CONSIDERATIONS FOR PLANTER DOWNFORCE AND SEEDING RATE TO MAXIMIZE EMERGENCE AND YIELD IN SINGULATED VERSUS HILL-DROP PLANTED COTTON

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Abstract

Obtaining early uniform crop emergence is highly dependent on correct selection of planter parameters as well as crop variety selection based on prevailing field conditions. A study was conducted during the 2018 growing season to evaluate crop emergence and yield of two cotton cultivars as affected by seeding rate and planter downforce under singulated and hill-drop seeding configurations. Two cotton cultivars differing in seed size and vigor (a small seeded low vigor variety and a large seeded high vigor variety) were planted using singulated and hill-drop cotton plates at a seed depth of 1 inch. Three different seeding rates (20,000, 28,000, and 43,500 seeds/ac) were used along with two planter downforce treatments of zero and 200 lbs. of applied force on the individual row-units. The study was planted using a 4-row Monosem Vacuum Planter equipped with a manual downforce control system under strip-till conditions. Field data collection consisted of stand counts at one and three weeks after planting (WAP) to evaluate crop emergence, and yield data during harvest. Results suggested that the large seeded high vigor cultivar had higher mean emergence (54-81%) at 3 WAP than the mean crop emergence (38-60%) for the small seeded low vigor cultivar irrespective of the seeding rate and downforce treatments. Statistical analysis did not show any significant differences ($p>0.05$) in crop emergence values between the singulated and hill-drop treatments in both cultivars. Significant differences were observed in the crop emergence (at 3 WAP) and lint yield between the zero and 200 lbs. downforce treatment at 28,000 seeds/ac rate in the singulated treatment. Higher mean yields (1510-1880 lb/ac) were recorded for the large seeded high vigor cultivar than the mean yields (1160-1680 lb/ac) for the small seeded low vigor cultivar. A comparison among seeding rates did not exhibit any significant advantage of planting higher seeding rates to improve crop emergence and yield in both singulated and hill-drop treatments. This study emphasized the careful consideration of planting parameters such as seeding rate and planter setup along with proper selection of cultivar and assessing existing in-field conditions to maximize crop emergence and yield potential in cotton.

Introduction

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, 2017). Sustaining and growing the profitability margin of cotton production in Georgia demands exploring and adopting new and efficient management practices that can save input costs and maximize returns. With costly inputs and expensive machinery involved in cotton production, it is necessary more than ever to research new ways to increase crop yields by smartly using and combining the agronomic knowledge with advancements in planting and seed technology. Advancements in planting technology have provided growers with the ability to increase crop productivity and improve field efficiency by offering precise seed metering and placement. 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 (Wanjura, 1982; Ford and Hicks, 1992). 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). 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.

Although, today's planting machinery and technology provide highly accurate seed singulation and precise seed placement in the soil, thus maximizing the chances of seed germination and crop emergence, many producers in the Southeastern US still employ the practice of hill-drop cotton. This practice consists of dropping usually two or three seeds per drop at the same location along the row, and is utilized typically to plant enough seeds per location in the row to ensure adequate stand establishment and to prevent replanting as traditionally practiced in cases of poor crop emergence. Even though hill-drop cotton is planted at the same seeding rates as singulated cotton, however since the two or three seeds are planted so close in proximity that only one plant emerges (survives) in most cases. This practice results in relatively inefficient utilization of crop inputs to obtain better stand establishment. With availability of new seed cultivars and advanced planting technology which can be adjusted for varying field conditions, it is hypothesized that singulated planted cotton with correct planter setup based on in-field conditions could provide similar, if not better, crop emergence than hill-drop planting even in harsher field environments. The recommended seeding rates for singulated cotton is at least 2 seeds per-row foot (29,040 seeds/ac) as per recommendations from the UGA cotton production guide (2018a). Growers in the Southeastern US typically plant as low as 1.5 seeds per-row foot and as high as 3 seeds per row-foot (between 21,780 seeds/ac to 43,560 seeds/ac) in order to achieve adequate stand establishment in both singulated and hill-drop conditions. However, compared to hill-drop planting, singulated planting provides better seed-to-seed spacing and seed placement within the soil ensuring better overall utilization of crop inputs. Singulated planted cotton using adequate planter setup and correct choice of seed variety can help in eliminating the need for hill-drop planting in most instances, thus helping in reducing the additional seed costs incurred in cotton production.

