EVALUATING THE EFFECT OF PLANTER DOWNFORCE AND SEED VIGOR ON CROP EMERGENCE AND YIELD IN HILL-DROP VS SINGULATED COTTON

S. S. Virk
W. M. Porter
K. Fue
J. L. Snider
J. Whitaker
Crop & Soil Sciences Department
University of Georgia
Tifton, GA

Abstract

Selection of correct planting parameters and their optimization based on current field conditions is crucial in achieving high crop emergence, which can translate to higher yields. A study was conducted during 2017 to evaluate the effect of planter downforce and seed vigor on crop emergence and yield in two cotton varieties planted with singulated and hill-drop seed plates. For this study, two cotton varieties (a small seeded low vigor variety and a large seeded high vigor variety) were planted at 1-inch seeding depth using two different planters to obtain singulated and hill-drop planting conditions. Two seeding rates of 29,000 seeds/ac and 42,500 seeds/ac were used to represent a typical low and high population for planting cotton in Georgia. Planter downforce treatments consisting of low, medium and high downforce values (100, 200 and 300 lbs., respectively) were implemented using the available downforce technology on both planters. Field data collection consisted of emergence counts at one and three weeks after planting and yield data from the center two rows of a four row plot at the end of the season. Data analysis indicated that singulated seeds were more effective in low downforce treatments independent of the crop variety. Hill-drop seeds exhibited better crop emergence (75-81%) in higher downforce treatments as compared to crop emergence (62-72%) obtained with singulated seeds. Yield data also suggested that singulated cotton can maximize emergence in low to medium downforce conditions for large seeded high vigor varieties whereas hill-drop cotton yields better with small seeded low vigor varieties planted at medium to high downforce. Results showed that low vigor varieties require higher seeding rates (more seeds per foot) when planted using low downforce to provide an overall high crop emergence rate whereas this trend was not observed in the high vigor variety. A comparison among seeding rates showed that higher seeding rates did not maximize crop emergence when planted as hill-drop. Overall results from this study emphasized the importance of using correct planting parameters (downforce, seeding rate, and variety) based on existing field conditions to maximize crop emergence and yield.

Introduction

Advancements in planting technology have provided growers with the ability to increase crop productivity and improve field efficiency by precisely metering and placing crop seeds. Planting constitutes one of the most important, if not most critical, field operation for any crop production. During planting, accurate seed placement in the soil is one of the most sought after and critical requirements when aiming to achieve a high yielding crop. Seed placement at shallower or deeper depths and inadequate seed-to-soil contact due to loose soil or compaction issues usually results in non-uniform and poor crop emergence, which generally translates to poor crop yields at the season end. Favorable planting conditions along with optimum planter performance in terms of seed placement are required for obtaining uniform seed germination and crop emergence (Carter et al., 1989). Past research has indicated that uniform emergence is required to maximize yield potential (Morrison et al., 1983; Wanjura, 1982). The opportunity for maximizing crop yield is even higher if the entire crop emerges as early as possible, typically within 7 to 10 days, after planting minimizing any yield penalties due to delayed emergence. Mostly, yield penalties from non-uniform emergence results from grower's negligence towards equipment setup and planter failures in achieving the required field performance during planting operation.

Cotton production in Georgia is a significant component of the state's agriculture industry and produces on average over two million bales of cotton from approximately one million harvested acres annually (USDA/NASS). Implementing new and efficient management practices is essential for sustaining and growing the profitability margin of cotton production in Georgia. With costly inputs and expensive machinery involved in cotton production, it is necessary more than ever to research new ways to maximize crop yields by intelligently using and combining the agronomic knowledge with advancements in planting technology. Many producers in Georgia still employ the practice of hill-drop cotton. It consists of dropping usually two or three seeds per drop at the same location along the row. This practice is used to plant enough seeds per location in the row to ensure stand establishment and to prevent replanting as traditionally practiced in cases of poor crop emergence. However, hill-drop also involves planting higher seeding rates (two or more seeds per drop) than seeding rates nominally planted in singulated (single seed per drop) cotton. With availability of new seed varieties and advanced planting technology that can compensate for varying field conditions, singulated cotton could provide similar, if not better, crop emergence than hill-drop planting in less than ideal field conditions. This can help in eliminating the need for hill-drop planting in most instances, thus reducing the additional seed costs incurred in cotton production.

