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AGRONOMY AND SOILS

Making the Replant Decision: Predicting Yield and Fiber Quality in the Mid-South from Planting Date and Population

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ABSTRACT

Cotton producers in the U.S. Mid-South often plant in cool, wet conditions to lengthen the growing season and maximize yield potential. Although multiple studies have been conducted to determine optimum planting windows and seeding rates, few studies have evaluated the interaction of these parameters. To make a replant decision, the yield potential of the current stand versus the yield potential of the replant must be estimated. The objective of this study was to determine the impact of plant population and planting date on lint yield and fiber quality. Field experiments were conducted in 10 site-years from 2016 to 2018 in Tennessee, Mississippi, and Missouri. Treatments included five seeding rates (10.5, 6.75, 3, 1.5, and 0.75 seeds m^{-1}) and multiple planting dates (typically early May, mid-May, and early June). Although yields were lowest at later planting dates and low populations, results suggested a uniform population of 74,000 plants ha^{-1} will not warrant a replant at any date, and uniform populations as low as 49,000 plants ha^{-1} planted after 5 May also will not warrant replanting. Fiber quality was impacted by environment and planting date, with micronaire decreasing and length, strength, and uniformity increasing as planting date was delayed. These data will assist with replant decisions by providing estimates of the current stand relative to the yield potential of a successful (or unsuccessful) replant. Furthermore, results suggest producers could reduce seeding rates at later planting dates without reducing yield potential.

The decision to accept a compromised cotton (*Gossypium hirsutum* L.) stand or to replant is complicated. To provide ample time to produce and mature their crop, growers in Tennessee target planting dates between 20 April and 10 May (Craig, 2010). Whereas early planting lengthens the growing season and shifts flowering and boll-fill into months that historically are cooler and receive greater amounts of rainfall, planting early increases the risk of seedling disease and cold stress (Pettigrew, 2002). Unfortunately, growers along the northern edge of the U.S. Cotton Belt are particularly at risk for inadequate soil temperatures and excessive rainfall during the optimum planting window. If the abiotic stressors of cold temperatures and excessive rainfall are severe enough to kill a substantial number of the emerging seedlings, a decision of whether to accept or replant the crop must be made. Although cotton seedlings typically emerge within 5 to 12 days after planting under favorable conditions (Wanjura et al., 1969), emergence rate decreases linearly with decreasing soil temperatures (Reddy et al., 2017). The narrow target planting window and length of time for a seedling to emerge under abiotic stresses complicates the replant decision; by the time the stand can be adequately assessed, the date of the replant typically will fall outside the optimum planting window. Subsequently, producers must decide between accepting the reduced yield potential of the current stand relative to the reduced yield potential and expense of the replant.

In Tennessee, uniform plant populations between 74,000 to 148,000 plants ha^{-1} are recommended for optimum yield potential (Main, 2012). Plant populations currently are assessed by counting plants within a certain number of row feet from several areas within the field, averaging the measured number of plants counted, and using that number to calculate the number of plants across the area (per hectare or acre) (Godfrey et al., 2010). A uniform, lower plant population established ear-

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lier in the planting window can outperform higher plant populations planted later (Adams et al., 2019; Siebert et al., 2006; Wrather et al., 2008). Late planted cotton, particularly along the northern edge of the cotton belt, might not receive enough heat units to fully mature (Raper and Gwathmey, 2015). In studying the effect of reduced seeding rates in narrow (76-cm) row spacing in Tennessee, Gwathmey et al. (2011) found that yield potential was not significantly reduced until populations fell below 30,000 plants ha^{-1}. However, lower populations can delay maturity, increase the risk of poor fiber quality, and must be managed for earliness (Jones and Wells, 1998; Wrather et al., 2008). Limited reports on the effect of stand uniformity and skip length suggested these effects greatly impact yield potential. Jost (2005) suggested yield reductions can be noticed with skip lengths greater than 10.5 m. Boman and Lemon (2007) reported that studies from the Texas High Plains in the 1980s suggested skips that reduced stands between 25 to 45% but were in excess of six plants m^{-1} lowered yields by 17 to 26%. Given the stand is uniform, it is generally recommended when making a replant decision, to accept stands when densities are uniform and greater than or equal to three plants row m^{-1} (Craig, 2010; Supak, 1990).