Except for the research studies conducted at the University of Georgia Tifton campus in the past two years, very limited research exists that have explored different planting parameters (downforce and seeding rate) in relation to crop emergence and yield in cotton specifically under these two hill-drop versus singulated seeding configurations. Siebert et al., 2006 suggested singulated cotton as a viable cost-saving option for reducing seeding rates when appropriate management practices and technology is employed. The authors recommended the need for future research to evaluate different seeding configurations for planting cotton under sub-optimal field conditions. Therefore, a research study was completed to study the effect of planter components specifically row-unit downforce as it helps to achieve desired seeding depth and ensure proper seed-to-soil contact, along with different seeding rates in cotton (ranging from low to high rates typically planted in the Southeastern US) planted in hill-drop versus singulated configurations. Further, since seed size and vigor is considered important in cotton production, two cultivars with considerable difference in seed mass and vigor were also tested in addition to the planter and seeding rate 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 seeding rates on crop emergence and yield in two cotton cultivars planted as singulated and hill-drop configuration. The specific objectives were to determine the effect of planter downforce and seeding rate on crop emergence and yield in singulated and hill-drop planted cotton, and to determine which downforce setting and seeding rate within each seed vigor would produce the highest levels of emergence and yield in given seeding configuration.

Materials and Methods

The study was conducted on a University of Georgia Research Farm located in Tifton, GA during the 2018 season. A 4-row Monosem NG*Plus* vacuum precision planter (Monosem Inc., Edwardsville, KS) set at crop row-spacing of 36 inches was used for planting cotton in this study (Figure 1a). The Monosem planter was equipped with a mechanically driven seed meter and a mechanical downforce control system equipped with heavy springs for applying additional force on the individual row-units. The downforce adjustments were accomplished by moving and securing the spring-attached lateral arm in different positions using a pin (Figure 1b) which allowed to increase or decrease the amount of applied force on the individual row-units. The four positions of the arm corresponded to 100, 200, 300, and 400 lbs. of applied force whereas disengaging the arm from the bracket resulted in zero lbs. of applied force in excess of the row-unit weight. An 18-cell singulated seed plate (Part# DN1830, Monosem Inc., Edwardsville, KS) and a 12-cell hill-drop seed plate (Part# DN1230, Monosem Inc., Edwardsville, KS) was used for planting singulated and hill-drop cotton, respectively in this trial. The seeding rates were achieved by changing the gear ratio between the drive and driven wheel (seed meter) as recommended in the Monosem NGPlus planter manual for achieving the desired seeding rates. All other planter settings such as vacuum pressure and seed depth adjustments were performed as per instructions in the operator manual for the Monosem planter.

(a) (b)

Figure 1. (a) 4-row Monosem NG*Plus* vacuum precision planter, and (b) downforce control assembly (spring-loaded arm and pin attachment shown in the dashed box) used for downforce adjustments in the study.

For this study, two different cotton cultivars, a small seeded low vigor (LV) cultivar and a large seeded high vigor (HV) cultivar, were selected to evaluate the effect of planter treatments on crop emergence. Further, three different seeding rates of 19,000 seeds/ac, 28,000 seeds/ac and 43,500 seeds/ac were planted. These seeding rates corresponded to low, nominal and high seeding rates typically planted by growers in South Georgia. These rates corresponded to a seed spacing of 16, 12, and 8 inches (19,000, 28,000 and 43,500 seeds/ac, respectively) between the two consecutive drops along the row for hill-drop cotton. It should be noted that the 20,000 seeds/ac seeding rate for the hill-drop treatment was actually planted at 64,000 seeds/ac due to a planter setup error (incorrect gear ratio) while implementing this rate for the hill-drop treatment. Therefore, the 20,000 (20.0 ksds/ac) seeding rate is illustrated as 64,000 (64.0 ksds/ac) for hill-drop cotton in the graphs in the results section. Cotton was planted at a 1-inch seed depth nominally utilized for planting cotton in the Southeastern US. Downforce treatments consisted of applying no addition downforce (row-unit weight only) and 200 lbs. of applied force on individual row-units using the mechanical downforce control system available on the Monosem planter. These downforce values were selected based on the existing in-field conditions at planting and were deemed appropriate for strip-till planting conditions in the selected field. The study was implemented in a completely randomized block design with treatments consisting of seeding configuration (singulated versus hill-drop), seeding rate, and downforce. A split-planter configuration was utilized for planting the two selected cultivars where the left half (rows 1 and 2) of the planter was set up to plant the LV cultivar, and the right half (rows 3 and 4) of the planter was setup to plant the HV cultivar. The plots measured 12 feet (4-rows wide) by 30 feet (length). Cotton was planted in strip-till conditions in heavy wheat residue with four replications for each treatment randomized within the field.