Limited research has been conducted in the past exploring the planter components that could affect crop emergence and yield in cotton. In addition, the effect of these parameters on cotton planted in different configurations (hill-drop versus singulated) is not researched extensively. Singulated cotton is suggested to be a viable cost-saving option for reducing seeding rates (contrary to high seeding rates generally practiced in hill-drop cotton) when appropriate management practices and technology is employed (Siebert et al., 2006). The authors also recommended the need for future research to evaluate different seeding configurations for planting cotton under sub-optimal field conditions. It is believed that newer planting technology can provide consistent and higher planter performance under harsh field conditions. Further, optimizing planter setup based on the available seed varieties and existing field conditions can help in increasing crop emergence, which ultimately translates to high yields. Useful information can be gained by evaluating the effect of planter components, especially row-unit downforce as it helps achieve desired seeding depth and ensures proper seed-to-soil contact, in cotton planted under hill-drop versus singulated configurations. Seed varieties with considerable difference in seed mass and vigor can also be tested along with planter treatments to examine their effect on crop emergence and yield in cotton.

Objectives

The main goal of this study was to evaluate the effect of planter parameters specifically planter downforce and seed vigor on crop emergence in cotton under different seeding configurations. The specific objectives were to determine the effect of planter downforce and seed vigor on crop emergence and yield in singulated and hill-drop planted cotton, and to determine which downforce settings would produce the highest levels of emergence and yield for each vigor in hill-drop and singulated cotton.

Materials and Methods

The study was conducted at University of Georgia's Gibbs Farm located in Tifton, GA during the 2017 season. Two different planter setups, a 4-row Monosem NGPlus vacuum planter and a 4-row John Deere 7300 vacuum planter, were used for planting cotton for this study (Figure 1a & 1b). The Monosem planter was equipped with a mechanically driven seed meter with hill-drop seed plate and a mechanical spring system for downforce control whereas the John Deere planter was retrofitted with Precision Planting's electric seed meter with singulated seed plate and Precision Planting's Deltaforce hydraulic downforce control system. The precision planting system also had an individual row unit downforce feedback in the tractor cab via the display to visualize and adjust the planter downforce as per test requirements. A 24-cell (2 holes/location) hill drop seed plate and a 32-hole singulated seed plate was used for planting hill-drop and singulated cotton using Monosem and John Deere planters, respectively.

(a)

(b)

Figure 1. (a) 4-row Monosem NGPlus vacuum planter and (b) 4-row John Deere 7300 planter equipped with Precision Planting's V-set and Deltaforce system used for planting cotton in this study.

For this study, two different cotton varieties, a small seeded low vigor variety and a large seeded high vigor variety, were selected to evaluate the effect of planter treatments on crop emergence. Further, low and high seeding rates of 29,000 seeds/ac and 42,500 seeds/ac were planted based on the nominal cotton seeding rates typically planted in south Georgia and as per recommendation from UGA's cotton agronomist. These rates corresponded to a seed spacing of 8 inches and 12 inches (42,500 seeds/ac and 29,000 seeds/ac, respectively) between the two consecutive drops along the row for hill-drop cotton. Cotton was planted at 1-inch seed depth, which is nominal depth used for planting cotton in the Southeast US. Downforce treatments consisted of applying 100, 200 and 300 lbs. of force on individual row-units using the available downforce control systems on each planter. These downforce values (100, 200 and 300 lbs.) were considered as low, medium and high downforce for planting cotton in this study. Downforce treatments were implemented using a spring-adjusted lever on the Monosem planter, and using the in-cab display for controlling the hydraulic system on the John Deere planter. Field trials consisted of planting randomized treatments of planter setups (Hill-drop and Singulated) and seed varieties whereas seeding rates and downforce treatments were randomized within individual planter and variety treatments.

Field data collection consisted of stand counts at one and three weeks after planting (WAP) in 10-feet sections of the middle two-rows within each 4-row plot for determining crop emergence. Stand count data was converted to percent crop emergence to standardize data analysis and for comparison among all treatments. Cotton was harvested at the end of the season using a 2-row cotton picker with a weighing mechanism and a bucket specifically designed for small-plot harvesting. Yield data was collected by harvesting the center two-rows of each plot and dividing the weight of cotton in pounds by the harvested area in acres. All statistical analyses on data was performed ($\alpha = 0.05$) using JMP Pro 13 (SAS Institute Inc., NC, 1989-2007) to determine significant differences among treatments.

