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Impact of row spacing/planting pattern and seed size on plant development and yield on cotton (Gossypium hirsutum L.).

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Pages in Study 39

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There is renewed interest in cotton performance grown using various row spacings and plantings patterns in the Midsouth. Cotton seed size has been reduced compared to sixty years ago. Planting smaller seeds is concerning due to having less energy for emergence as well as complicating the ginning process. Two row spacings, two planting patterns, and two cotton varieties were evaluated over eight site years from 2019-2020. The solid planting pattern produced a higher yield on a land area basis. In addition, two varieties, each with three seed counts, were planted at three seeding rates and evaluated over six site years from 2019-2020. Greater seedcotton yields were observed from larger seed sizes and higher seeding rates. Row spacing had no impact on yield but depending on input cost, a 2x1 skip pattern could be beneficial. Also, higher seeding rates and larger seeds maximized yields.

DEDICATION

I would like to dedicate this research to my wife, Amber Hall and my parents, Dale and Polly Hall. They provided me the support I needed strive to achieve my goals. I am very thankful for the guidance and work ethic shown by my parents and the love from my wife which without would have been unimaginable to accomplish.

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CHAPTER I

DETERMINING THE IMPACT OF ROW SPACING AND VARIETY ON COTTON DEVELOPMENT, FRUIT DISTRIBUTION, AND YIELD

1.1 Abstract

Determining fruit distribution and yield potential of cotton varieties has been routinely evaluated. The objective of this research was to determine the impact of row spacing, planting pattern, and variety on cotton fruit distribution and yield. Studies were conducted in four locations. Row spacings consisted of 76 or 97 centimeter (cm) rows and were either solid planted or planted using a 2x1 skip row pattern utilizing two different varieties which included PHY 350 W3FE and PHY 400 W3FE. The solid planting pattern produced greater yield than the 2x1 skip row pattern on a land area basis. However, on a planted area basis, the 2x1 skip row produced slightly greater yield than the solid planting pattern. When seed cost was subtracted from gross return, the solid planting pattern resulted in greater net returns than the 2x1 skip row pattern. Fruit distribution at the first and third fruiting positions was impacted by planting pattern. The solid planting pattern resulted in increased first position fruit compared to the 2x1 skip row pattern. The 2x1 skip row pattern produced a slight increase in third position fruit and cotton partitioned to vegetative branches compared to the solid planting pattern. Therefore, when a grower is considering switching from one row pattern and row spacing to another it would be beneficial to consider the input cost and commodity value of the crop.

1.2 Introduction

Cotton (*Gossypium hirsutum* L.) was produced on 250,910 hectares in Mississippi in 2018 (NASS, 2018a). Cotton in Mississippi has been grown on row spacings ranging from 38 cm to 102 cm. However, the primary row spacing utilized for commercial production is 97 cm with some growers utilizing 76 cm row spacings (Reddy et al. 2009). Given seed cost and incidence of foliar disease, interest in alternate row configurations such as 2x1 skip row is increasing (Parvin et al. 1999).

Growers in Mississippi who plant cotton on 76 cm rows commonly do so to accommodate the same equipment for multiple crops. Utilizing the same equipment for planting, spraying, and fertilizer application on cotton and grain crops increases production and financial efficiency. Planting cotton on narrower row spacings can aid in faster canopy closure thus helping with weed suppression during the growing season (Molin et al. 2004; Robinson 1993; Gwathmey et al. 2008). Yields from cotton grown on 76 cm rows have been reported to be equal to (Williford et al. 1986; Harrison et al. 2006; Balkom et al. 2007; Gwathmey et al. 2007) and in some cases greater than cotton grown on wide row spacings (Hielman et al. 1987; Buehring et al. 2006; Reddy et al. 2007; Gwathmey et al. 2008).

Interest exists in modifying planting pattern to reduce inputs and optimize financial returns. A 2x1 skip pattern consists of two planted rows followed by a fallow row. On a land acre basis, yield from cotton produced on narrow rows utilizing a 2x1 skip planting pattern have been similar to the yield produced from a solid planting pattern at the same row spacing (Buehring et al. 2006). Heitholt et al. (1993) reported no difference in cotton maturity or yield due to row spacing. These results suggest that some agronomic traits of cotton might be similar across row spacings.

Cost of cotton production has increased over the past 25 years. Seed cost and associated technology on average was $37.05 per hectare in 1995 (Parvin 2004), $148.20 per hectare in 2004 (Parvin 2004), and $253.42 per hectare in 2019 (MSUE 2019). Depending on seed price, a 2x1 skip row pattern can produce slightly greater net returns compared to those from solid planted cotton by reducing the amount of seed planted per land acre (Spurlock et al. 2006). However, other reports indicate no difference in lint yield to the land acre between cotton produced on narrow rows using a solid or 2x1 skip row pattern. Additional research indicates cotton produced on 97 or 102 cm row spacings and a solid planting pattern produced greater lint yield than cotton grown using a 2x1 skip row pattern grown on the same wider row spacings (Jones 1997; Gwathmey et al. 2008; Buehring et al. 2006).

Cotton fruit distribution can be impacted by many factors including variety (Jenkins et al. 1990; Huff et al. 2010), herbicide application (Dodds et al. 2010), and population density (Bednarz et al. 2000). Fruit distribution in cotton is categorized by monopodial and sympodial branches. First position bolls produce the greatest percent (66-75%) of seedcotton yield (Jenkins et al. 1990). The bulk of fruit production from a cotton plant is typically from first position bolls on sympodial branches at nodes five through twelve. Early maturing varieties produce the bulk of fruit on nodes five through eight. While later maturing varieties produce the bulk of fruit from nodes nine through twelve (Jenkins et al. 1990; Huff et al. 2010). Labeled herbicide application has little impact on fruit distribution but applications above the maximum allowable rate can reduce the amount of fruit partitioned to first position bolls (Dodds et al. 2010). Cotton fruit distribution can also be impacted by population density. As population density increases, increased seedcotton is partitioned to nodes higher on the plant. As plant populations decrease, increased fruit partitioning to second and third position bolls and to monopodial branches has been observed (Bednarz et al. 2000).

An abundance of research evaluating the effect of row spacing and planting patterns exists. However, published data on the effect of planting pattern and row spacing with modern varieties is lacking. Furthermore, data are lacking regarding the impact of this management practice on cotton fruit distribution. Therefore, research was conducted to evaluate the effect of planting pattern, row spacing, and variety on cotton growth, development, yield, fruit distribution, and economic return.

