Where β_0 is the upper asymptote (clip sum and %GC), B_1 is the overall slope estimate.
Values for each parameter within a column and cultivar followed by the same letter are not significantly different at $\alpha = 0.05$.

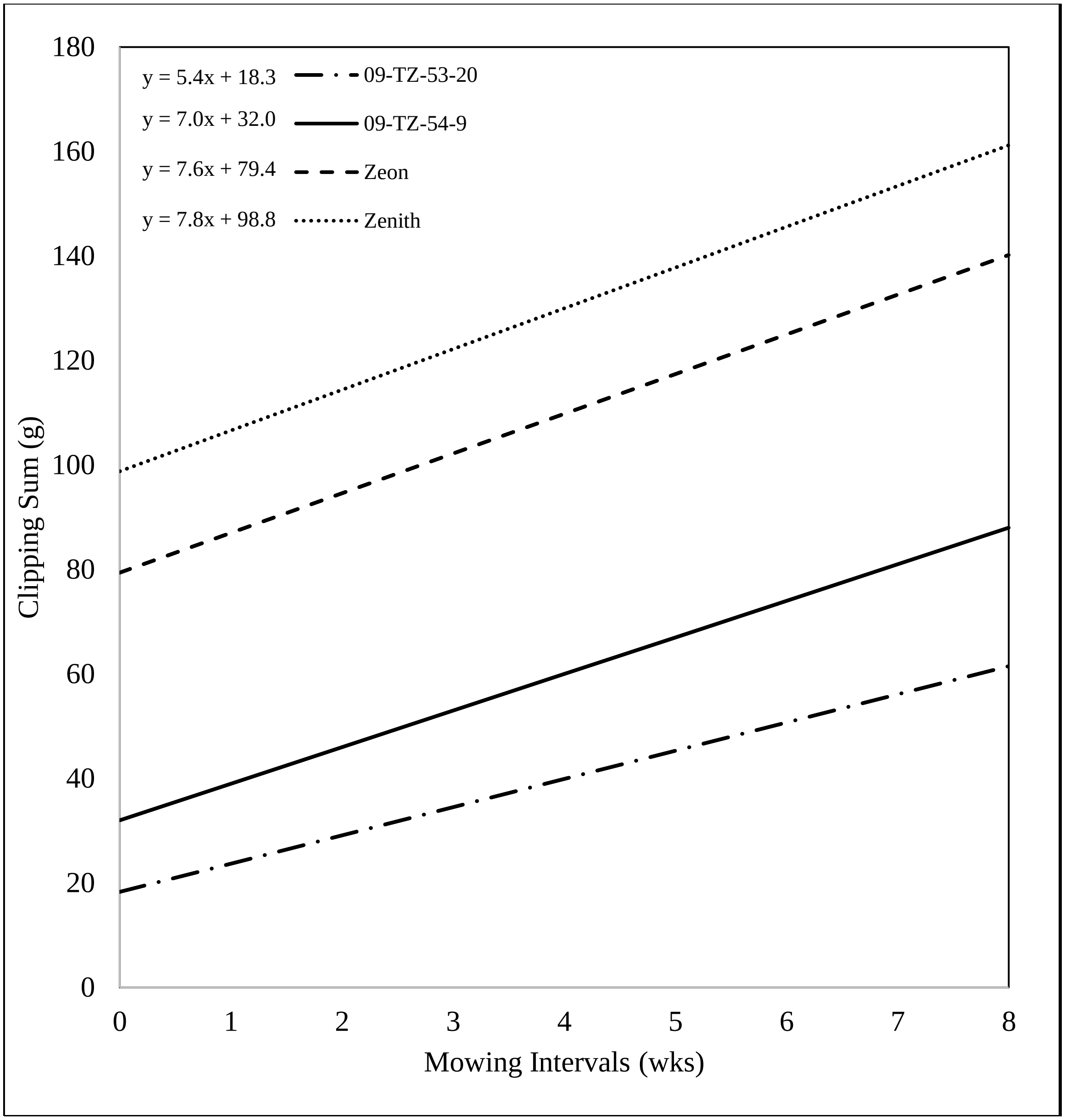
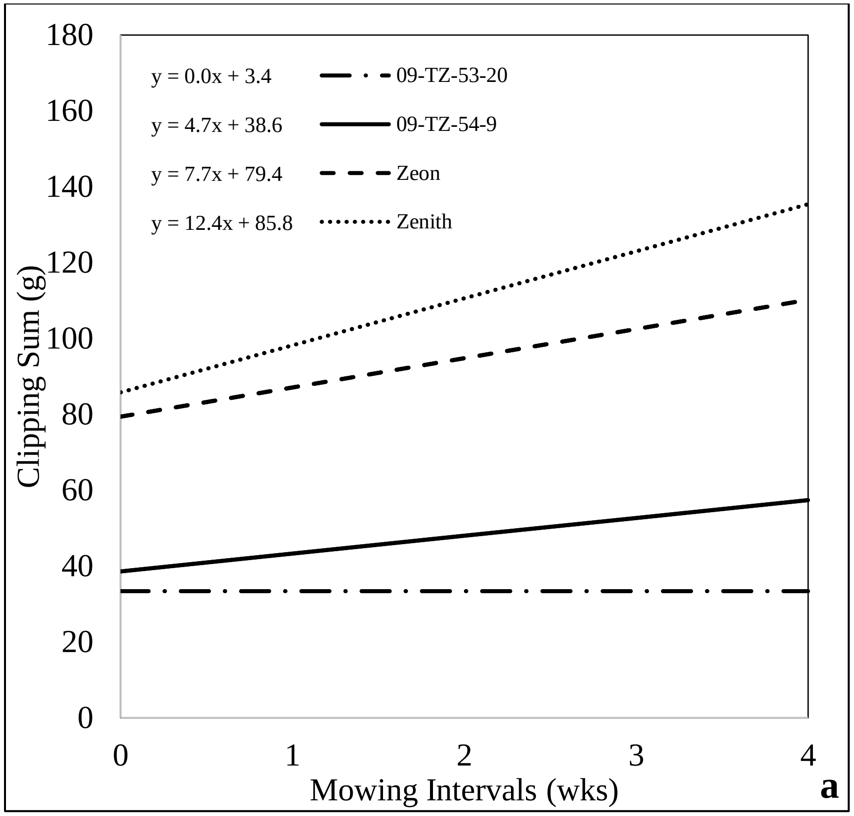