Results and Discussion

Emergence Data

Figures 2 and 3 show the cotton emergence data recorded for large seeded high vigor variety after one and three weeks, respectively after planting. The data is arranged by downforce treatments within each seeding rate used in this study. It can be observed from figure 2 that singulated cotton performs best (mean emergence >80%) when planted using low to medium downforce irrespective of the seeding rates. Emergence dropped to as low as 60-65% for singulated cotton when high downforce (300 lbs.) was applied. Statistical analysis showed significant differences between emergence rates observed for low-medium downforce treatments and high downforce treatment for singulated cotton. Contrary to singulated seed, hill-drop planted cotton performed equally well (mean emergence 75-85%) at all downforce treatments irrespective of the seeding rates. In addition, the emergence for hill-drop cotton planted using high downforce was comparably higher (mean emergence >80%) compared to the low emergence recorded for singulated cotton. Statistical analysis also confirmed that hill-drop planted cotton exhibited high emergence rates at all downforce treatments. Similar trends in the emergence data were observed at 3 weeks after planting as shown in Figure 3.

The low crop emergence at high downforce treatments in singulated cotton suggests soil compaction around the seedbed during planting as well as the possibility of pushing the seed deeper than 1-inch due to high downforce. Although similar conditions existed for hill-drop cotton, the presence of more seeds per foot helped in maximizing the emergence in compacted soils. The presence of two seeds per location provided extra force for emergence (at least one seed out of two) than the singulated seed. Therefore, it can be implied that large seeded high vigor varieties can exhibit higher emergence rates in harsh field conditions, especially in wet and compacted soils, when compared to low vigor varieties both planted as singulated cotton in those field conditions. The data also suggests that singulated cotton performs better in non-compacted soils when planted using low to medium (100 – 200 lbs.) downforce. In this scenario, cotton production can benefit by planting singulated cotton instead of hill-drop when planting in dry and non-compacted field conditions.

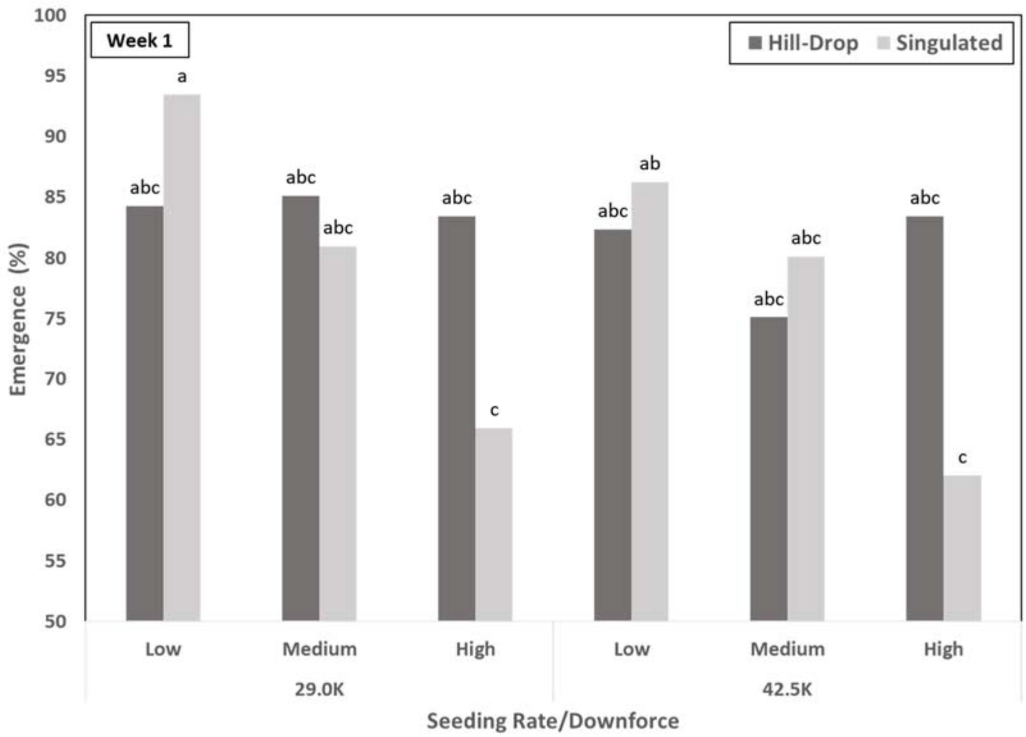

Figure 2. Emergence data (in percent) recorded at one week after planting for large seed high vigor variety. (Same letters on bars represent treatments that are not statistically different)