1.3 Materials and Methods

Studies were conducted in 2019 and 2020 in Starkville and Stoneville, MSi; Jackson, TN; and Belle Mina, AL evaluating row spacing, planting pattern, and variety on cotton fruit distribution and yield. A 2x2x2 factorial arrangement of treatments within a randomized complete block design was utilized for all experiments. Factor A consisted of variety and included PHY 350 W3FE (Corteva Agriscience Indianapolis, IN) and PHY 400 W3FE (Corteva Agriscience Indianapolis, IN); Factor B consisted of row width and included 76 cm or 97/102 cm rows; and factor C consisted of planting pattern and included solid planted cotton or cotton planted using a 2x1 skip pattern. Phytogen 350 W3FE and Phytogen 400 W3FE seed were treated with azoxystrobin, fludioxanil, imidacloprid, mefenoxam, metalaxyl, myclobutanil, and sedaxane (Phytogen TRiO, Corteva Agriscience Indianapolis, IN) and were seeded 2.5 cm deep and planting population at 110,000 seeds planted ha^{-1}. Planting and harvest dates are given in Table 1.1. Plots consisted of eight rows that were 12.2 m in length and replicated four times at all locations. Experiments in Starkville, MS and Stoneville, MS were furrow irrigated (5 cm $irrigation^{-1}$) two times in 2019 and two times in 2020 using 38 cm lay flat polyethylene pipe

(Delta Plastics). Plots in Belle Mina, AL and Jackson, TN were grown under dryland conditions. Fertilizer nitrogen (30% UAN) was injected 5 cm deep in a single application of 134 kg N ha^{-1} approximately 30 days after planting at the Starkville, MS; Stoneville, MS; and Jackson, TN locations. Fertilizer nitrogen (34-0-0) at the Belle Mina location was applied in a single application preplant at a rate of 123 kg N ha^{-1}. All fertilizer nitrogen applications were made using a ground driven knife applicator except at the Belle Mina location which used a granular formulation spread with a Vicon fertilizer applicator (Kverneland Group Klepp Stasjon, Norway). Plant growth regulator, pest management and harvest aid applications were based on Extension recommendations at each location. Cotton stand counts were recorded at 21 days after planting. Cotton height, total node, and node above white flower data (NAWF) were collected at first bloom. Cotton height, total node, and node above cracked boll data (NACB) were collected immediately prior to harvest aid application. All data were collected from five randomly selected plants in each plot in all replications. Immediately prior to harvest, box mapping data were collected following the guidelines set forth by Jenkins et al. (1990). All plants were collected from 3-m length of row and each boll was hand harvested and sorted by the associated mainstem node and by sympodial branch position (Jenkins et al. 1990). The total number of plants in the 3-m row section were counted and the total bolls for each position from all plants were enumerated and weighed. Seedcotton from vegetative branches was also collected and added to the total weight. Seedcotton distribution was analyzed by horizontal fruiting position and vertical fruiting zone. Horizontal fruit distribution from fruiting position one (closest to the mainstem), two, three and beyond was evaluated. Vertical fruit distribution from nodes five through eight, nine to twelve, and twelve and above was also evaluated. Machine harvested seedcotton yield was collected by a spindle picker modified for small plot research. Prior to mechanical harvest, seedcotton from 25 bolls was hand collected and ginned on a 10-saw Continental Eagle laboratory gin (Continental Eagle Corp., Prattville, AL) to determine turnout and fiber quality. Fiber quality was determined using high volume instrumentation (HVI) at the USDA-AMS fiber quality laboratory in Memphis, TN. All data were pooled over location and subjected to analysis of variance using the PROC MIXED procedure in SAS v 9.4 and means were separated using Fisher's Protected LSD at a significance level of 0.05.

1.4 Results

No differences in plant populations were observed. Plant populations averaged 100,188 plants ha^{-1} (data not shown). At first bloom, differences in cotton height were observed. Cotton height ranged from 75 to 79 cm. PHY 350 W3FE was significantly taller but had similar number of main stem nodes compared to PHY 400 W3FE at first bloom (Table 1.3). Cotton planted on 76 cm row spacings was 4% shorter (75cm) than cotton planted on 97/102 cm row spacings (78cm) (Table 1.3). Cotton planted on 76 cm row spacings had 3% fewer nodes (14.6 nodes) than cotton planted on 97/102 cm row spacings (15.1nodes) (Table 1.3). PHY 350 W3FE had greater NAWF at first bloom than PHY 400 W3FE (Table 1.3).

Cotton height at the end of the growing season ranged from 85 to 91 cm. PHY 350 W3FE was taller (91cm) than PHY 400 W3FE (86cm) at the end of the season (Table 1.3). There were no differences in total node counts at the end of the season due to variety, row spacing, or planting pattern. Nodes above cracked boll ranged from 3.4 to 4.2 with PHY 300 W3FE having 8% more NACB (4.0) than PHY 400 W3FE (3.6) at the end of the season (Table 1.3). The 2x1 skip row planting pattern produced cotton with 4.2 NACB compared to 3.9 NACB in solid planting cotton at the end of the season (Table 1.3).

Horizontal distribution of first position seedcotton as well as seedcotton partitioned to vegetative branches was impacted by an interaction between variety and planting pattern. Seedcotton partitioned to position one fruit ranged from 51.4-59.4% of the total weight. Seedcotton partitioned to bolls on vegetative branches, ranged from 19.3-25% of the total seed cotton weight (Table 1.5). PHY 400 W3FE, grown using a solid planting pattern, produced greater fruit distribution to first position bolls compared to PHY 400 W3FE planted on a skip row pattern or PHY 350 W3FE on either planting pattern. However, PHY 400 W3FE planted with a 2x1 skip row pattern resulted in greater fruit partitioning to vegetative branches bolls than when solid planted or PHY 350 W3FE on either planting pattern (Table 1.5).

When pooled over planting pattern and row spacing, horizontal fruit distribution to second and third position bolls was affected by variety. Second position bolls accounted for 18-20.9% of the total seedcotton weight and third position bolls produced 4.4-5.7% of the total weight. PHY 350 W3FE had a greater percentage of fruit partitioned to second and third position bolls than PHY 400 W3FE (Table 1.6).

Vertical fruit distribution to zone one (all fruiting positions on nodes five through eight) ranged from 31-32 %. Vertical distribution of fruit partitioned to zone two was affected by an interaction between variety and planting pattern. The percentage of total weight partitioned to zone two ranged from 33.1-37.3%. PHY 400 W3FE planted with a 2x1 skip row pattern had significantly less fruit distributed to zone two when compared to all other treatments (Table 1.5).