Although numerous studies have established that plant population and planting date greatly influence growth and development of cotton (Jones and Wells, 1998; Siebert et al., 2006; Smith et al., 1979; Wrather et al., 2008), few studies have been conducted determining the interaction of planting date and plant population on cotton lint yield (Wrather et al., 2008). Galanopoulou-Sendouka et al. (1980) demonstrated the effect of population density, planting date, and genotype on growth and development of cotton in Greece. Planting date had the strongest influence on maturity and earliness, whereas density had the strongest impact on morphological characteristics and yield components. No impact amongst the interactions of planting date, population, or selected cultivar on lint yield was observed. Wrather et al. (2008) conducted similar work in the Mississippi River Delta Region. The interaction of planting date and plant population was significant and suggested as population decreased and planting was delayed, lint yield decreased. Interestingly, lint yield from 17,000 seed ha^{-1} planted in late April was significantly greater than or equal to all plant populations planted in mid-May. Although densities greater than or equal to 2.5 plants row m^{-1} did not significantly impact cotton lint yield, fiber color and maturity was negatively affected. Populations between 50,000 and 100,000 plants ha^{-1} have been demonstrated to have no significant differences in lint yield amongst differing varieties (Pettigrew et al., 2013), whereas lint yield progressively increases as year of varietal release increases (Constable and Bange, 2015; Wells and Meredith, 1984). Due to these occurrences, producers have looked to maximize profits by stabilizing yield goals while decreasing seeding rates.

Currently, producers, scouts, and consultants possess minimal data supporting the decision to accept or replant a stand of cotton outside of personal judgement from past experiences. A model considering cotton plant population and planting date to predict lint yield potential could greatly assist in the replant decision-making process and provide guidance towards management requirements throughout the season. Therefore, the objective of this study was to determine the impact of plant population and planting date on lint yield and fiber quality to provide improved guidance in the replant decision-making process.

MATERIALS AND METHODS

Field trials were established across 10 site-years from 2016 to 2018. During 2016, a pilot study was conducted at Ames Plantation in Grand Junction, TN (Table 1). Field sites were scattered throughout the upper Mid-South to capture variable environments. Five seeding rates were planted at each location and respective date. Seeding rates included: 10.5 seeds m^{-1} (~118,970 seeds ha^{-1}), 6.75 seeds m^{-1} (~76,480 seeds ha^{-1}), 3 seeds m^{-1} (~33,990 seeds ha^{-1}), 1.5 seeds m^{-1} (~17,000 seeds ha^{-1}), and 0.75 seeds m^{-1} (8,500 seeds ha^{-1}). The initial planting date at each location was targeted to fall within the range of the recommended planting window for Tennessee of 20 April to 10 May (Craig, 2010). To normalize planting dates across the differing environments, the second and third planting dates were triggered approximately 7 and 14 days, respectively, after 50% emergence of the 10.5 seed m^{-1} plots. In 2017, initial planting was delayed until after 15 May in the three field sites in Tennessee due to excessive rainfall. Locations, planting dates, and soil types are listed in Table 1.

Table 1: Planting dates and the five-day growing day accumulation for five locations across three years

Location	Year	Soil Type	Initial		Second		Third		Fourth	
			Date	5d DD60[Z]	Date	5d DD60	Date	5d DD60	Date	5d DD60
Grand Junction, TN	2016	Loring Silt Loam	10 May	46.5	-	-	-	-	-	-
	2017		18 May	73.5	30 May	65.0	7 Jun	48.0	-	-
	2018		4 May	42.5	21 May	81.0	30 May	85.0	-	-
Jackson, TN	2017	Alamo Silt Loam	16 May	83.5	1 Jun	77.0	7 Jun	55.0	-	-
	2018		20 Apr	0.0	3 May	47.5	15 May	85.0	19 Jun	93.5
Milan, TN	2017	Falaya Silt Loam	17 May	86.5	31 May	80.5	7 Jun	51.5	-	-
	2018		15 May	80.5	20 Jun	83.5	-	-	-	-
Brooksville, MS	2017	Brooksville Silty Clay	9 May	60.0	12 May	53.0	21 May	48.5	-	-
	2018		9 May	79.0	6 Jun	108.0	20 Jun	107.0	-	-
Portageville, MO	2017	Dundee Silt Loam	10 May	53.5	22 May	35.0	1-Jun	90.5	-	-

[Z] **5D DD60 represents the five-day growing degree day accumulation after planting for the corresponding planting date at a given location.**