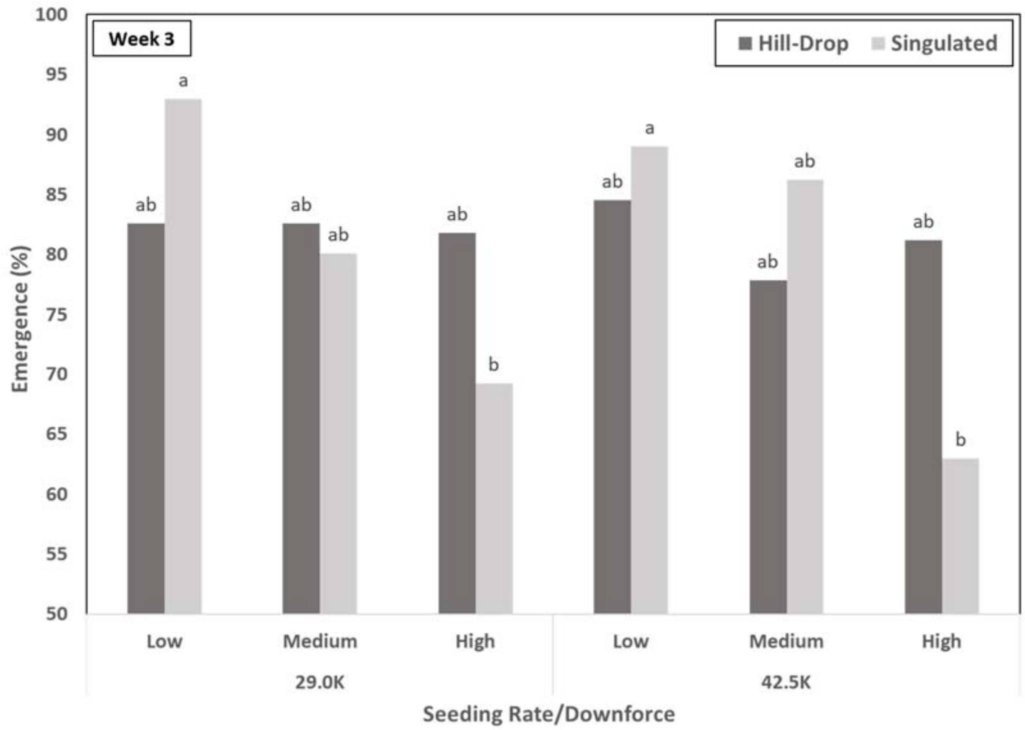

Figure 3. Emergence data (in percent) recorded at three weeks after planting for large seed high vigor variety. (Same letters on bars represent treatments that are not statistically different)

Figures 4 and 5 represent the cotton emergence data collected for the small seed low vigor variety after one and three weeks after planting respectively. The data is arranged by downforce treatment within individual seeding rates used in the study. Emergence data recorded at week one shows an overall higher mean emergence (72 – 83%) for hill-drop planted cotton under all treatments except for one treatment (42,500 seeds/ac and low downforce) than singulated cotton. High emergence rates (mean emergence >75%) for singulated cotton were only observed when planted using low downforce for the low vigor variety. It was also noted that singulated cotton planted at a higher seeding rate (42,500 seeds/ac) had higher mean emergence than cotton planted at the low seeding rate, which indicated the effect of seeding rate on crop emergence in singulated cotton. This effect was not observed in hill-drop cotton as suggested by the similar mean emergence (72 – 82%) recorded for all the treatments. When comparing downforce treatments, singulated cotton exhibited low mean emergence (60-65%) when planted using medium to high downforce at both seeding rates. Statistical analysis also indicated significant differences between singulated cotton planted using low downforce and cotton planted using medium to high downforce.