Field data collection consisted of stand counts at one and three weeks after planting (WAP) in the 10-feet section (same 10-feet section for one and three WAP data collection) in the two rows planted with each cultivar to determine crop emergence. Stand count data was converted to percent crop emergence to standardize data analysis and for comparison among all test treatments. Yield was collected by harvesting the two data rows in each plot and lint weight was measured by ginning samples at University of Georgia's microgin located in Tifton, GA. Lint yield was calculated by dividing the weight of lint in pounds by the harvested area in acres for each plot. All statistical analyses on these data was performed using JMP Pro 13 (SAS Institute Inc., NC, 1989-2007) to determine significant differences among treatments at 95% confidence interval (± = 0.05).

<u>Results and Discussion</u>

Table 1 provides the summary statistics for the emergence data collected at one and three WAP, and the crop yield. The data presented in the table show the test effects (at 95% confidence interval and alpha value of 0.05*)* for different treatments utilized in the study, and their corresponding p-values for crop emergence and yield. It can be observed from the data that cultivar significantly affected 1 and 3 WAP crop emergence ($p<.0001$), and crop yield ($p=0.0092$). Seeding configuration (singulated versus hill-drop) was not found to be significant ($p>0.05$) indicating no significant effect of singulation on crop emergence and cotton yield. This can be explained as that there were no significant differences in the crop emergence and yield values between the singulated and hill-drop treatments. Seeding rate and downforce were not found to be significant, however the singulation-downforce interaction had a significant effect on the crop emergence at 3 WAP. Singulation-seeding rate and seeding rate-downforce interactions were found to be significant at 10% level of significance but not at the 5% significance level. All other interactions were not significant at the 5% level of significance as indicated by the test p-values.

Table 1. Summary Statistics showing test effects and corresponding p-values for emergence at one and three WAP and yield (±=*0.05)*.

Treatment/ Effect	**Emergence (p-value)**		**Yield (p-value)**
	1 WAP	**3 WAP**	
Singulation	0.7751	0.1137	0.1397
Seeding Rate	0.3221	0.2725	0.1986
Downforce	0.2011	0.3727	0.5549
Cultivar	<.0001**	<.0001**	0.0092**
Singulation-Seeding Rate	0.1077	0.0805	0.1389
Singulation-Downforce	0.1041	0.0467*	0.4816
Seeding Rate-Downforce	0.1047	0.0718	0.5106
All Other Interactions	>.05	>.05	>.05

**Significant at less than 1% Probability level, *Significant at less than 5% Probability level

Emergence Data

Figures 2 and 3 show the cotton emergence data recorded at one and three WAP for the HV cultivar and the LV cultivar, respectively for both the singulated and hill-drop treatments. The data is arranged by seeding rate treatment within each downforce treatment along the x-axis of the graphs. It can be observed from figure 2 that the crop emergence for both singulated and hill-drop treatments was very similar at one and three WAP indicating the early uniform emergence in both types of singulation treatments for the HV cultivar. The overall mean crop emergence at three WAP varied between 54-81% with the lowest mean emergence of 54% recorded for the 64.0 ksds/ac at 200 lbs. of downforce for the hill-drop treatment, and the highest mean emergence of 81% recorded for the 20.0 ksds/ac at zero lbs. of downforce for the singulated treatment. As shown in figure 3, the overall mean crop emergence at three WAP for the LV cultivar was comparably lower (38-60%) than the mean crop emergence at three WAP for the HV cultivar. It can be noted for this cultivar that the crop emergence at three WAP for both singulated and hill-drop treatments was considerably higher than the crop emergence at one WAP indicating delayed non-uniform emergence in the LV cultivar. The delayed emergence observed 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.