Trials were established using a double-disc opening planter with a specially designed research cone seed singulation system. Experimental cone planters allow each plot's respective seeding rate to be packaged individually, dumped into each row unit per plot, and dispersed evenly across the planted plot row. Prior to planting, seeds are counted based upon requirement-to-plant selected seeding rate per 10.7-m plot lengths. Plots are then reduced to 9.1 m by hand trimming to align each replication. If seeds were unevenly displaced within the cone system, uniformity and population within plot could vary. Final plant stand was collected during the season to account for differences in seeding rate and plant population. Within planting date, seeding rates were arranged in a randomized, complete block design with four replications. Planting dates were blocked. Plots consisted of four 96.5-cm spaced rows, 9.1 m in length. To standardize in-season management and simulate multiple replant dates within the same field, all planting dates and populations were managed the same as the initial planting based upon respective state extension recommendations for cotton; that is, all inputs were applied at the appropriate growth stage for the initial planting date. In each year and location, DP 1522 B2XF (DeltaPine, Bayer CropScience, Raleigh, NC), an early to mid-maturing variety, was selected for its popularity and suitability across differing environments. Prior to harvest, all cotton plants within each individual harvest row were hand counted and recorded as plant populations. Counted plant populations, not seeding rates, were used for modeling. Harvest time was based on the average plot within each trial. When the average plot exceeded 60% open, trials were defoliated and the two center rows of each plot were harvested with a mechanical spindle picker equipped with a load-cell style weigh basket to generate seed cotton weights. Seed cotton from each plot was subsampled to determine turnout (percentage lint) for all locations but the 2018 Milan and 2017 Brooksville locations. Seed cotton subsamples were ginned at the UT MicroGin in Jackson, TN. For the 2018 Milan and 2017 Brooksville locations, turnout was 38%. Fiber quality samples from each plot of all locations (except 2018 Milan, 2017 Brooksville, and 2017 Portageville locations) were shipped to the USDA Cotton Classing Office in Memphis, TN for classification of micronaire, length, strength, and uniformity by high volume instrument (HVI) testing.

To normalize yield data across varying environments and years, each plot weight was divided by maximum plot weight within that location and year, resulting in a unitless measurement of relative yield ranging from 0 to 1. To provide a continuous value for regression modeling, calendar date was converted to day of year, such that dates ranged from 0 to 365. The regression was bound to the range of observed planting dates. To characterize the relationship of planting date and plant population on seed cotton yield, lint turnout, and fiber quality, planting dates and plant populations were subjected to response surface regression modeling in SAS (SAS 9.4, SAS Institute, Cary, NC). Response surface regression is a type of multiple regression that uses more than one independent variable (Baş and Boyacı, 2007). The objective of response surface regression modeling is to use multiple independent variables to predict the dependent variable. Polynomial equations were obtained by the analysis and were accepted as adequate when tested by the lack of fit and coefficient of determination. Noted differences were considered significant at $p \leq 0.05$. Planting dates of 20 April; 1, 10, 20 May; 1, 10, and 20 June and plant populations of 24,000; 49,000; 74,000; 98,000; and 123,000 plants ha^{-1} were selected as benchmarks and subjected to the model, and yield potential curves for each interaction were generated to understand the response. Planting date ranges were selected based upon typical times that cotton planting is initiated and replant decisions are made. Plant populations subjected to the model were selected based upon the uniformity and relevance when selecting a desired seeding rate. Dates and populations subjected to the model were represented by at least one observation within the field studies. The first derivative of this curve was calculated in SAS 9.4 to distinguish rate of change in yield potential across planting date intervals for the five subjected plant populations.

RESULTS

Selected trial location yield environments were variable, with average lint yield for each site-year across all planting dates and plant populations ranging from 440 to 1,328 kg ha^{-1}. Differences in locule fallout across planting date and population treatments were not noted. Average lint yield across all site-years equaled 837 kg ha^{-1} (Table 2). The difference between reported state average yields and average yield observed within these trials can be attributed to the large number of treatments that were either planted outside the target planting date window, were planted below typical plant populations, or both. In contrast, lint yields for each site-year of treatments within typical planting dates and plant populations closely mirrored state average yields (data not shown). Across all site-years, plant populations averaged 23.5% below seeding rates. It is suspected this variance can be explained by 1) seed germination; 2) the large number of planting dates established in adverse conditions (particularly early in the planting window); 3) at low populations, small reductions in stands resulted in high percentage variances; and 4) a substantial number of no-till locations. Treatments planted at the latest planting date and at the lowest seeding rate generally produced the lowest yields. The variance between the maximum and minimum yields varied by the number of planting dates included, the range of planting dates, and the environment at a given site-year. Turnout, micronaire, length, strength, and uniformity averaged across all site years equaled 37%, 4.5, 28.8 mm, 297 kN m kg^{-1}, and 82.4%, respectively.