Although emergence data at week three (Figure 5) shows comparable emergence values for both singulated and hill-drop cotton, it also suggests delayed emergence in singulated cotton as compared to early uniform emergence observed in hill-drop cotton observed during the week one data collection. The delayed emergence in singulated cotton between week one and three could be an issue as it can present additional problems such as delayed crop growth, weed pressure, more susceptibility to diseases, insects and pests, etc., during the season. Therefore, early and uniform emergence is usually preferred and helps in achieving higher yields. Results suggested that hill-drop planted cotton would provide better emergence than singulated cotton when planting small seed low vigor varieties in less than ideal field conditions using medium to high downforce. This can be explained by the fact that small seeded low vigor varieties usually have lower emergence in compacted or crusted soils when compared to large seeded high vigor varieties. Singulated cotton with small seed low vigor variety should only be considered when planting in near-perfect field conditions using low downforce. Producers should be more cautious about planter setup (hill-drop versus singulated) and seeding rates (low and high) when planting small seeded low vigor varieties. Hill-drop should generally be preferred over singulated cotton in most field conditions when planting low vigor varieties.

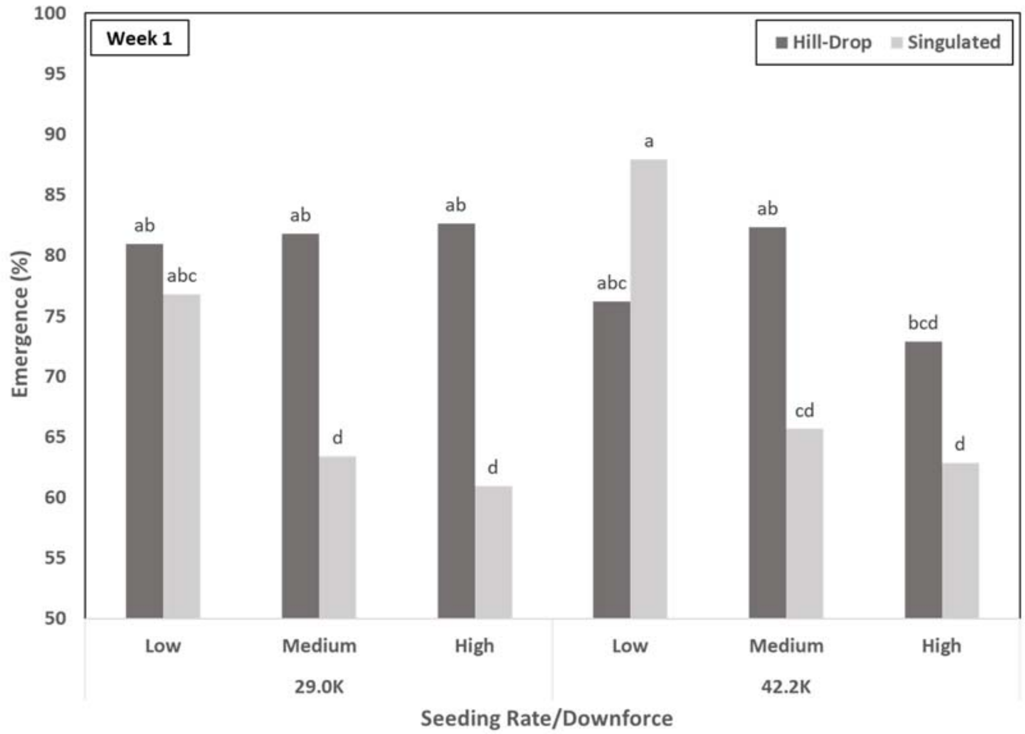

Figure 4. Emergence data (in percent) recorded at one week after planting for small seed low vigor variety. (Same letters on bars represent treatments that are not statistically different)