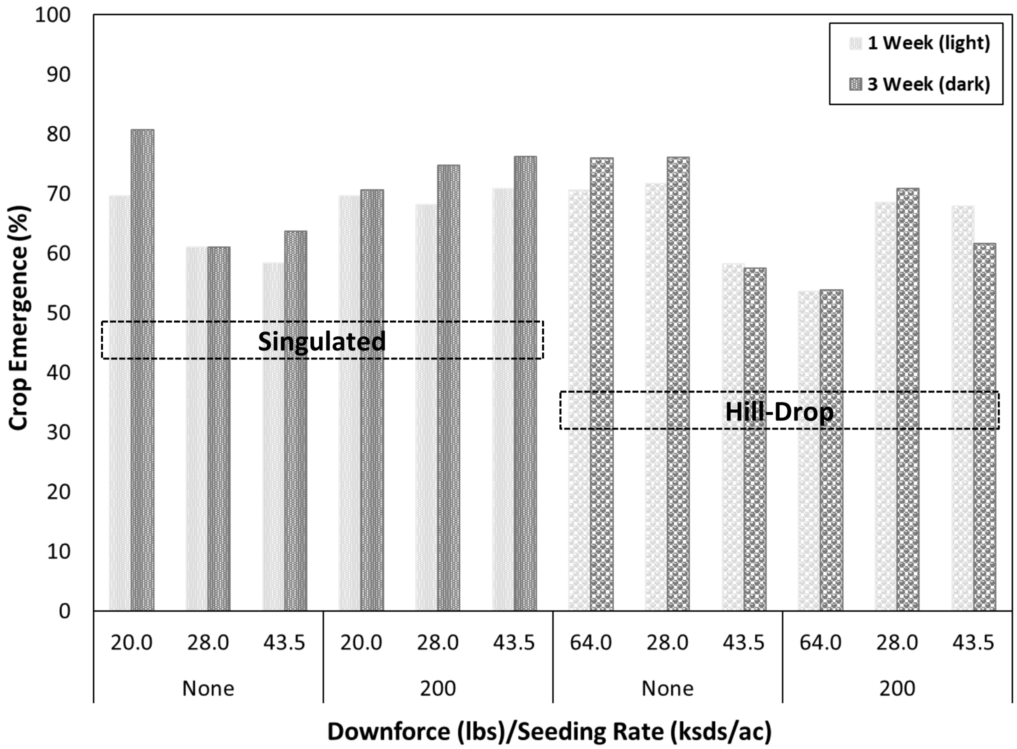

Figure 2. Mean emergence (in percent) recorded at one and three weeks after planting for the HV cultivar.

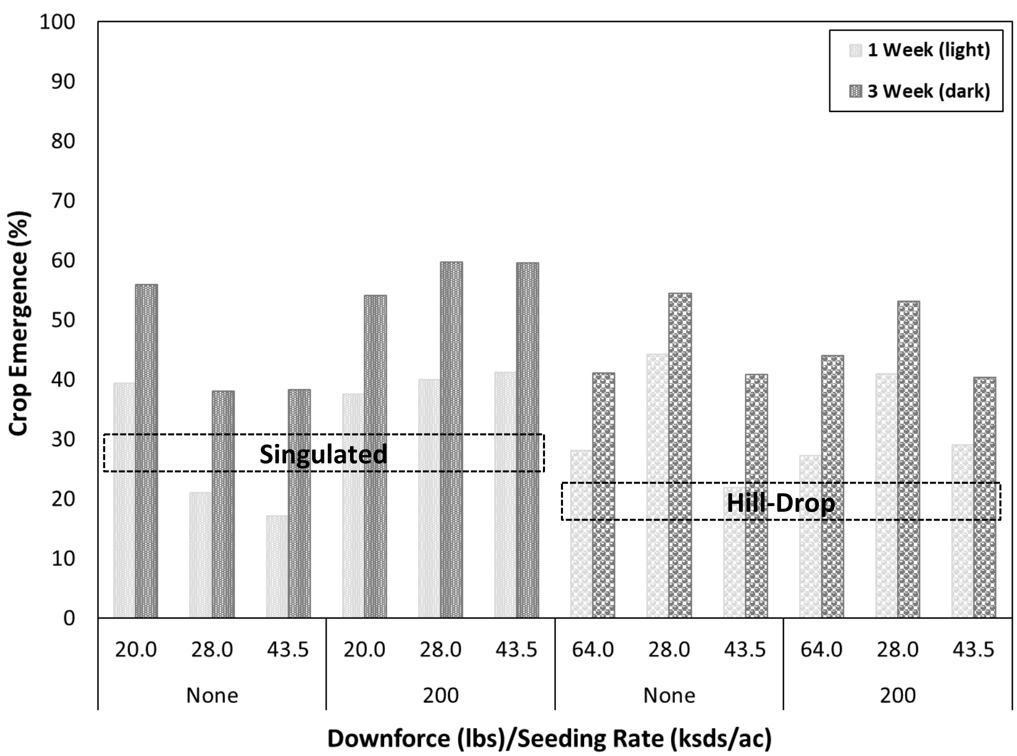

Figure 3. Mean emergence (in percent) recorded at one and three weeks after planting for the LV cultivar.