Table 2: Average, maximum, and minimum lint yield and average micronaire, length, strength, and uniformity observed from each site-year

Location	Year	Lint Yield Kg ha^{-1}			Turnout %	Micronaire reading	UHML mm	Strength kN m kg^{-1}	Uniformity %
		μ	max	min	μ	μ	μ	μ	μ
Grand Junction, TN	2016	1037	1373	606	40	5.2	27.8	299	81.9
	2017	440	1040	33	39	3.4	29.4	301	83.4
	2018	860	2159	175	39	4.6	29.4	301	83.4
Jackson, TN	2017	904	1836	160	36	4.4	28.9	297	82.4
	2018	781	1708	177	35	4.7	28.3	297	81.5
Milan, TN	2017	941	1538	169	37	4.2	29.2	299	82.7
	2018	554	1540	26	-[z]	-	-	-	-
Brooksville, MS	2017	442	1120	23	-	-	-	-	-
	2018	1328	1909	288	37	5.0	28.2	286	81.8
Portageville, MO	2017	1080	1852	283	36	-	-	-	-
Average		837	1608	194	37	4.5	28.8	297	82.4

[z] Fiber quality data not collected from the 2018 Milan, TN; 2017 Brooksville, MS; and 2017 Portageville, MO trials. Lint yield calculated assuming 38% turnout.

Planting date and plant population data collected from 10 site-years was predictive of relative cotton lint yield potential when subjected to response surface regression modeling (Fig. 1A), with a coefficient of determination equal to 0.663 (Table 2). The interactions of planting date, plant population, and planting date by plant population were all significant ($p < 0.0001$, < 0.0001, and $= 0.0009$, respectively). Additionally, quadratic terms of date and population were also significant ($p < 0.0001$ and < 0.0001, respectively). Mean yield potential of the response surface equaled 49.9%, conveying an even distribution of yield results across the model. Root mean square error equaled 0.15137 with a coefficient of variation of 30.3521, suggesting residuals were relatively concentrated close to the response surface (Fig. 1B). It is suspected the large coefficient of variance is a function of the number of site-years included and the variable impact of planting date and plant population on yield within each site-year. Canonical analysis of the response surface model indicated maximum yield could be achieved on 15 April when possessing a germinated plant population stand of 126,774 plants ha^{-1}, however, the model suggested an unrealistic yield potential of 105% at the stationary point.

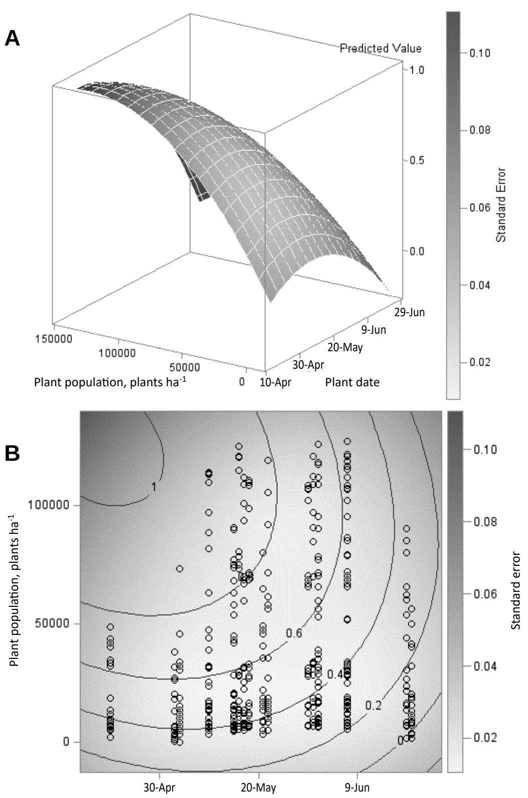

Figure 1. A: Response surface model of potential yield predicted by planting date and plant population. B: Contour plot response of lint yield potential across planting date and population.

$$f(x) = -2.544416 + 0.000018166(x_1) + 0.046308(x_2) - 0.000000057528(x_1*x_2) - 0.00000000004772((x_2)^2) - 0.000185((x_1)^2)$$

Where:
$f(x)$ = lint yield potential (%)
x_1 = plant population ha^{-1}
x_2 = planting date (day of year).