Figure 4.1. 2-8 week mowing interval relationship between clipping sum for cultivars 09-TZ-54- 9, 09-TZ-53-20, ‘Zeon’, and ‘Zenith’ through a combined linear regression from 2019-2021 in Tifton, GA.



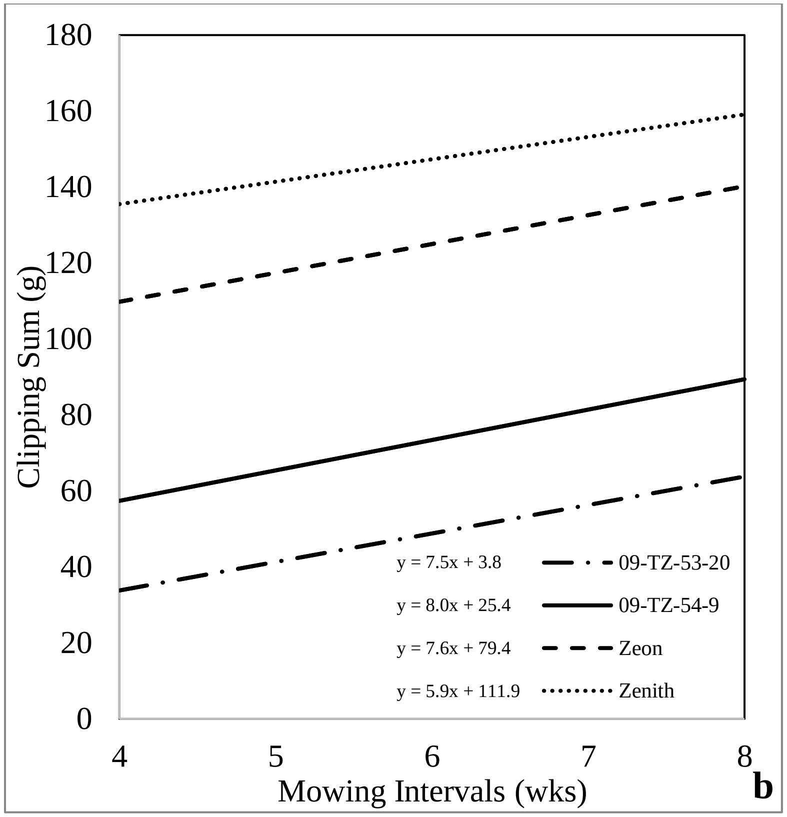


Figure 4.2 (a). 2-4 week mowing interval relationship between clipping sum for cultivars 09-TZ-54- 9, 09-TZ-53-20, ‘Zeon’, and ‘Zenith’ through a modified linear regression from 2019-2021 in Tifton, GA.

Figure 4.3 (b). 4-8 week mowing interval relationship between clipping sum for cultivars 09-TZ-54- 9, 09-TZ-53-20, ‘Zeon’, and ‘Zenith’ through a modified linear regression from 2019-2021 in Tifton, GA.