Figures 4 and 5 display cotton emergence data recorded at three WAP for both the singulated and hill-drop treatments planted with the HV cultivar and LV cultivar, respectively. The data is arranged by seeding rate within individual downforce treatments along the x-axis of the graphs. As observed in figure 4, there were no statistical differences between the crop emergences for singulated and hill-drop treatments for the same seeding rate and downforce treatments as denoted by the same letters on the bars in the graph. This observation indicated that both singulated and hill-drop treatments performed comparably well irrespective of the seeding rate and downforce treatments for the HV cultivar. This result was expected as past research on other plant species has indicated that a more vigorous cultivar would tend to compete better for available resources and outperform a less vigorous cultivar in sub-optimal field conditions (Coomes and Grubb, 2003; Muller-Landau, 2012). It was interesting to note that the crop emergence at 20.0 ksds/ac for the singulated treatment was not significantly different than the crop emergence at 64.0 ksds/ac for the hill-drop treatment for both the zero and 200 lbs. downforce treatments. Given the fact that the hill-drop treatment had close to a tripled seeding rate than the singulated treatment, it did not provide an increase in emergence due to more seeds per foot planted in the row.

Although the graph in figure 5 shows visual differences between emergence values for singulated and hill-drop treatments, no statistical differences were found between the two seeding configurations for the seeding rate and downforce treatments used in the study. This result verified the similar findings as observed for the HV cultivar indicating comparable performance between both the singulated and hill-drop treatments. Also, no statistical differences existed between the mean crop emergence at the 20.0 ksds/ac seeding rate for the singulated treatment, and 64.0 ksds/ac seeding rate for the hill-drop treatment at both downforce treatments. However, within the singulated treatment, the mean crop emergence at 28.0 ksds/ac and 43.5 ksds/ac (both 38%) for the zero downforce treatment was significantly lower than the mean crop emergence at 28.0 ksds/ac and 43.5 ksds/ac (both 60%) for 200 lbs. downforce treatment. This can be explained by the fact that the LV cultivar needs additional downforce, especially in strip-till conditions, to achieve the desired seeding depth or the soil depth with enough moisture where soil-to-seed contact is favorable for optimal germination. It can also be stated from the data that accurate seed placement especially within a favorable soil moisture condition is more critical when planting a LV cultivar as it is less compensating and more susceptible to varied planting conditions when compared to a HV cultivar.

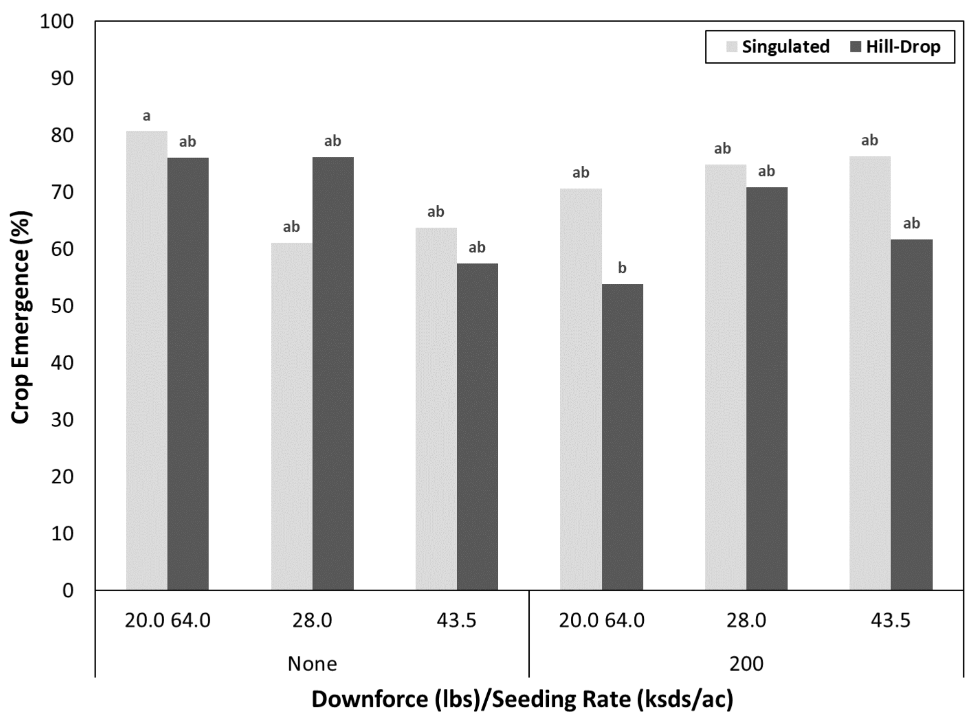

Figure 4. Mean emergence (in percent) recorded at three weeks after planting for the HV cultivar planted in singulated and hill-drop treatments. (Same letters on bars represent treatments that are not statistically different)