Selected planting dates and plant populations were subjected to the response surface model:

Predicted yield results were plotted and curves were generated for each associated interaction. Interpretations of percentage cotton lint yield potential generated from six plant populations suggest yield potential is relatively stable across all populations from 20 April until 10 May (Fig. 2). Yield potentials of plant populations from 74,000 to 123,000 plants ha^{-1} varied only slightly, populations of 49,000 plants ha^{-1} possessed drastically lower yield potential within the recommended planting window. Although a population of 24,000 plants ha^{-1} followed similar trends across planting dates, the model indicated yield potential of the 24,000 plants ha^{-1} population never exceeded 60%. Interestingly, the population of 98,000 plants ha^{-1} provided either equal or greater yield potential than other plant populations across all reported planting dates. Furthermore, after 20 May, populations equal to or greater than 49,000 plants ha^{-1} provided equivalent yield potential to increased plant stands, which suggests target plant stand should decline later in the year and producers will likely be able to utilize lower seed rates if replanting beyond the recommended planting window. It should be noted that Figs. 2 and 3 represent data generated from plant populations achieved from seeding rates defined in the materials and methods and not seeding rate; seeding rates required to achieve plant populations will be greater than plant populations, and this variance will be based on factors of seedling viability and survivability.

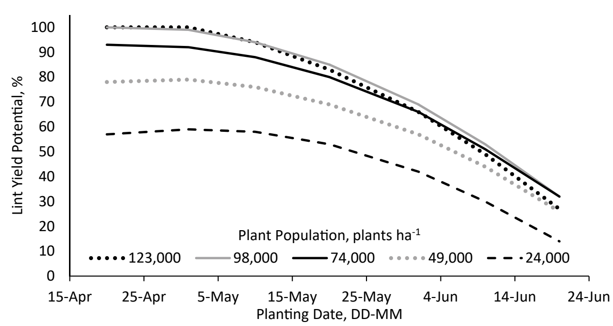

Figure 2. Predicted lint yield potential based on planting date graphed by plant population. Model generated from five populations across seven planting dates in Mississippi, Missouri, and Tennessee.

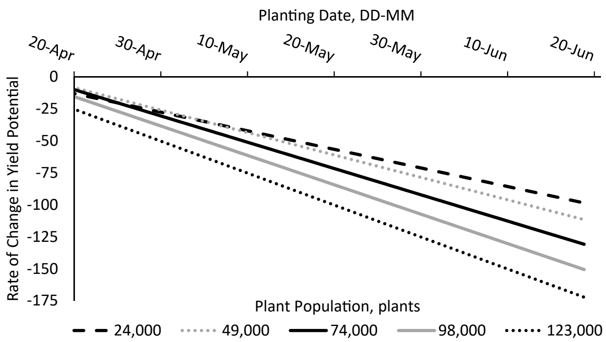

Figure 3. First derivative of percent cotton lint yield potential from five plant populations across planting date.

Graphical representation of the slope for the five selected plant populations over planting date captures this varied rate of change (Fig. 3). Yield potential from the lowest comparative population of 24,000 plants ha^{-1} (Table 3), decreased at the slowest rate as planting date increased. As plant population is increased, yield potential decreases at a greater rate at later planting dates, with the rate of decline in yield potential becoming greatest at a population of 123,000 plants ha^{-1}. It is likely the rate of change in yield potential is lowest at less dense populations due to the low yield potential that characterizes these populations across the entire planting window (maximum yield potential across planting dates within the 24,000 plants ha^{-1} population varies from approximately 15 to 60%). At greater populations, yield potential is maximized early in the planting window but decreases at the greatest rate as planting date is delayed. It is hypothesized that as planting is delayed, denser plant stands could compete more with neighboring plants for resources. Increases in vegetative growth within higher populations could be the result of reduced sunlight interception and heat accumulation required to progress growth stages of each individual cotton plant (Hutmacher et al., 2002).