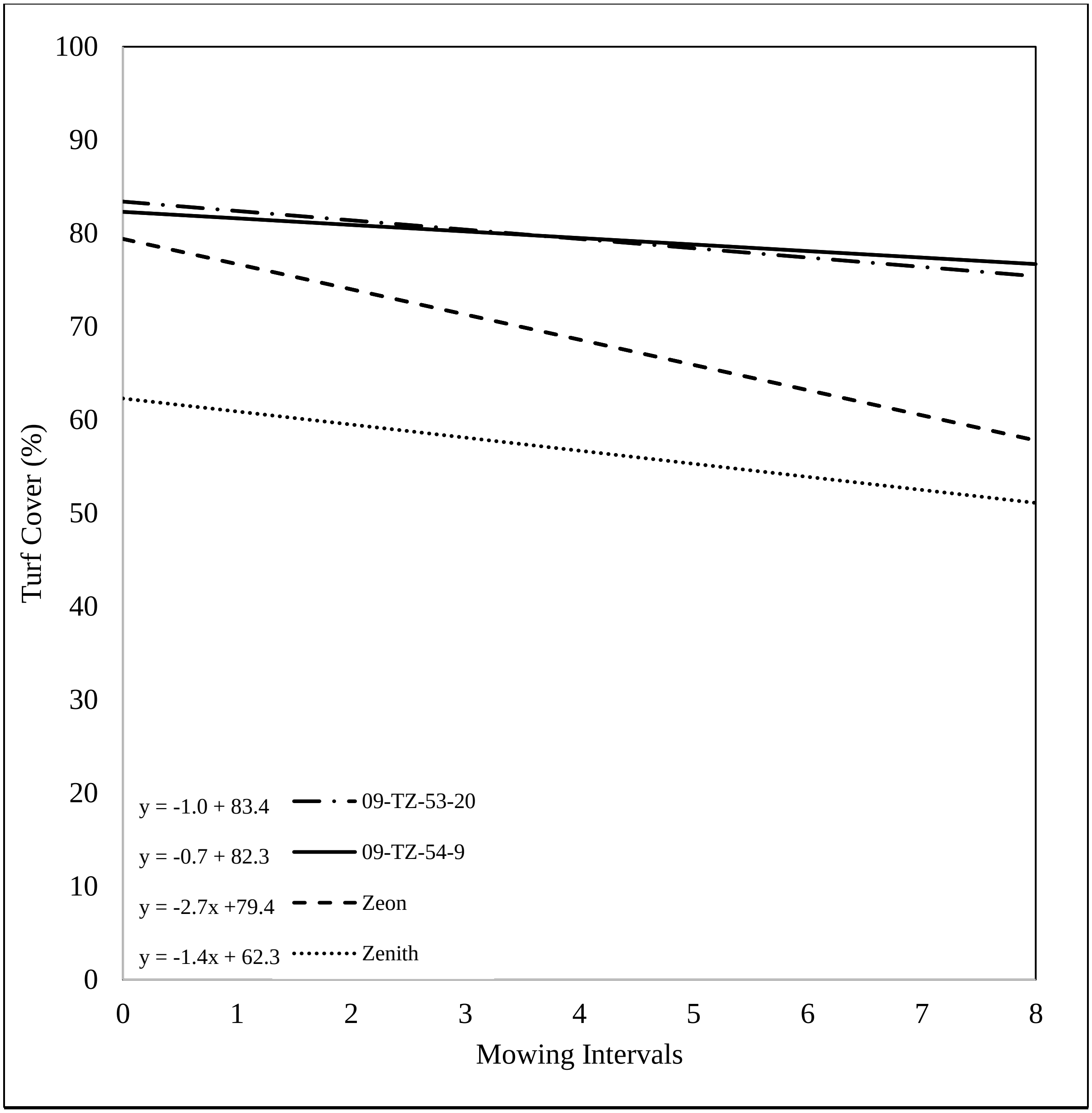
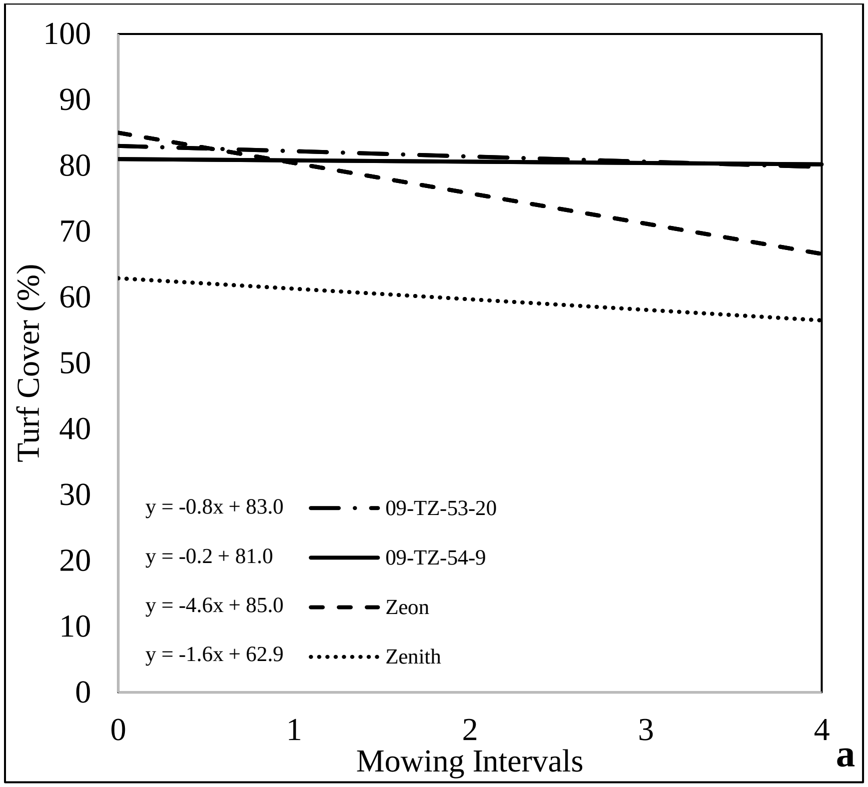


Figure 4.4. 2-8 week mowing interval relationship between clipping sum for cultivars 09-TZ-54- 9, 09-TZ-53-20, ‘Zeon’, and ‘Zenith’ through a combined linear regression from 2019-2021 in Tifton, GA.