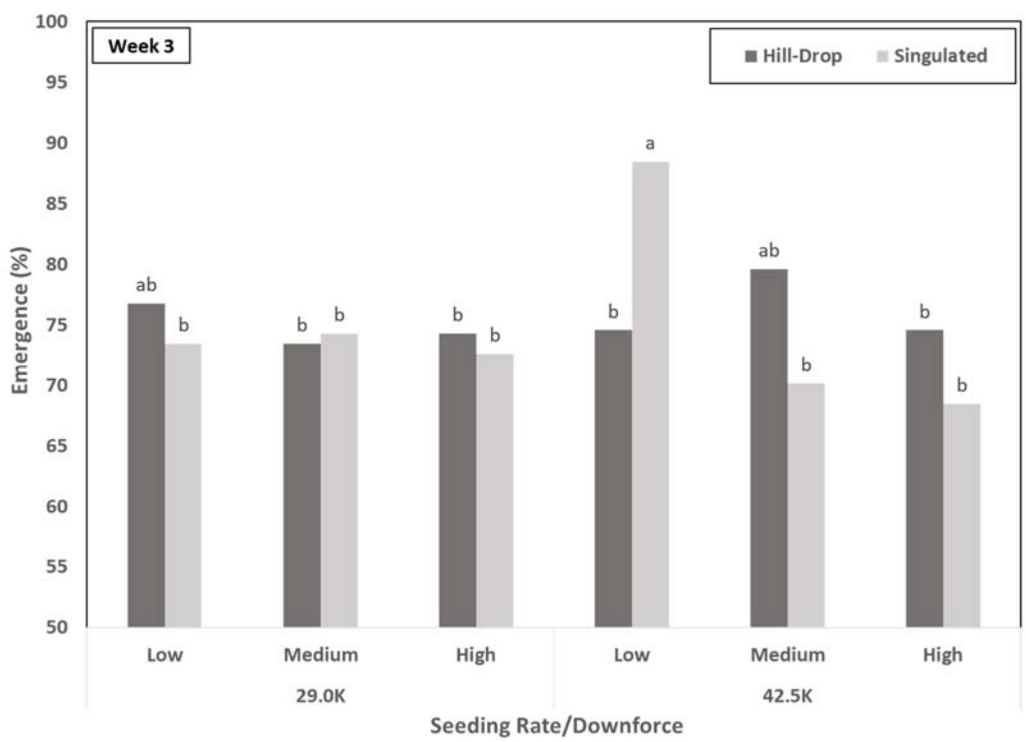

Figure 5. Emergence data (in percent) recorded at three weeks after planting for small seed low vigor variety. (Same letters on bars represent treatments that are not statistically different)

Yield Data

Figure 6 shows the cotton lint yield in lbs/ac for large seed high vigor variety at different downforce treatments and seeding rates used in the study. Both singulated and hill-drop cotton produced comparable yields when planted using low and medium downforce treatments. There were no significant differences between yields for singulated and hill-drop cotton except for when planted using high downforce. Yield data followed a similar trend as emergence data for cotton planted at high downforce for the high vigor variety. Hill-drop cotton planted using high downforce provided significantly higher yields compared to singulated cotton planted using the same downforce. This observation verified the results from the emergence data that hill-drop cotton has the ability overcome harsher field conditions (wet and compacted soils) better than singulated cotton. Contrary to the expected result, lower seeding rates in both hill-drop and singulated cotton produced higher yields than yields observed at higher seeding rates.

Cotton yield data in lbs/ac for small seed low vigor variety for different downforce treatments and seeding rates is shown in Figure 7. There were statistical differences between mean yields for hill-drop and singulated cotton for two test treatments: low seeding rate (29,000 seeds/ac) planted using low downforce and high seeding rate (42,500 seeds/ac) planted using medium downforce. For all other seeding rate and downforce treatments, mean yields for hill-drop were similar to the mean yields for singulated cotton. Similar trends were observed in the emergence data recorded at three weeks after planting for this variety. Some of the comparable yields between treatments at the season end can also be explained by the fact that cotton is known to compensate for varying field and environment conditions throughout the season. Hill-drop cotton planted using low and high downforce treatments produced similar yields irrespective of the low and high seeding rates. This data also suggested that planting higher seeding rates in hill-drop cotton under these downforce treatments does not necessarily provide a yield advantage over lower seeding rates. These results confirm that hill-drop should be preferred over singulated cotton especially when considering planting small seed low vigor varieties in less than ideal field conditions. Additionally, producers can also benefit from planting lower than nominal seeding rates when planter parameters are correctly matched to the existing field conditions.