The effect of planting date, plant population, and environment interactions on fiber quality parameters of micronaire, length, strength, and uniformity were assessed using response surface regression modeling. Plant population did not significantly impact measured fiber quality parameters. In contrast, both environment and planting date impacted several fiber quality parameters, although the impact was often slight. Whereas environment impacted micronaire and length, both planting date and environment only slightly impacted strength and uniformity (Table 4.). As planting date increased, micronaire decreased and length, strength, and uniformity all increased. The model was most predictive of micronaire (r^2 = 0.7), followed by length (r^2 = 0.5), with minimal correlation between strength and uniformity within the interaction of environment and planting date (r^2 = 0.3) (Table 5).

Table 3: Response surface model parameters and statistics for the prediction of relative lint yield from planting date and plant population

Parameter	Slope	Pr > F
Intercept	-2.544416	< .0001
Population	0.000018166	< .0001
Date	0.046308	< .0001
Population * Population	-4.77E-11	< .0001
Date * Date	-0.000185	< .0001
Date * Population	-5.75E-08	0.0009
Statistic	**Value**	
Coefficient of Determination	0.663	
Response Mean	0.499	
Root Mean Square Error	0.151	
Coefficient of Variation	30.4	

Table 4. First derivative parameters generated from yield potential generated from response surface regression modeling for five increasing plant populations

Plant Population plants ha^{-1}	Linear Equation
24,000	*y* = -0.71177 (Plant Date) + 144.870
49,000	*y* = -0.85879 (Plant Date) + 182.129
74,000	*y* = -1.00625 (Plant Date) + 213.308
98,000	*y* = -1.12557 (Plant Date) + 234.383
123,000	*y* = -1.22363 (Plant Date) + 246.325

Table 5. Linear regression parameters and statistics for the prediction of fiber quality parameters from planting date

Fiber Quality Parameter	Significance (Pr > F)		R^2	Optimized Equation
	Environment	Plant Date		
Micronaire	< 0.0001	0.0004	0.70	*y* = -0.0046 (Plant Date) + 5.2152
Length	< 0.0001	0.0017	0.50	*y* = 0.0003 (Plant Date) + 1.0801
Strength	< 0.0001	< 0.0001	0.33	*y* = 0.0238 (Plant Date) + 26.6854
Uniformity	< 0.0001	< 0.0001	0.33	*y* = 0.0225 (Plant Date) + 79.0786

DISCUSSION

Few studies have examined concurrently the impact of planting date and plant population on parameters of cotton lint yield and fiber quality. Similar to early studies conducted by Galanopoulou-Sendouka et al. (1980), increasing plant population resulted in positive significant effects on lint yield, however, Galanopoulou-Sendouka et al. noted no interaction of planting date and population. In contrast, the results of the present study more closely mirror the significant interaction of plant date and population captured by Wrather et al. (2008); however, in contrast to the findings by Wrather et al., the greatest rate of decline in yield potential as planting date increased was associated with the greater plant populations, not the lowest. It is suspected the limited number of site-years, different environmental conditions, and improved varieties could explain some of the discrepancies noted between the present study and those of Wrather et al. (2008) and Galanopoulou-Sendouka et al. (1980).

When assessing the effect of planting date and plant population on fiber quality parameters of micronaire, fiber length, strength, and uniformity, planting date influenced some quality parameters, whereas population had no impact. These results are consistent with reports by Siebert (2006) and Wrather et al. (2008). In the present study, environment had the greatest impact on fiber quality parameters. Campbell and Jones (2005) have reported growing conditions, soil type, and management dominate the generation and development of cotton fibers. Although soil type across locations was similar, the number of sites and geographic spread provided considerable variability in environment. Fiber harvested from later planting dates was less mature, resulting in reduced micronaire. Surprisingly, later planting dates tended to increase length, strength, and uniformity, although this response was not strong. Wrather et al. (2008) also noted an increase in length and strength and a decrease in micronaire at later planting dates but did not note increases in uniformity. A better understanding of the effects of planting date on fiber quality could be important in securing premiums or avoiding penalties. The small parameter estimates will likely limit the power of fiber quality parameters to ultimately determine when to plant. Previous evaluations of planting date on fiber quality have indicated slight changes in fiber quality often will not impact lint value (Wrather et al., 2008). Harvest timing can limit the response of some fiber quality parameters, because all plots within these trials were harvested at the same time, harvesting at a single date could have negatively impacted yellowness and reflectiveness of the earliest planted because many of the bolls within these treatments likely opened earlier. Still, impacts observed within these studies also indicated the role of fiber quality on selecting planting date will be minor in comparison to lint yield.