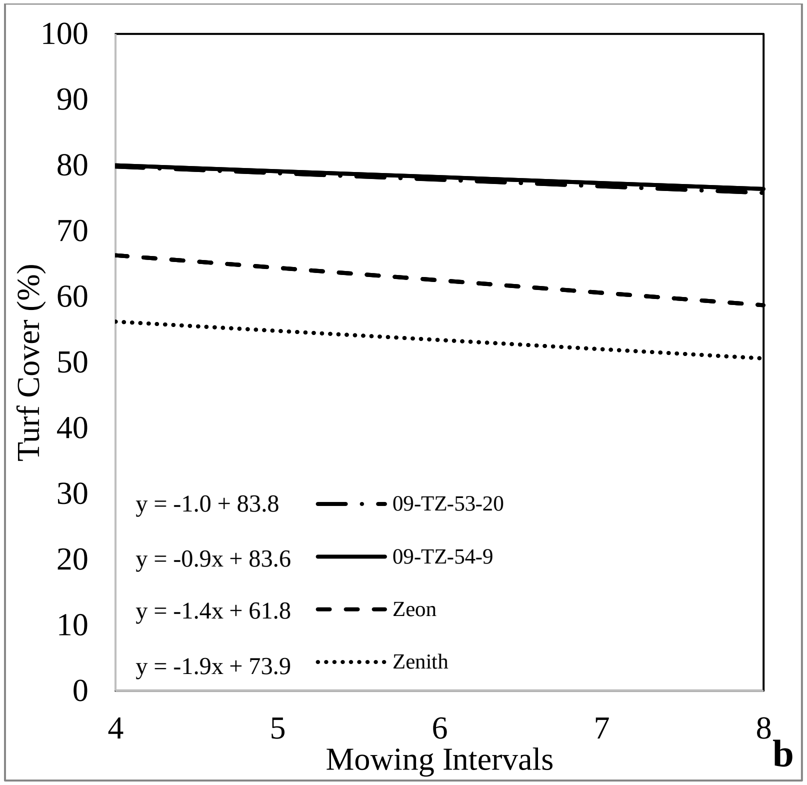


Figure 4.5 (a). 2-4 week mowing interval relationship between turf cover for cultivars 09-TZ-54- 9, 09-TZ-53-20, 'Zeon', and 'Zenith' through a modified linear regression from 2019-2021 in Tifton, GA.

Figure 4.6 (b). 4-8 week mowing interval relationship between turf cover for cultivars 09-TZ-54- 9, 09-TZ-53-20, 'Zeon', and 'Zenith' through a modified linear regression from 2019-2021 in Tifton, GA.

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CHAPTER 5

OVERALL CONCLUSIONS

Experiments were conducted in 2018, 2019, 2020, 2021, and 2022 in order to determine 1) effects of three in-furrow fertilizers on peanut emergence in a bare-ground greenhouse, 2) effects of an in-furrow fertilizer product (7-17-3+micros) in multiple locations across the peanut belt, 3) the effects of three mowing intervals on two experimental zoysiagrass genotypes and two market-type zoysiagrass genotypes.

In chapter 2, runner-type peanut cultivars (Georgia-07W and Georgia-06G) were evaluated in a bare-ground greenhouse with optimal growing conditions for emergence from 6-14 DAP. IF1 (7-17-3+micros) (Nutrient Ag Solutions, Loveland, CO), IF2 (1-0.5-1) (Success Nutrients, Denver, CO), and IF3 (2-6-16) (Nachurs Alpine Solutions, Marion, OH) were tested at 0.0, 4.7, 9.4, and 18.7 l/ha with each treatment being ran independently. Though treatments were run separately, trends remained consistent throughout all treatments. All fertilizer rates slowed emergence across dates at all locations. All rating dates of the untreated check had higher emergence compared to all treatments. 18.7 l/ha and 28.1 l/ha rates of IF1, IF2, and IF3 significantly reduced stand at 14 days after planting. This seed emergence procedure could assist growers by determining the impacts of in-furrow fertilizer on the germination, emergence, and vigor of peanuts over time.