Fruit distribution to zone three was affected by a variety by row spacing by planting pattern interaction. The percentage of the total weight partitioned to zone three ranged from 8.9-13.7%. PHY 350 W3FE planted using a 2x1 skip row planting pattern planted on 76 cm or 97/102 cm row spacings had greater fruit partitioned to zone three and when PHY 400 W3FE was planted solid on 97/102 cm row spacing, less fruit was distributed to zone three when compared to all other treatments (data not shown).

Cotton lint yield was significantly affected by planting pattern and ranged from 1,105 kg ha^{-1} to 1,340 kg ha^{-1}. Cotton planted using a 2x1 skip row planting pattern resulted in 18% less lint per hectare on a land area basis than cotton planted with a solid planted pattern (Table 1.3). However, on a planted area basis the 2x1 skip row pattern resulted in a 22% increase in lint yield. When the average cost of seed was subtracted from the gross return, differences in net returns were present. Solid planted cotton resulted in a 15% greater net return than cotton planted using a 2x1 skip row pattern (Table 1.3).

1.5 Discussion

Differences in cotton height and total nodes at first bloom were observed due to row spacing; however, differences were minimal. These data agree with Nichols et al. (2004) who observed that reductions in cotton height and total nodes at first bloom when cotton was planted on narrow row spacings. Reductions in NAWF at first bloom were negligible with minimal differences in maturity due to variety. At the end of the growing season, average cotton height was affected only by variety. However, NACB was impacted by planting pattern. Cotton grown using a 2x1 skip row pattern was slightly delayed in maturity when compared to the solid planting pattern. These data agree with Buehring et al. (2009) and Gwathmey and Steckel (2006) in that a skip row planting pattern can slightly delay maturity.

Jenkins et al. (1990) reported that first position bolls comprised the bulk of cotton fruit production and these data agree with those findings. However, differences in horizontal fruit distribution to first position bolls were observed when variety and planting pattern were pooled over row spacing. This interaction may be attributed to minimal differences between varieties in terms of maturity and mainly driven by planting pattern. When pooled over variety and row spacing, a solid planting pattern resulted in a greater percentage of first position bolls. Utilizing a 2x1 skip row pattern resulted in decreased first position weight but greater percentage of the total weight partitioned to third position bolls and to vegetative branches. These data agree with Miller (2005) who reported that a solid planting pattern resulted in a greater percentage of fruit partitioned to position one than skip row patterns and that the skip row patterns resulted in a greater amount of fruit partitioned to vegetative branches. These differences can be attributed to cotton plants compensating for the row that was skipped during planting.

Jenkins et al. (1990), Huff et al. (2010), and Dodds et al. (2010) reported that nodes 5-12 produced the majority of fruit and these data agree with those findings. However, differences in vertical distribution of fruit to all zones were observed when planting pattern data were pooled over row spacing and variety. Cotton grown using a solid planting pattern had more fruit distributed to zones one (all fruit on nodes five through 8) and two (all fruit on nodes nine through 12). While a 2x1 skip row planting pattern had more fruit distributed to zone three. Miller (2005) reported that solid planting patterns partitioned more fruit to nodes 5-12 than cotton planted with a 2x1 skip row pattern. These differences in vertical distribution can be attributed to cotton compensating for the missing row and the 2x1 skip row pattern having a higher percentage of fruit on vegetative branches and on upper third of nodes.

No differences in lint yield were observed due to row spacing. Previous research has reported that yields from cotton grown on 76 cm rows was equal to yield of cotton grown on wider row spacings (Williford et al. 1986; Harrison et al. 2006; Balkom et al. 2007; Gwathmey et al. 2007). However, differences in lint yield were observed between planting patterns. Parvin et al. (1999) reported that growers considering shifting to a 2x1 skip row pattern must be able to produce yields more than 90% of the solid yield on a land area basis. In this experiment the 2x1 skip row pattern resulted in lint yields that were 82% of solid planting patterns.

1.6 Conclusion

Fruit distribution is impacted by planting pattern. A 2x1 skip row pattern resulted in greater fruit partitioned to vegetative branches when compared to a solid planting pattern. Also, a 2x1 skip row pattern did not produce enough yield on a land area basis to compensate for the missing row. Based on these data, there were no differences in yield due row spacings. Overall, cotton grown with a 2x1 skip row pattern resulted in less lint yield than a solid planting pattern on a land area basis. If growers wanted to move to 76 cm row spacings to accommodate other cropping systems, these data suggest that there would be no loss in yield in doing so. If growers are considering moving to a skip row planting pattern, based on these data it would not be beneficial to do so, but moving from a 97/102 cm row spacing to a 76 cm row spacing could be a viable option without a reduction in lint yield.

1.7 Tables

Table 1.1 Dates of cotton planting and harvest for all locations and years

Cotton Planting & Harvest			
	Location	Planting Date	Harvest Date
2019	Belle Mina, AL	15 May	10 November
	Jackson, TN	18 May	19 November
	Starkville, MS	24 May	N/A*
	Stoneville, MS	23 May	24 October
2020	Belle Mina, AL	21 May	26 October
	Jackson, TN	15 May	17 November
	Starkville, MS	4 May	13 November
	Stoneville, MS	7 May	5 October

*Late season flooding of trial area prevented crop harvest

Table 1.2 Analysis of variance *p*-values for cotton growth parameters as affected by variety, row spacing, and planting pattern in Belle Mina, AL, Jackson, TN, Starkville, and Stoneville, MS in 2019 and 2020.

Effect	FBHT[a]	FBN[b]	NAWF[c]	HVTHT[d]	HVTN[e]	NACB[f]	YIELD[g]	Net Return
Variety	0.0005	0.2454	0.0141	0.0002	0.1676	0.0235	0.7943	0.0713
Row Spacing	0.0030	<0.0001	0.2421	0.6671	0.5328	0.3291	0.3338	0.5014
Planting Pattern	0.5655	0.2523	0.0619	0.2353	0.0930	<0.0001	<0.0001	<0.0001
Variety*Row Spacing	0.2870	0.4381	0.4744	0.1222	0.0651	0.1779	0.4799	0.4799
Variety*Planting Pattern	0.8437	0.3455	0.7477	0.7671	0.5631	0.2512	0.2305	0.2305
Row Spacing*Planting Pattern	0.8329	0.7486	0.4872	0.3683	0.2133	0.0999	0.4090	0.4090
Variety*Row Spacing*Planting Pattern	0.7267	0.6732	0.7635	0.5776	0.7492	0.7628	0.6306	0.6306

[a] Height at first bloom.
[b] Nodes at first bloom.
[c] Nodes above white flower.
[d] Height at harvest.
[e] Nodes at harvest.
[f] Node above cracked boll.
[g] Cotton lint yield.