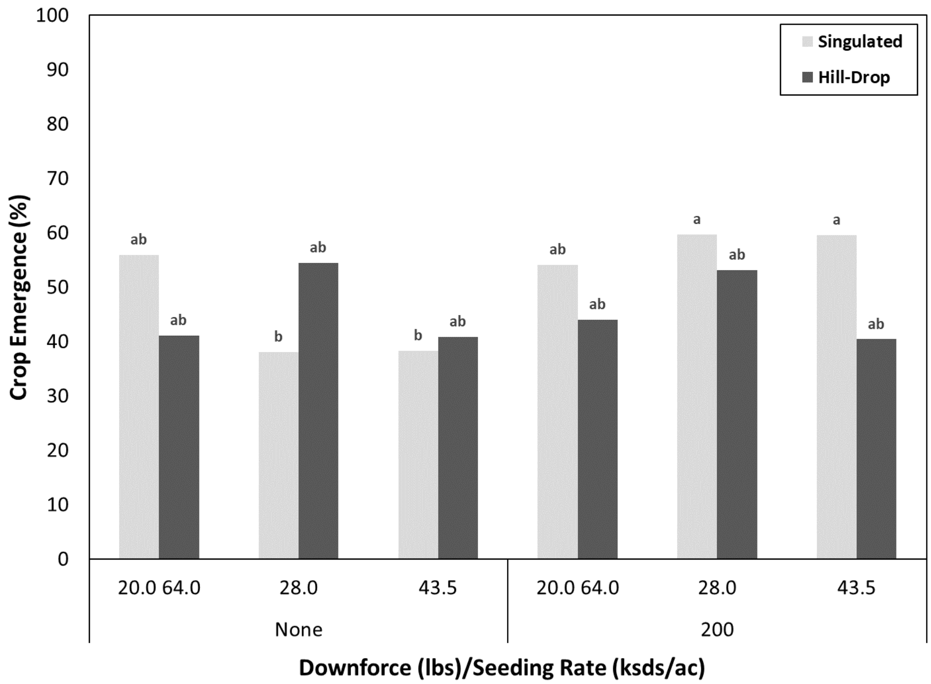

Figure 5. Mean emergence (in percent) recorded at three weeks after planting for the LV cultivar in singulated and hill-drop treatments. (Same letters on bars represent treatments that are not statistically different)

Yield Data

Figure 6 shows the cotton lint yield in lb/ac (pounds/acre) for the HV cultivar at different downforce treatments and seeding rates used in the study. Both singulated and hill-drop treatments exhibited similar mean yields (ranging between 1510–1880 lb/ac) for this cultivar at the selected seeding rate and downforce treatments used in the study. As indicated by the same letters above the bars in the graph, there were no significant differences between yield for the singulated and hill-drop treatments irrespective of the seeding rate and downforce treatments. These observations also verified the results from the emergence data that high vigor cultivars tend to overcome harsher field conditions better than low vigor cultivars. It was observed that the mean yield for the singulated treatment at 20.0 ksds/ac seeding rate was not statistically different from the mean yield for the hill-drop treatment at 64.0 ksds/ac irrespective of downforce treatments. This implies that higher cotton yields can be achieved by planting singulated cotton at lower to nominal seeding rates especially when planting high vigor cultivars. This data also suggests that planting hill-drop cotton especially at high seeding rates can be avoided in order to obtain a higher crop stand and yield, when planting high vigor cultivars. This would help in saving seed costs as well as helps in being efficient with the utilization of available crop inputs (cotton seed).

Cotton yield data in lb/ac for the LV cultivar for different downforce and seeding rate treatments is shown in Figure 7. The mean yields varied between 1160-1680 lb/ac for the singulated treatment, and between 1380-1680 lb/ac for the hill-drop treatment. Overall, the mean yields for the LV cultivar was lower than the mean yields for the large HV cultivar. Similar trends were observed in the crop emergence data for both cultivars. Similar to the observations for the HV cultivar, no significant differences were observed between the singulated and hill-drop treatments at the selected downforce and seeding rate treatments for the LV cultivar. Some of the comparable yields between treatments at the season end can be explained by the fact stated earlier that cotton is known to compensate for varying field and environmental conditions throughout the season. However, there were significant differences between mean yields at the 28.0 ksds/ac rate for zero and 200 lbs. of downforce (1160 and 1680 lb/ac, respectively) for the singulated treatment. This trend was also reflected in the crop emergence data for the singulated treatment at the 28.0 ksds/ac and 43.5 ksds/ac rate for this cultivar. Mean yields for both singulated and hill-drop treatments were comparable between all seeding rate treatments irrespective of the zero and 200 lbs. of downforce treatments. This suggests that planting higher seeding rates in both singulated and hill-drop treatments does not necessarily provide a yield advantage over planting lower or nominal seeding rates. Although certain producers are biased towards planting a particular cultivar and also prefer planting hill-drop cotton, they can benefit from planting lower or nominal seeding rates by correct selection of planter parameters based on the existing in-field conditions.