Although data suggest both calendar date and plant population must be considered when gauging whether to accept or replant cotton stands, additional expenses associated with seed cost, preemergence herbicides, planting costs, logistics, and labor also must be considered. Because these vary substantially by operation, it is difficult to make absolute, sweeping recommendations concerning the plant populations and dates that would warrant replants. However, based upon these data, a few trends should be noted. First, assuming it will take 15 days to determine if a stand should be replanted, a uniform population of 74,000 plants ha^{-1} likely will not warrant a replant at any date. Furthermore, uniform populations of 49,000 plants ha^{-1} established after 5 May also will not warrant a replant because greater populations established on 20 May were characterized by equal or reduced yield potential in comparison to 5 May, 49,000 plants ha^{-1} observations. These data are consistent with seeding rate recommendations from Georgia and Tennessee issued in the early 2000s (Bednarz et al., 2000; Gwathmey et al., 2011). Similar studies by Wrather et al. (2008) in the Mississippi Delta Region suggested plant population does not affect yield potential at densities as low as 34,000 plants ha^{-1}, however, 24,000 plants ha^{-1} significantly decreased yield in one evaluated site-year. In a recent study from the Texas High Plains, a breakpoint threshold for seeding rates was established as 35,000 plants ha^{-1} when planting into optimum germination conditions (Adams et al., 2019). Although producers possess the luxury of accepting a wide range of populations, higher seeding rates of up to 123,000 plants ha^{-1} demonstrated the greatest yield potential when planted early and demonstrated the greatest rate of change as planting date was delayed.

Yield potential was relatively stable across all populations during the recommended planting window (20 April to 10 May). These results are consistent with recommendations for cotton planting date windows across the Mid-South (Main, 2012; Robertson et al., 2018). Wrather et al. (2008) suggested lower plant populations seeded in early May have the potential to outperform greater plant populations seeded in late May. However, when evaluating the effect of plant population on yield potential when seeding in late May or early June, the time when most replant decisions are made, yield potential decreases at a slower rate. Subsequently, growers making a replant decision could achieve optimum yield potential with reduced seeding rates; these results agree with the findings of Pettigrew et al. (2013).

Although the generated data can provide insight into the response of yield and fiber quality to the parameters of plant populations and date in the Mid-South, it should be noted that logistical limitations in completing these trials likely played some role in response. It is possible that slight shifts in management associated with later planting dates could have slightly reduced some of the strong negative responses of yield and slight responses of fiber quality to later planting dates. Unfortunately, it was not possible to make these management changes within the trial and still evaluate the number of treatments required to generate such a dataset. Still, the model provides valuable insight into the role of planting date and observed plant population on crop yield potential. The present study will be particularly valuable to individuals within the Mid-South attempting to estimate the yield potential of their current stand relative to a replanted stand. The current data suggest that greater cotton populations planted earlier have ample time to fully grow and mature to the level of optimum yield, however, as planting date becomes later, these greater populations begin to compete with neighboring in-row plants for sunlight (Pettigrew and Meredith, 2012). In contrast, lower seeding rates are not capable of achieving the same yield potential as greater populations at early planting dates. As planting dates are delayed, however, the yield potential of greater populations declines more rapidly than the yield potential of lower populations.

The current study does not quantify stand uniformity and the impacts of uniformity on yield potential or fiber quality; still, uniformity must be considered when accepting reduced plant stands. The method of establishing population treatments within these experiments generally resulted in a consistent distance between plants that might not capture variability noted within-field. Until studies quantifying uniformity are conducted and incorporated into the replant decision matrix, the potential yield penalty from large skips should be considered severe.

CONCLUSIONS

The significant interaction of planting date and plant population suggests producers in the Mid-South must consider both calendar date and plant population when gauging whether to accept or replant cotton stands. Although additional expenses associated with seed cost, preemergence herbicides, planting costs, logistics, delayed harvest, and labor must be included within the decision matrix, the developed model suggests a uniform population of 74,000 plants ha^{-1} likely will not warrant a replant at any date, and uniform populations as low as 49,000 plants ha^{-1} planted after 5 May also will not warrant a replant. Furthermore, stronger reductions in the yield potential of greater plant populations were noted as planting date shifted to later within the year. These trends suggest reduced seeding rates could be more cost effective later in the year or under a replant situation. Although additional research must be conducted to incorporate some measure of stand uniformity and operation-specific expenses, the developed relationship between plant population, planting date, and yield potential provides insight into the yield potential of a replant relative to the yield potential of a current stand.

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