Table 1.3 Cotton growth parameters as affected by variety, row spacing, and planting pattern in Belle Mina, AL, Jackson, TN, Starkville, and Stoneville, MS in 2019 and 2020.

Variety	Row Spacing	Planting Pattern	FBHT[a]	FBN[b]	NAWF[c]	HVTHT[d]	HVTN[e]	NACB[f]	YIELD[g]	Net Return[h]
			–cm–	—#—		—cm—	—#—		—kg ha^{-1}—	—$ ha^{-1}—
Phytogen 350 W3FE	--	--	79 a	15.0 a	6.3 a	91 a	18.4 a	4.0 a	1,199 a	1,644.70 a
Phytogen 400 W3FE	--	--	75 b	14.8 a	6.0 b	86 b	18.1 a	3.6 b	1,247 a	1,721.97 a
--	97/102 cm	--	78 a	15.1 a	6.2 a	88 a	18.3 a	3.9 a	1,214 a	1,668.99 a
--	76 cm	--	75 b	14.6 b	6.1 a	89 a	18.2 a	3.7 a	1,232 a	1,697.68 a
--	--	Solid	76 a	14.8 a	6.1 a	88 a	18.1 a	3.4 b	1,340 a	1,818.24 a
--	--	2x1 Skip	77 a	15.0 a	6.3 a	89 a	18.4 a	4.2 a	1,105 b	1,548.43 b

[a] Height at first bloom.
[b] Nodes at first bloom.
[c] Number of nodes above white flower.
[d] Plant height at harvest.
[e] Number of nodes at harvest.
[f] Number of nodes above cracked boll.
[g] Cotton lint yield.
[h] Seed cost subtracted from gross return.
*Each column is separated by a means when the p value is less or equal to .05

Table 1.4 Analysis of variance *p*-values for cotton growth parameters as affected by variety, row spacing, and planting pattern in Belle Mina, AL, Jackson, TN, Starkville, and Stoneville, MS in 2019 and 2020.

Effect	1st Position[a]	2nd Position[b]	3rd Position[c]	Vegetative[d]	Zone 1[e]	Zone 2[f]	Zone 3[g]
Variety	0.0733	0.0039	0.0002	0.0723	0.0437	0.0061	0.0039
Row Spacing	0.2401	0.3105	0.6678	0.0531	0.7104	0.0574	0.7295
Planting Pattern	<0.0001	0.6496	<0.0001	0.0164	0.8554	0.0061	0.2497
Variety*Row Spacing	0.4204	0.3525	0.6090	0.8572	0.7048	0.1662	0.3604
Variety*Planting Pattern	0.0097	0.8280	0.8224	0.0164	0.8554	0.0244	0.2497
Row Spacing*Planting Pattern	0.5967	0.5649	0.7602	0.3461	0.1741	0.9016	0.5263
Variety*Row Spacing*Planting Pattern	0.9850	0.8015	0.7713	0.7475	0.4610	0.9653	0.0293

[a] Percent of total weight distributed to 1st position bolls.
[b] Percent of total weight distributed to 2nd position bolls.
[c] Percent of total weight distributed to 3rd position bolls.
[d] Percent of total weight distributed to vegetative branch bolls.
[e] Percent of total weight distributed in zone 1 (nodes 5-8).
[f] Percent of total weight distributed in zone 2 (nodes 9-12)
[g] Percent of total weight distributed in zone 3 (nodes 13 and above).

Table 1.5 Percent of seedcotton distribution as affected by planting pattern and variety when pooled over row spacing in Belle Mina, AL, Jackson, TN, Starkville, and Stoneville, MS in 2019 and 2020.

Variety	Planting pattern	1^{st} Position[a]	2^{nd} Position[b]	3^{rd} Position[c]	Vegetative[d]	Zone 1[e]	Zone 2[f]	Zone 3[g]
Phytogen 400 W3FE	Solid	59.4 a	17.7 a	3.6 a	19.3 b	33.4 a	37.3 a	9.9 a
Phytogen 400 W3FE	2x1 skip	52.4 b	18.3 a	5.2 a	25.0 a	30.9 a	33.1 b	10.9 a
Phytogen 350 W3FE	Solid	54.2 b	20.8 a	5.0 a	20.0 b	32.2 a	36.4 a	11.3 a
Phytogen 350 W3FE	2x1 skip	51.4 b	21.0 a	6.4 a	20.2 b	30.1 a	36.0 a	13.6 a

[a] Percent of total weight distributed to 1^{st} position bolls.
[b] Percent of total weight distributed to 2^{nd} position bolls.
[c] Percent of total weight distributed to 3^{rd} position bolls.
[d] Percent of total weight distributed to vegetative branch bolls.
[e] Percent of total weight distributed in zone 1 (nodes 5-8).
[f] Percent of total weight distributed in zone 2 (nodes 9-12)
[g] Percent of total weight distributed in zone 3 (nodes 13 and above).
*Each column is separated by a means when the p value is less or equal to .05

Table 1.6 Percent of seedcotton distribution as affected by variety when pooled over planting pattern and row spacing in Belle Mina, AL, Jackson, TN, Starkville, and Stoneville, MS in 2019 and 2020.

Variety	1st Position[a]	2nd Position[b]	3rd Position[c]	Vegetative[d]	Zone 1[e]	Zone 2[f]	Zone 3[g]
Phytogen 350 W3FE	53.3 a	20.9 a	5.7 a	20.1 a	31.2 a	36.2 a	12.5 a
Phytogen 400 W3FE	55.4 a	18.0 b	4.4 b	22.2 a	32.2 a	35.2 a	10.4 b

[a] Percent of total weight distributed to 1st position bolls.
[b] Percent of total weight distributed to 2nd position bolls.
[c] Percent of total weight distributed to 3rd position bolls.
[d] Percent of total weight distributed to vegetative branch bolls.
[e] Percent of total weight distributed in zone 1 (nodes 5-8).
[f] Percent of total weight distributed in zone 2 (nodes 9-12)
[g] Percent of total weight distributed in zone 3 (nodes 13 and above).
*Each column is separated by a means when the p value is less or equal to .05

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CHAPTER II

DETERMINING THE EFFECT OF COTTON SEED SIZE AND SEEDING RATE ON COTTON GROWTH, DEVELOPMENT, AND YIELD

2.1 Abstract

Interest in cotton seeding rate and planting seed size exists due to the overall seed size of cotton varieties decreasing as well as increased seeding costs. An experiment was conducted in 2019 and 2020 in Jackson, TN, Starkville, MS, and Brooksville, MS to determine the impact of seed size and seeding rate on cotton plant development and yield. Early season vigor was impacted by seed size and seeding rate. Visual vigor ratings indicated that larger seeds and higher seeding rates produced the greatest visual vigor ratings. Fresh weight biomass was also impacted by seed size as larger seed produced greater fresh and dry cotton plant biomass when pooled over seeding rate and variety. Greatest seedcotton yields were obtained from planting larger seed, higher seeding rates, and from DP 1646 B2XF. Therefore, planting larger seed and increasing seeding rates may be beneficial depending on the growing conditions for a given crop season.