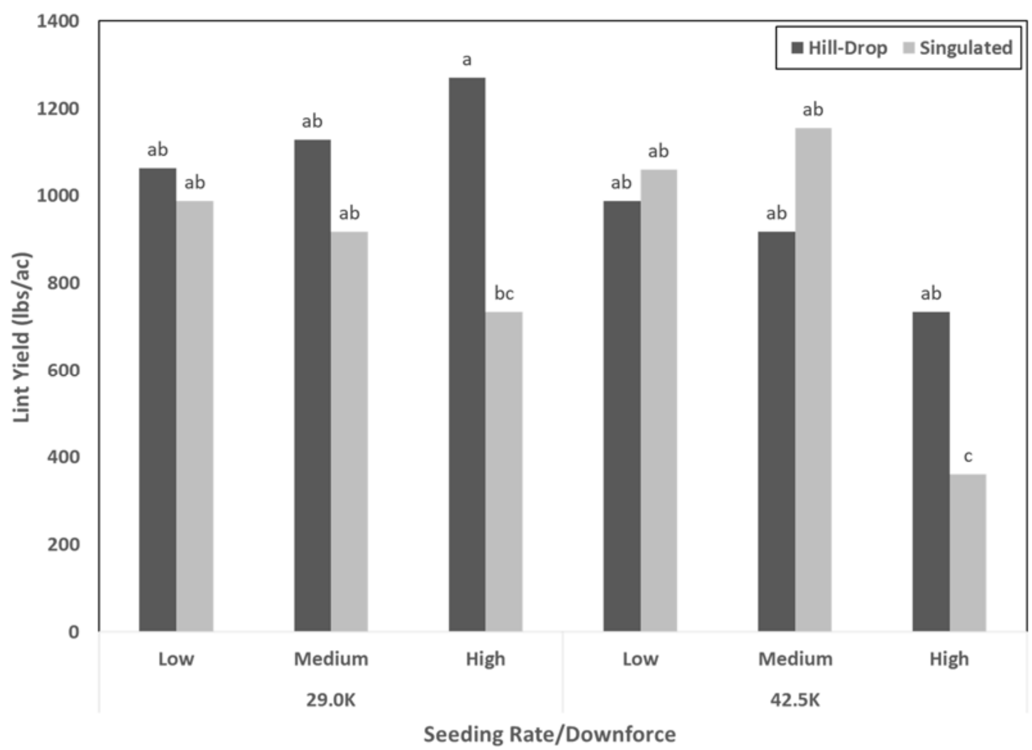

Figure 6. Cotton lint yield data (in lbs/ac) for large seed high vigor variety arranged by seeding rate and downforce. (Same letters on bars represent treatments that are not statistically different)

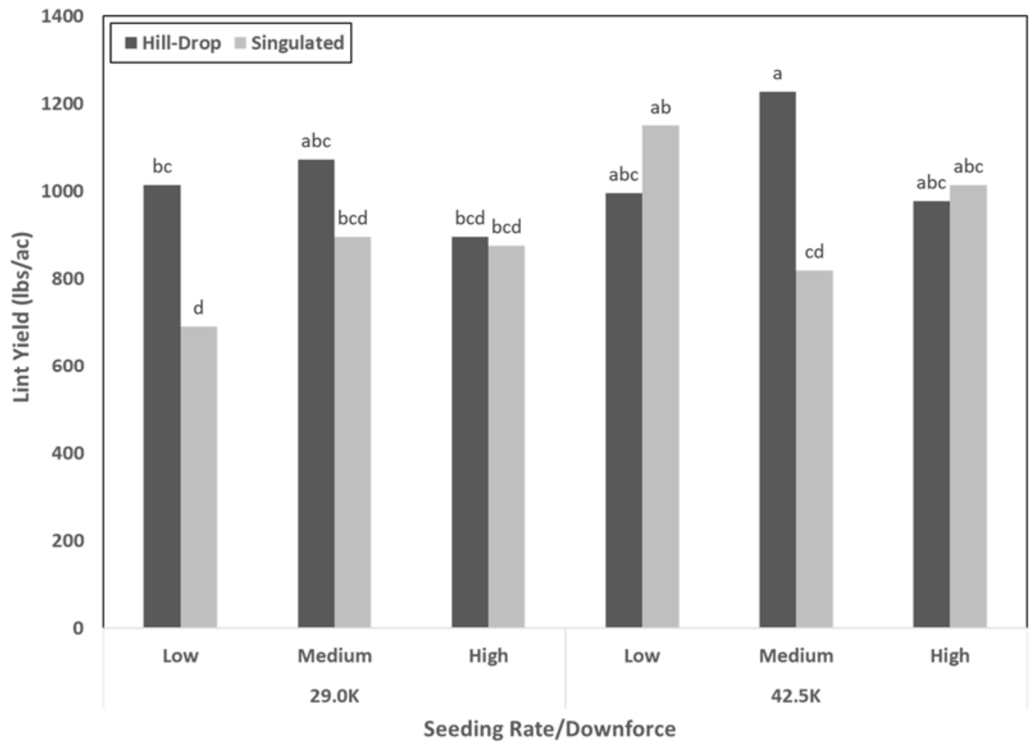

Figure 7. Cotton lint yield data (in lbs/ac) for small seed low vigor variety arranged by seeding rate and downforce. (Same letters on bars represent treatments that are not statistically different)