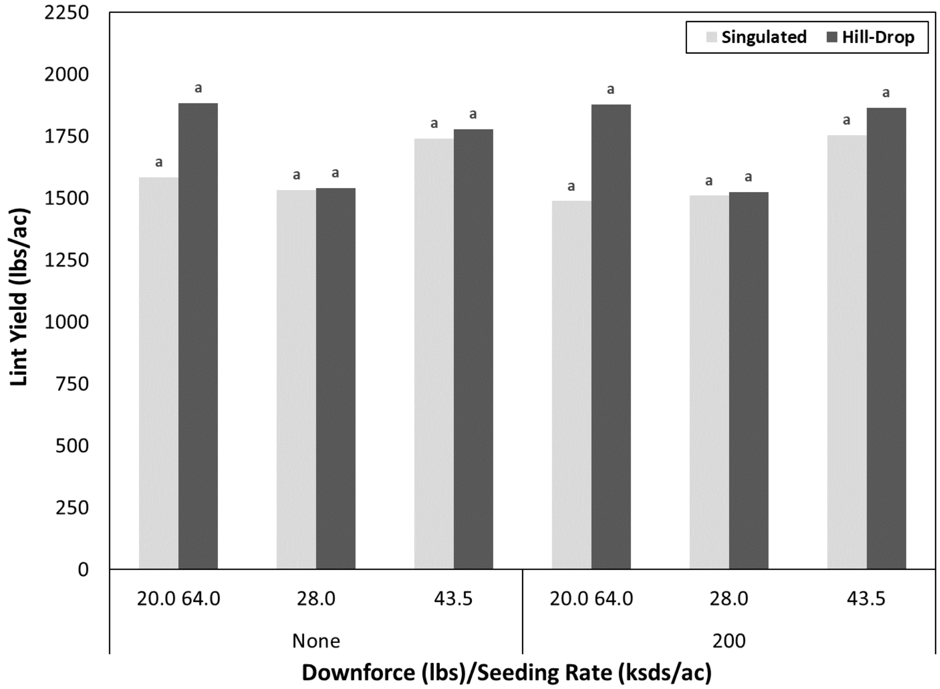

Figure 6. Mean lint yield (lb/ac) recorded for the HV cultivar arranged by the seeding rate and downforce treatments. (Same letters on bars represent treatments that are not statistically different)