2.2 Introduction

Cotton (*Gossypium hirsutum* L.) was the fourth ranked agricultural commodity in farm-gate value in Mississippi in 2018 producing $623 million in revenue (MDAC 2018). In general, seed size of cotton cultivars has decreased in recent years (Bednarz et al. 2007; Main et al. 2013). Seed size, density, and nutrient content can impact early season vigor of cotton (Ferguson and

Turner, 1971; Bartee and Krieg, 1974; Krieg and Bartee, 1975; Snider et al., 2014). Cotton seed size can also impact the amount of lint a boll can produce due to differences in the surface area of the seed in boll (Harrell and Culp, 1976).

Early season vigor is important for stand establishment but is not directly correlated to yield. Vigorous growth in the early stages of cotton development can aid in getting plants beyond the period of susceptibility to early season pests such as thrips (Thysanoptera: Thripidae) (Cook et al. 2011; Liu et al. 2015). Vigorous early season growth can also lead to quicker canopy closure which may assist with weed control and save on herbicide cost. Previous research suggests that larger cotton seed will produce increased early season vigor compared to smaller seeds (Coombes and Grubb 2003). A direct correlation between seedling vigor and the seed size of a given cultivar has been previously observed (Snider et al. 2016). Cultivars grown from smaller seeds produced less fresh weight at the two- to three-leaf stage of growth compared to fresh weight of plants at the same growth stage grown from larger seeds. Seeds weighing 90 mg each produced plants at the two to three-leaf stage of growth with fresh weights of 2.0 g each. Seeds weighing 110 mg each produced plants at the two to three-leaf stage of growth with fresh weights of 2.7 g each (Snider et al. 2016).

Cotton lint is made up of fibers that originate from seeds inside the boll. The number of bolls per unit of land area impacts yield (Worley et al., 1974). As a result, cultivar selection has focused on increasing the number of bolls per unit of land area. The number of seeds per boll can also impact yield as many small seeds in a given boll may have greater surface area than a smaller number of large seeds in a boll (Culp and Harrell, 1975). Over the last 40 years, decreased seed size and increased lint percentage has been observed (Bednarz et al. 2007; Main et al. 2013). Planting density can also impact seed size in the boll at the end of the growing season. Higher planting densities may reduce seed size as well as oil and protein content (Bednarz et al 2000; Bednarz et al. 2006; Bednarz, 2007; Dowd et al., 2018).

Since transgenic cotton was introduced, producers have incurred increased costs for technology fees. With the cost to plant transgenic crops increasing, reducing the seeding rate to minimize planting expense is a temptation for many growers (Pettigrew and Johnson, 2005). Numerous studies evaluated plant densities necessary to maximize yield (Buxton et al., 1977; Mohamad et al.,1982; Kerby et al., 1990; Sawan et al., 1993; Bednarz et al., 2005). Previous research reports no yield differences between 90,000, 110,000 and 130,000 plants ha^{-1} to a reduction in yield when reducing the plant density from 90,000 plants ha^{-1} to 70,000 plants per hectare (plants ha^{-1}) (Pettigrew and Johnson, 2005). Other studies have reported no decreases in cotton yield when plant populations were as low as 37,000 plants ha^{-1} (Samples et al., 2014; Jones and Wells, 1997).

Interest in seeding rate and cotton seed size due to the overall seed size of cotton varieties decreasing and increased seeding costs exists. No literature could be located that evaluated cotton seeding rate and cotton seed size. Therefore, research was conducted to evaluate the effect of cotton seeding rate and seed size on cotton growth, development, and yield.

2.3 Materials and Methods

An experiment was conducted in 2019 and 2020 in Starkville, MS; and Brooksville, MS; and Jackson, TN to evaluate the impact of cotton seed size and seeding rate on cotton growth, development, and yield. Plots consisted of four 97 cm rows that were 12.2 m in length and each plot was replicated four times. Studies were conducted using a factorial arrangement of treatments within a randomized complete block design. Factor A consisted of variety and included: Deltapine 1646 B2XF (Bayer Crop Science St. Louis, MO) treated with metalaxyl, fluxapyroxad, pyraclostrobin, myclobutanil, imidacloprid, clothianidin, and *Bacillus firmus* I-1582 (Acceleron Elite; Bayer Crop Science St. Louis, MO) and NexGen 3406 B2XF (Americot, Inc. Lubbock, TX) treated with metalaxyl, fludioxonil, myclobutanil, and imidacloprid (CottolyST BASE; Americot, Inc. Lubbock, TX); Factor B consisted of seed size and included: Deltapine 1646 B2XF at 11,346 seed/kg, 12,033 seed/kg, and 13,103 seed/kg; NexGen 3406 B2XF at 10,202 seed/kg, 11,321 seed/kg, and 12,216 seed/kg; Factor C consisted of seeding rate and included: 49,400 seed/ha, 98,800 seed/ha, and 148,200 seed/ha. Planting and harvest dates are given in Table 2.1. Cotton grown in Starkville, MS was furrow irrigated once in 2019 and twice in 2020 with 7.5 cm of irrigation water delivered using 38 cm lay flat polyethylene pipe (Delta Plastics). Cotton grown in Brooksville, MS and Jackson, TN was grown under dryland conditions. Fertilizer nitrogen (30% UAN) was injected 5 cm deep into the soil in a split application with 56 kg N ha^{-1} applied at planting and 78 kg N ha^{-1} applied approximately 30 days after planting at the Starkville, MS location. At the Brooksville, MS and Jackson, TN location, fertilizer nitrogen (30% UAN) was injected in a single application at 134 kg N ha^{-1} approximately 30 days after planting. All fertilizer nitrogen applications were made using a ground driven knife applicator. One plant growth regulator application was applied to the entire experiment area at the Starkville, MS (29 July 2019 and 21 July 2020) and Brooksville, MS (01 August 2019 and 23 July 2020) locations using a 0.35 lb ai gal^{-1} mepiquat chloride (Mepiquat, Loveland Products, Inc., Loveland, CO) at 49 g ai ha^{-1}. Pest management and harvest aid applications were based on Extension recommendations at each location.