In chapter 3, peanut seeds were planted in field conditions in Alabama, Arkansas, Florida, Georgia, Mississippi, New Mexico, North Carolina, South Carolina, Texas, and Virginia and seedling emergence was observed from 6-14 DAP and most locations collected yield data. In 2021 and 2022, IF1 (7-17-3+micros) (Nutrien Ag Solutions, Loveland, CO) was used at rates of 0.0, 4.7, 9.4, 18.7, and 28.1 l/ha.

All fertilizer rates slowed emergence across dates at all locations. All rating dates of the untreated check had higher emergence compared to all treatments. 18.7 and 28.1 l/ha rates of IF1 significantly reduced stand at 14 days after planting. IF1 (7-17-3+micros) did not have an impact on increasing yield. The application of in-furrow products negatively impacted stand and revenue. UGA recommendation confirmed, do not apply in-furrow fertilizers in peanut.

In chapter 4, clipping sum and turf cover were evaluated from 2018 to 2021 at 2, 4, and 8 week mowing intervals on 09-TZ-54-9, 09-TZ-53-20, ‘Zeon’, and ‘Zenith’. 09-TZ-53-20 and 09-TZ-54-9 performed similarly in producing less clipping weight(g) for the 2, 4, and 8 week mowing intervals. ‘Zenith’ and ‘Zeon’ both displayed decreased turf cover after mowing which correlates to scalping instances. Data will be useful in improving cultivar options and availability for homeowners to reduce inputs.

APPENDIX A

UGA EXTENSION ASSISTANSHIP

Before starting my master's program, I wanted a catered experience to my future career goals. That goal being going into school with the intent of being a county agent or in the UGA extension system afterward. Therefore, I decided to be co-advised between Dr. Scott Monfort, UGA Extension Peanut Specialist and Dr. Brian Schwartz, UGA Turfgrass Breeder. In addition, I was given the opportunity to have an assistantship through UGA Southwest District Extension at the Worth County Extension office. At my time at the extension office, I have shadowed agents Scott Carlson (Agriculture and Natural Resources) (ANR), Ty Torrance (ANR), and Kristen Ford (4-H).

My contract stated ~20 hours at the extension office weekly answering client calls, making farm visits, attending educational trainings, taking on special projects, 4-H activities, and county livestock shows. While the job description was limited and somewhat unknown, I have received more out of this experience than I ever thought possible. I was able to see the connection from the research going on at UGA Tifton and how it directly impacts our growers daily. Through the peanut in-furrow fertilizer project, I was able to do an on-farm trial with Tim and Tommy Sumner of Worth County, Georgia. The impact that this project has had across the southeast started there not far from my desk. I was able to help plant, collect data, and harvest the cotton variety trial on-farm under Dr. Camp Hand. In addition to on-farm trials, I was able to help 4-H agent Kristen Ford educate the students of Worth County about where their food and fibers come from.

I would recommend this master's program to any student interested in going into extension. I was able to get real-world Extension agent experience in the field, meetings, office, schools, county ordinances, and much more. I am grateful to UGA Southwest District Extension for the funding of this assistantship and the opportunity to work at the Worth County Extension Office.