Summary

This study examined the effects of planter downforce and seed vigor treatments on crop emergence and yield for two different planting scenarios in cotton: hill-drop and singulated. For both planting conditions, three planter downforce treatments (low, medium and high) along with two different seeding rates (low and high) were tested on two cotton varieties of varying seed size and vigor. Emergence data collected at one and three weeks after planting showed significant differences between singulated cotton planted using low to medium downforce (mean emergence > 80%) and high downforce (mean emergence 60-65%) for the large seeded high vigor variety. Downforce treatments did not have a significant effect on emergence in hill-drop cotton as indicated by the similar emergence rates (mean emergence 75 -85%) at different downforce treatments. These results showed that hill-drop planted cotton was able to overcome the compacted soils conditions created by high downforce better than singulated cotton. The presence of extra seeds per foot in hill-drop cotton helps in maximizing crop emergence especially under harsh field conditions. Yield data for the large seeded high vigor variety also confirmed the findings from emergence data. Singulated cotton produced similar yields as hill-drop cotton when planted using low to medium downforce in more ideal field conditions. Higher yields for hill-drop cotton planted using high downforce irrespective of the seeding rate treatments were observed. For the small seeded low vigor variety, singulated cotton exhibited similar emergence to hill-drop cotton only in a low downforce conditions for both seeding rate treatments. Hill-drop cotton (mean emergence 72-83%) had significantly higher emergence than singulated cotton (mean emergence 60-65%) at all other downforce and seeding rate treatments as shown by early (week one) emergence data. Week three emergence data in the small seeded low vigor variety indicated delayed non-uniform emergence in singulated cotton. Cotton yields for hill-drop cotton were significantly higher than singulated cotton for two test treatments: 29,000 seeds/ac (low seeding rate) planted using low downforce and 42,500 seeds/ac (high seeding rate) planted using medium downforce. For all other test treatments, hill-drop cotton produced comparable mean yields than singulated cotton for the low vigor variety. Comparison among seeding rates also indicated no significant yield advantage of planting higher than nominal seeding rates in hill-drop cotton.

Results from the study showed that crop emergence and yield could be significantly affected by choice of seed variety and planter downforce when planting cotton. Further, seed variety and planter downforce can be correctly matched and setup for existing field conditions in order to take advantage of both singulated and hill-drop cotton planting. This study also emphasized the importance of evaluating pre-plant field conditions such as presence of excessive soil moisture, which can create compaction problems while planting, or extremely dry field conditions that would require excess downforce to place seed at desired seeding depth. The study suggests that producers who prefer large seeded high vigor varieties could benefit their cotton production by planting singulated cotton in ideal field conditions by utilizing low to medium planter downforce. For producers considering small seed low vigor varieties, hill-drop planting would be a good option as it can produce better crop emergence and yield even in harsher field conditions as compared singulated cotton. In conclusion, careful selection of seed variety and optimization of planter settings based on seed variety and exiting field conditions is necessary in order to achieve uniform crop emergence and high cotton yields.

Acknowledgements

Authors would like to thank the Georgia Cotton Commission for funding and support of this project.

References

Carter, P. R., E.D. Nafzinger and J.G. Lauer. 1989. Uneven emergence in corn. North Central Extension Service. Publication No. 344.

Morrison, J. E. and T.J. Gerik. 1983. Planter depth-control predictions and projected effects on crop emergence. ASABE. (1):1-16.

Siebert, J. D., A. M. Stewart and B. R. Leonard. 2006. Comparative growth and yield of cotton planted at various densities and configurations. Agronomy Journal. 98(3): 562-568.

USDA/NASS. 2017. State Agriculture Overview for Georgia." Nass.usda.gov. USDA, Web. Accessed 19 Jan 2018.

Wanjura, D. F. 1982. Reduced cotton productivity from delayed emergence. Transactions of the ASAE, 25 (6), 1536-1539.