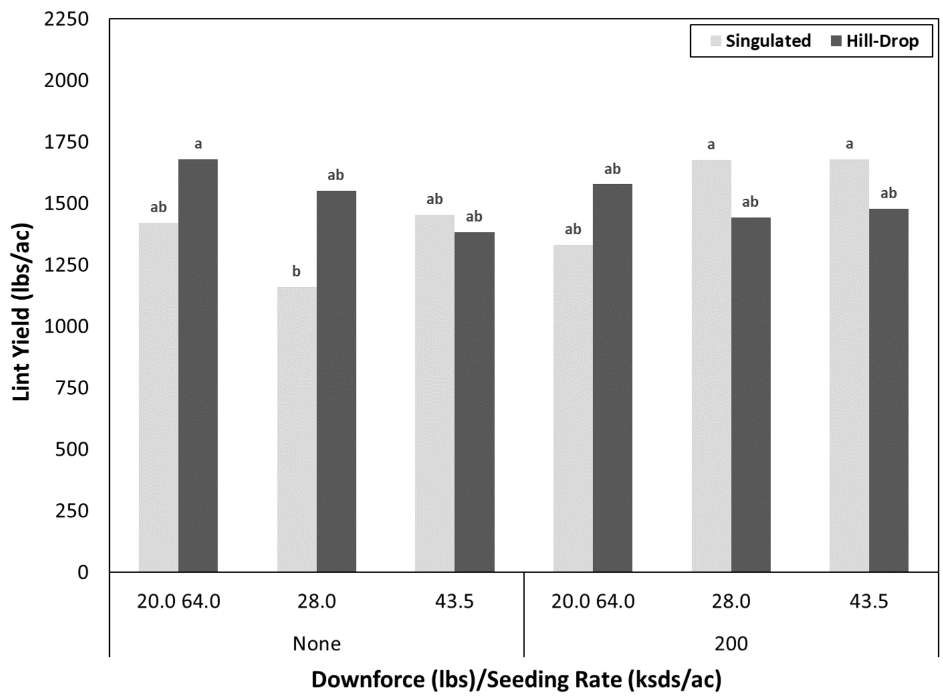

Figure 7. Mean lint yield (in lb/ac) recorded for the LV cultivar arranged by the seeding rate and downforce treatments. (Same letters on bars represent treatments that are not statistically different)

Summary

The main goal of this study was to investigate the effects of planter downforce and seeding rate treatments on crop emergence and yield for two cotton cultivars under singulated and hill-drop seeding configurations. For both seeding configurations, three seeding rates (20.0, 28.0 and 43.5 ksds/ac) along with two different downforce settings (none and 200 lbs. of additional force applied on row-units) were tested using a small seeded low vigor (LV) and a large seeded high vigor (HV) cultivar. A planter setup error while planting resulted in a considerably higher seeding rate (64.0 ksds/ac) for the 20.0 ksds/ac rate treatment for the hill-drop treatment. Emergence data analysis showed no considerable differences between crop emergences at one and three WAP for the HV cultivar for both singulated and hill-drop treatments indicating early uniform emergence in this cultivar. The LV cultivar exhibited delayed non-uniform emergence as indicated by notable differences between the crop emergence values at one and three WAP for all seeding rate and downforce treatments. In comparison, the HV cultivar had higher overall mean emergence (54-81%) than the mean emergence (38-60%) for the LV cultivar irrespective of the singulation type, seeding rate and downforce treatments. A comparison between the singulated and hill-drop treatments showed no statistical differences between the crop emergence values for both planting treatments for either the HV or the LV cultivars. However, the singulated treatment planted with the LV cultivar showed significant differences in crop emergence values between the downforce treatments at 28.0 ksds/ac and 43.5 ksds/ac seeding rate treatments. Similar to crop emergence, overall higher mean yields (1510-1880 lb/ac) were observed for the HV cultivar than the mean yields (1160-1680 lb/ac) for the LV cultivar. Yield data analysis showed no significant differences in the mean yields between the singulated and hill-drop treatments within each cultivar for the selected seeding rate and downforce treatments in the study.

Results from the study showed that the choice of cultivar (seed size and vigor) in conjunction with correct planting parameters could significantly affect crop emergence and yield when planting cotton. Although cotton is generally known to compensate for varying field and environmental conditions, high vigor cultivars tend to compensate better for harsher field conditions and planting parameters such as lower or higher than adequate downforce and low or high seeding rates. Low vigor cultivars typically do not compensate as well as high vigor cultivars so the selection of correct planting parameters (downforce and seeding rate) is more critical to ensure uniform crop emergence and higher crop yields. Correct selection of planter parameters also requires assessing at-plant in-field conditions such as soil moisture and texture within the field, and selecting planter settings which can maximize emergence potential for the crop. While utilizing higher than desired downforce can cause compaction issues in the field with excess moisture, it may be required to apply additional downforce in dry soil conditions to place the seed at the desired seeding depth. Planter downforce largely depends on the type of tillage conditions as planting cotton in conventional tillage will require none to low (100 lbs) downforce whereas planting cotton in strip- or no-till conditions will require medium to high (200–300 lbs.) downforce to ensure accurate seeding depth. As observed in this study, the LV cultivar showed increased crop emergence at 200 lbs. of downforce as compared to zero lbs. of downforce at 28.0 and 43.5 ksds/ac seeding rates. The results suggest that producers can reduce seed costs by planting low or nominal seeding rates especially when planting hill-drop cotton as no significant yield advantage was observed at higher seeding rates for either singulated or hill-drop treatments in this study. When trying to decide between hill-drop and singulated planting, growers who prefer high vigor cultivars could benefit by planting singulated cotton in ideal field conditions. For producers considering low vigor cultivars making a decision between hill-drop and singulated planting would largely depend on at-planting field conditions, however either seeding configuration would require careful consideration of planting parameters such as downforce and seeding rate in order to obtain early high uniform emergence in a low vigor cultivar. Overall, it can be concluded from this study that optimization of planter settings based on grower preferred seed cultivar and existing field conditions at planting is highly desired to ensure high crop emergence and yield potential in cotton.

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