Data collection included visual vigor ratings at 7, 14, 21, and 28 days after planting (DAP) on a 1-9 scale (1=worst, 9=best). Stand counts were also evaluated 14, 21, and 28 DAP. Fresh and dry cotton biomass was determined from five cotton plants per plot at the four to six leaf growth stage. Cotton plants were cut at the soil line and fresh weight data were collected. Cotton plants were placed in a forced air dryer at 60°C for 72 hours at which time dry weight biomass were determined. Cotton height, total nodes and node above white flower (NAWF) data were collected at first bloom and cotton height, total nodes and node above cracked boll (NACB) were evaluated immediately prior to harvest aid application. Prior to mechanical harvest, seed cotton from 25 bolls per plot was hand collected and ginned to determine turnout and fiber quality. Yield was collected using a spindle picker modified for small plot research. Seedcotton was ginned on a 10-saw Continental Eagle laboratory gin (Continental Eagle Corp., Prattville, AL) and fiber quality was determined using high volume instrumentation (HVI) at the USDA-AMS fiber quality laboratory in Memphis, TN. All data were subjected to analysis of variance using the PROC MIXED procedure in SAS v 9.4 and means were separated using Fisher's Protected LSD at a significance level of 0.05. Location and replication were considered random effects.

2.4 Results

Visual vigor ratings (1-9 scale; 1=worst, 9=best) at 7 DAP ranged from (5.5-5.8) and were unaffected by any variable. Visual vigor was impacted by a variety by seed size interaction and ranged from 5.5-6.1 at 14 DAP. Small and large seed size Deltapine 1646 B2XF and large seed size NexGen 3406 B2XF resulted in greatest visual vigor (data not shown). Visual vigor was also impacted by variety by seeding rate at 14 DAP ranging from 5.5-6.3. Deltapine 1646 B2XF and NexGen 3406 B2XF with a seeding rate of 148,200 seed ha^{-1} resulted in greater visual vigor at 14 DAP. Visual vigor at 21 and 28 DAP were impacted by seeding rate. Cotton planted at 148,200 seeds ha^{-1} had 6% greater visual vigor at 21 (6.1) and 28 (6.4) days after planting when compared to all other treatments (Table 2.4). Stand counts at 14, 21, and 28 DAP were also affected by seeding rate. Cotton planted at 148,200 seeds ha^{-1} had significantly greater stand counts when compared to all other treatments (Table 2.4). Cotton planted at 148,200 seed ha^{-1} resulted in stand counts of 118,494-125,948 plants ha^{-1} at 14 and 28 DAP.

Seeding rate affected fresh and dry biomass weights of cotton at the four to six leaf growth stage. Cotton planted at 148,200 seeds ha^{-1} resulted in greater fresh and dry biomass weights at four to six leaf growth stage when compared to all other treatments. Fresh and dry biomass weights of cotton planted at 148,200 seeds ha^{-1} were 7% greater (24.7g & 5.6g, respectively) than each weight at the four to six leaf stage when cotton was seeded at 49,400 seed ha^{-1} and 98,800 seeds ha^{-1} (Table 2.6).

Fresh biomass weight at four to six leaf growth stage was also impacted by seed size when pooled over seeding rate and variety. Planting large seeds resulted in greater fresh weight biomass (24.6g/five plants) at the four to six leaf stage compared to fresh weight biomass (22.3-22.8g/five plants) at the same stage from small and medium size seeds. However, seed size had no impact on dry biomass weights at four to six leaf growth stage.

Cotton height, nodes, and NAWF at first bloom were impacted by variety when pooled over seed size and seeding rate. Cotton height at first bloom ranged from 67-73 cm. Deltapine 1646 B2XF was 8% taller than NexGen 3406 B2XF at first bloom (Table 2.8). Total node counts at first bloom ranged from 15.5-16 nodes. Deltapine 1646 B2XF had 3% more total nodes (16.0) than NexGen 3406 B2XF (15.5) at first bloom (Table 2.6). NAWF counts ranged from 6.1-6.5. Deltapine 1646 B2XF had 6.4% (6.5) more NAWF than NexGen 3406 B2XF (6.1) at first bloom (Table 2.6). Seeding rate also impacted NAWF at first bloom when pooled over variety and seed size. Cotton planted at 49,400 seeds ha^{-1} had 3.4% more NAWF than cotton planted at 148,000 seeds ha^{-1} at first bloom (Table 2.6). However, NAWF at first bloom were similar between cotton planted at 49,400 seed ha^{-1} and cotton planted at 98,800 seeds ha^{-1}.

Cotton height at the end of the growing season ranged from 85-88cm. Cotton height was impacted by variety when pooled over seed size and seeding rate at the end of the growing season. Deltapine 1646 B2XF was 3% taller (88cm) than NexGen 3406 B2XF (85cm) at the end of the growing season (Table 2.6). Seeding rate also impacted cotton height at the end of the growing season with cotton planted 49,400 seeds ha^{-1} being 2.8% taller plants when compared to other seeding rates (Table 2.6). Node counts ranged from 17.2-17.7 at the end of the growing season and were impacted by variety. Deltapine 1646 B2XF had 2.6% more nodes than NexGen 3406 B2XF (Table 2.6). No differences in maturity as defined by NACB were observed.

Cotton lint yield was impacted by seeding rate and an interaction between variety and seed size. Lint yield ranged from 793-1036kg ha^{-1}. Deltapine 1646 B2XF at 11,346 seed/kg (large seed) and Deltapine 1646 B2XF at 13,103 seed/kg (small seed) produced 10-12% greater lint yields (1,036 and 1,000 kg lint ha^{-1} respectively) than Deltapine 1646 B2XF planted with medium size seed (909 kg lint ha^{-1}) as well as NexGen 3406 B2XF all seed sizes (793-908 kg lint ha^{-1}). Deltapine 1646 B2XF at 12,033 seed/kg (medium size) and NexGen 3406 B2XF at 10,202 seed/kg (large size) produced a 9-13% greater lint yield than NexGen 3406 B2XF at 11,321 seed/kg (medium size) or 12,216 seed/kg (small size) (Table 2.5). Cotton lint yield was impacted by seeding rate when pooled over seed size and variety. Cotton planted at 148,200 seeds ha^{-1} produced 6% greater lint yield (976 kg lint ha^{-1}) than cotton planted at 98,800 seeds ha^{-1} (922 kg lint ha^{-1}) and cotton planted at 98,800 seeds ha^{-1} had 9% greater lint yield than cotton planted at 49,400 seeds ha^{-1} (839 kg lint ha^{-1}) (Table 2.6). However, when the average cost of seed for each seeding rate were subtracted from the gross return, there were no significant differences in net return due to seeding rates (Table 2.6).