APPENDIX B

PRELIMINARY GREENHOUSE TRIAL WITH CORN, COTTON, AND SOYBEAN

Due to the preliminary greenhouse results with in-furrow fertilizers with peanut, it was decided to expand the crops being tested in hopes that other researches may be interested. Experiments were conducted in 2021 and 2022 in Tift County at The University of Georgia Tifton Campus (31.4505° N, 83.5085° W) in a bare ground greenhouse (Figure 1) composed of Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults). The experiment was conducted in a randomized complete block design with 4 replicates of the 4 treatments and untreated control. Corn, cotton, and soybean were planted on 5 April 2022.

Greenhouse preparations for all experiments included hand ploughing followed by levelling with rakes and thoroughly watered. Plots were 60.96 cm long by 30.48 cm. 8 seeds were planted 5 cm apart and 5 cm deep in-furrow for corn and both cotton varieties. 20 seed were planted 1.27 cm apart and 5 cm deep in-furrow for soybean. Treatments consisted of a) 4.7 b) 9.4, c) 18.7, d) 28.1 l/ha of a liquid fertilizer with a 7-17-3 formulation (IF1) (Nutrient Ag Solutions, Colorado) and an untreated control of 0.0 l/ha. Due to the availability in products IF1 was the only in-furrow fertilizer product selected for evaluation.

Treatments were applied by hand with a 5mL syringe at 1.8m l/m calibrated based off of liters per hectare (65.6 l/ha). Rates were based off of industry recommendations and product label. Heaters were set to 23.88 ˚C to 26.66 ˚C to ensure soil temperatures remained above 20˚C to ensure soil temperatures were above 20 ˚C. Plots were watered as needed to prevent wilting. Stand counts were accessed from 1 to 14 DAP. After the 14-day assessment the trial was terminated all seed and plants were exterminated. This test was only completed once.

Statistical Analysis

Treatment, run, and treatment x run were subjected to ANOVA using the GLIMMIX procedure in SAS software, version 9.4 (SAS Institute, Cary, NC) with Tukey's LSD test at $\alpha = 0.05$ for mean separation. Runs and replications were considered random effects.

Results

Corn showed no significant differences at 8 DAP or 14 DAP. The highest rate of 28.1 l/ha was significantly different at 8 DAP and 14 DAP in the large seeded cotton variety. The small seeded cotton variety showed no significant differences at 8 DAP and 14 DAP. At 8 DAP, soybean showed no significant differences in emergence across all rating dates. At 14 DAP, the highest rate of 28.1 showed a significant difference from all other treatments.

In the future, this trial should be repeated in the greenhouse for preliminary data, on-farm, and in multiple locations. With more data running a linear regression will show the interaction in treatment by each rating date.

Table 1. Corn, large seed cotton, small seed cotton, and soybean at 8 DAP and 14 DAP at each treatment of IF1 (7-17-3+micronutrients) (Nutrient Ag Solutions, Colorado)

	Corn		**Large Seed Cotton**		**Small Seed Cotton**		**Soybean**	
TRT (l/ha)	**8 DAP**	**14 DAP**	**8 DAP**	**14 DAP**	**8 DAP**	**14 DAP**	**8 DAP**	**14 DAP**
0.0	100ns	100ns	93.8a	100a	74.6ns	93.8ns	65ns	82.5a
4.7	96.9ns	100ns	87.5a	96.9a	62.2ns	87.5ns	58.8ns	76.3ab
9.4	93.8ns	100ns	87.5a	93.8a	54.5ns	87.5ns	53.8ns	75ab
18.7	84.4ns	96.9ns	71.8a	81.3a	52.3ns	71.9ns	47.5ns	65ab
28.1	78.1ns	87.5ns	15.6b	34.4b	33.3ns	15.6ns	21.3ns	42.5b

Table Footnote.
Values for each parameter within a column and cultivar followed by the same letter are not significantly different at α = 0.05.

Figure 1. Bare-ground greenhouse prior to furrow closer.

Figure 2. Large seed cotton prior to furrow closure.

Figure 3. Small seed cotton prior to furrow closure.

Figure 4. Soybean prior to furrow closure.

Figure 5. Corn prior to furrow closure.