Differences were observed in micronaire, fiber length, fiber strength and uniformity. Micronaire ranged from 4.6-4.8 and was impacted by an interaction between seeding rate and seed size. Cotton with medium seed sizes planted at 148,200 seeds ha^{-1} and small seed planted at 98,800 seeds ha^{-1} had a 6% reduction in micronaire when medium seed was planted at 49,400 seed ha^{-1} and large seed planted at 98,800 seed ha^{-1}. NexGen 3406 B2XF planted at 148,200 seed ha^{-1} resulted in the lowest micronaire (4.6) when compared to all other treatments. These data suggest that no impact on premiums or deductions were observed.

Differences in fiber length, fiber strength, and uniformity were observed between varieties when pooled over seed size and seeding rate. Fiber length ranged from 28.9-30.6 mm and fiber strength ranged from 30.2-30.7 g/tex. Deltapine 1646 B2XF produced a 5.5% increase in fiber length and a 2.7% increase in fiber strength when compared to NexGen 3406 B2XF (Table 2.6). However, NexGen 3406 B2XF produced increased uniformity when compared to Deltapine 1646 B2XF (Table 2.9). When seed size data were pooled over seeding rate and variety, fiber strength was affected. Small seed sizes (Deltapine B2XF at 13,103 seed/kg and NexGen 3406 B2XF at 12,216 seed/kg) produced a 2% increase in fiber strength compared to large seed sizes (Deltapine 1646 B2XF at 11,346 seed/kg and NexGen 3406 B2XF at 10,202 seed/kg) (data not shown). Differences in uniformity were observed between seeding rates when pooled over seed size and variety. Cotton planted at 49,400 seeds ha^{-1} produced an increased uniformity when compared to cotton planted at 148,200 seeds ha^{-1} (Table 2.6). According to these data a premium 25 points was observed for fiber strength.

2.5 Discussion

Previous research has reported that larger seed sizes have resulted in increased early season vigor (Coombes and Grubb 2003, and Snider et al. 2016). However, no differences in visual vigor ratings in these studies were observed due to seed size. Differences in visual vigor ratings were observed at 14, 21, and 28 days after planting due to increased seeding rates. Snider et al. (2016) reported that larger seed sizes produced a greater fresh weight than smaller seed sizes at the 2-3 leaf growth stage. Our research is consistent with those findings in that large seed sizes produced cotton plants with a greater fresh weight at the four to six leaf stage than observed from medium or smaller seed sizes at the four to six leaf growth stage. However, no differences were observed in dry biomass weight of cotton plants at the four to six leaf stage due to seed size. Fresh and dry biomass weights were impacted by seeding rate with planting higher seeding rates producing a greater fresh and dry cotton biomass at the four to six leaf growth stage.

Differences in height, node counts, and NAWF counts were observed at first bloom. These differences were impacted by variety. Deltapine 1646 B2XF produced taller plants and greater total nodes and NAWF counts than NexGen 3406 B2XF. Previous research has reported that as seeding rates increase there is a positive relationship with plant height (Siebert er al. 2006). However, findings in this research found that lower seeding rates resulted in taller plants at the end of the growing season. Varietal differences in height and total node counts have been previously reported and the findings from this study agree with previous reports. No differences in maturity at the end of the growing season were observed.

Differences in lint yield were observed. Planting larger seed resulted in a greater lint yield than planting medium or small seed sizes. Snider et al. (2016) reported that seed size was of minimal importance in determining lint yield for most situations. Higher lint yields have been obtained from increasing seeding rate (Hawkins and Peacock, 1970, 1971 and Siebert et al. 2006). However, conflicting reports exist that show no differences in lint yield due to seeding rate (Franklin et al., 2000; Bednarz et al., 2000; and Jones and Wells, 1998). Our data agree with previous research that when seeding rate was increased, there was a positive relationship with respect to lint yield. However, when seed cost was subtracted from the gross return there were no differences in net return was observed due to seeding rates.

Previous reports regarding the impact of plant population on fiber properties exist. Siebert et al. (2006), Baker (1976), Bridge et al. (1973), and Hawkins and Peacock (1971) reported that most cotton fiber properties were unaffected by plant populations, while Bridge et al. (1973) and Jones and Wells (1998) reported that micronaire tended to increase as population decreased. Data from this research agrees with these previous findings in that lower seeding rates impacted micronaire; however, lower seeding rates resulted in increased uniformity when compared to high seeding rates. Although there were differences in micronaire, these differences would not result in a penalization due to micronaire as they were in the allowable range on the CCC loan chart. Differences in fiber strength were observed due to seed size with planting small seed resulting in greater fiber strength when compared to planting large seed. Fiber length, strength, and uniformity very impacted by variety. Deltapine 1646 B2XF resulted in greater fiber length and strength. While NexGen 3406 B2XF resulted in an increase in uniformity. Differences in micronaire were observed due to an interaction between seed size and seeding rate. These differences can be attributed to minimal micronaire differences in seed size and driven by seeding rate.

2.6 Conclusion

Based on these data, large and small seed size Deltapine 1646 B2XF produced greatest lint yield. These data confirm that differences in lint yield are impacted more so by variety selection than seed size. However, large seed size resulted in greater fresh biomass weight and lint yield. Seeding rate impacted visual vigor ratings, fresh biomass, and dry biomass weights, suggesting that if vigorous early season growth was needed or wanted it could be obtained from increasing seeding rate and would not result in an impact on overall returns. Depending on certain input cost increased cotton seeding rates to achieve increased yields would not be beneficial.

2.7 Tables

Table 2.1 Dates of cotton planting and harvest for all locations and years

		Cotton Planting & Harvest	
	Location	Planting Date	Harvest Date
2019	Brooksville, MS	13 June	19 November
	Jackson, TN	18 May	19 November
	Starkville, MS	22 May	18 October
2020	Brooksville, MS	12 May	4 November
	Jackson, TN	15 May	16 October
	Starkville, MS	11 May	20 October

Table 2.2 Analysis of variance *p*-values for cotton growth parameters as affected by variety, seed size, and seeding rate in Jackson, TN, Brooksville and Starkville, MS in 2019 and 2020.

	Visual Vigor Rating				Stand Counts			Biomass							
Effect	7 DAP[a]	14 DAP[a]	21 DAP[a]	28 DAP[a]	14 DAP[a]	21 DAP[a]	28 DAP[a]	Fresh[b]	Dry[c]	FBHT[d]	FBN[e]	NAWF[f]	HVTHT[g]	HVTN[h]	NACB[i]
Variety	0.5340	0.2700	0.3999	0.0709	0.7503	0.1500	0.1609	0.1407	0.1455	<.0001	<.0001	<.0001	0.0023	0.0015	0.1129
Seed Size	0.6253	0.1974	0.4686	0.1988	0.4255	0.0483	0.7303	0.0217	0.1384	0.1665	0.5743	0.8983	0.4774	0.1541	0.8996
Seeding Rate	0.0930	0.0012	<.0001	<.0001	<.0001	<.0001	<.0001	0.0099	0.0139	0.4384	0.3849	0.0141	0.0250	0.2607	0.0889
Variety*Seed Size	0.2804	0.0016	0.1642	0.1948	0.1246	0.1674	0.0460	0.0930	0.2521	0.4147	0.6625	0.7571	0.4881	0.7471	0.5177
Variety* Seeding Rate	0.6652	0.0128	0.5700	0.7714	0.9305	0.1686	0.6571	0.9143	0.9937	0.4453	0.8541	0.2373	0.8744	0.4064	0.9467
Seed Size* Seeding Rate	0.2592	0.0640	0.9157	0.1531	0.7059	0.7366	0.4592	0.8195	0.8974	0.3514	0.6125	0.1485	0.8859	0.8219	0.2612
Variety*Seed Size*Seeding Rate	0.0612	0.5493	0.5727	0.9838	0.7861	0.7938	0.9305	0.6048	0.6182	0.9163	0.7911	0.4241	0.5751	0.3142	0.9877

[a] DAP = Days after planting
[b] Cotton fresh weight at 4-6 leaf stage.
[c] Cotton dry weight at 4-6 leaf stage.
[d] Height at first bloom.
[e] Nodes at first bloom.
[f] Nodes above white flower at first bloom.
[g] Height at harvest.
[h] Nodes at harvest.
[i] Nodes above cracked boll at harvest.

Table 2.3 Analysis of variance *p*-values for cotton lint yield, net return, and fiber quality parameters as affected by variety, seed size, and seeding rate in Jackson, TN, Brooksville and Starkville, MS in 2019 and 2020.

Effect	Lint Yield	Net Return	Mic	Length	Strength	Uniformity
	———————————	———————	——*p*-values——	———————	———————	———————
Variety	<.0001	<.0001	0.9100	<.0001	<.0001	0.0001
Seed Size	<.0001	<.0001	0.8202	0.5208	0.0288	0.6197
Seeding Rate	<.0001	0.2112	0.0217	0.3179	0.0843	0.0477
Variety[7]*Seed Size	0.0095	0.0095	0.8292	0.7293	0.1484	0.0630
Variety[7]*Seeding Rate	0.7172	0.7172	0.0231	0.3605	0.6146	0.8051
Seed Size[8]* Seeding Rate	0.5035	0.5035	0.0240	0.7053	0.2704	0.9689
Variety[7]*Seeding Rate[9]*Seed Size	0.3124	0.3124	0.5774	0.5135	0.6112	0.9135

Table 2.4 Cotton growth parameters as affected by seeding rate when pooled over seed size and variety in Jackson, TN, Brooksville, and Starkville, MS in 2019 and 2020.

Seeding Rate	Visual Vigor Rating				Stand Counts		
——seed ha^{-1}——	7 DAP[a]	14 DAP[a]	21 DAP[a]	28 DAP[a]	14 DAP[a]	21 DAP[a]	28 DAP[a]
49,400	5.5	5.7	5.5 c	5.9 b	48,596 c	46,475 c	45,446 c
98,800	5.7	5.8	5.7 b	6.0 b	88,756 b	88,097 b	85,029 b
148,200	5.8	6.1	6.1 a	6.4 a	125,948 a	121,374 a	118,494 a

[a] DAP = Days after planting

*Each column is separated by a means when the p value is less or equal to .05

Table 2.5 Cotton growth parameters as affected by variety and seed size when pooled over seeding rate in Jackson, TN, Brooksville, and Starkville, MS in 2019 and 2020.

Variety	Seed Size	Visual Vigor Rating 14 DAP[a]	Lint Yield\[b] -kg ha^{-1}-	Net Return[c] —$ ha^{-1}—
DeltaPine 1646 B2XF	Small (13,103 seed kg^{-1})	6.1 a	1000 a	1300.96 a
DeltaPine 1646 B2XF	Medium (12,033 seed kg^{-1})	5.5 c	909 b	1157.34 b
DeltaPine 1646 B2XF	Large (11,346 seed kg^{-1})	6.1 a	1036 a	1357.69 a
NexGen 3406 B2XF	Small (12,216 seed kg^{-1})	5.6 bc	793 c	972.19 c
NexGen 3406 B2XF	Medium (11,321 seed kg^{-1})	6.0 ab	829 c	1030.16 c
NexGen 3406 B2XF	Large (10,202 seed kg^{-1})	5.9 abc	908 b	1154.87 b

[a] Visual vigor rating at 14 days after planting.

[b] Lint yield

[c] Seed cost subtracted from gross return

*Each column is separated by a means when the p value is less or equal to .05

Table 2.6 Cotton growth parameters as affected by variety and seeding rate in Jackson, TN, Brooksville, and Starkville, MS in 2019 and 2020.

Variety	Seeding Rate	Biomass		FBHT[a]	FBN[b]	NAWF[c]	HVTHT[d]	HVTN[e]	YIELD[d]	Length[g]	Strength[h]	Unif[i]
	-seed ha^{-1}-	Fresh	Dry	--cm--	---------#---------		---cm---	----#----	kg ha^{-1}	--mm--	--g/tex--	--%--
DeltaPine 1646 B2XF	--	--	--	73 a	16.0 a	6.5 a	88 a	17.7 a	--	30.6 a	30.7 a	83.3 b
NexGen 3406 B2XF	--	--	--	67 b	15.5 b	6.1 b	85 b	17.2 b	--	28.9 b	30.2 b	83.7 a
--	49,400	22.1 b	5.1 b	--	--	6.5 a	88 a	--	839 c	--	--	83.6 a
--	98,800	22.9 b	5.2 b	--	--	6.3 ab	85 b	--	922 b	--	--	83.6 ab
--	148,200	24.7 a	5.6 a	--	--	6.1 b	85 b	--	976 a	--	--	83.4 b

[a] Fresh biomass weight in grams at 4-6 leaf growth stage.
[b] Dry biomass weight in grams at 4-6 leaf growth stage.
[a] Height at first bloom.
[b] Nodes at first bloom.
[c] Number of nodes above white flower.
[d] Plant height at harvest.
[e] Number of nodes at harvest.
[f] Lint yield
[g] Fiber length
[h] Fiber strength
[i] Fiber uniformity
*Each column is separated by a means when the p value is less or equal to .05

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