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Seed Quality and Planting Date Effects on Cotton Lint Yield, Yield Components, and Fiber Quality

William T. Pettigrew* and William R. Meredith, Jr.

ABSTRACT

Poor quality cotton (*Gossypium hirsutum* L.) seed resulting from unfavorable growing conditions in seed production areas, complicates planting decisions for producers, particularly when higher-priced transgenic cultivars are involved. Studies were conducted to investigate how varying planting dates and genetic backgrounds affected the development, lint yield, and fiber quality for seed lots of varying quality or seed size. Twelve different seed lots of varying cultivars, seed germination rates, and seed sizes were planted at either an early April or early May planting date from 2002 through 2004 at Stoneville, MS. Seeding rate adjustments were made based upon the germination rate of the seed lots and seedling survival expectations for the two planting dates. Seedling emergence counts, dry matter partitioning, lint yield and yield components, and fiber quality data were collected each growing season. Although early planting reduced seedling emergence by 16%, lint yield increased 14%. Planting seed lots of varying germination rates or seed lots generated by blending seeds of varying germination for individual cultivars had essentially no impact on lint yield production and few effects on dry matter production or fiber quality. The larger seed size seed lot of PM 1218BR resulted in 17% more seedlings emerging than the small seed size lot, and that translated into 7% more lint yield for the large size seed lot. The overt negative consequences from inadequate stand establishment on lint yield production by using poor quality seed can mostly be avoided by adjusting the seeding rate to account for poorer germination rates or the poor emergence conditions associated with early planting.

W.T. Pettigrew, W.R. Meredith, Jr., USDA-ARS, Crop Genetics and Production Research Unit, P.O. Box 345, Stoneville, MS 38776
*Corresponding author: bill.pettigrew@ars.usda.gov

The introduction of transgenic technologies to cotton production systems in the mid-1990's has changed many aspects of producing cotton. These transgenic benefits, primarily herbicide and insect resistance traits, were also accompanied with increased seed costs due to the technology fees assessed for each transgenic trait incorporated into the seed. Many producers adjusted to this increased seed input cost by utilizing a minimal seeding rate that still provided an acceptable profit potential. Utilization of these minimal seeding rates places a premium on the quality of the seed that is planted. Unfortunately, seed quality can vary among seed lots due to a variety of factors including environmental conditions during seed development (Leffler, 1986); post-maturation weathering (Halloin, 1986); and harvesting, ginning, and processing (Delouche, 1986).

Numerous studies have documented yield reductions when poor quality seed are planted (Wanjura et al., 1969; Minton et al., 1982; Wheeler et al., 1997). Most of these yield reductions were attributed to inadequate stand establishment that was directly connected to seedling germination and emergence. Adjusting seeding rates to account for variations in germination should stabilize the level of stand establishment among seed lots. However, surviving seedlings from poor quality seed may also struggle in performance compared to those from a superior quality seed lot (Turner and Ferguson, 1972; Minton and Supak, 1980). Although Turner and Ferguson (1972) documented differences in seedling dry matter production, blooming rates, and maturity among different seed quality lots for a single cultivar, it is not entirely clear how the growth, development, yield and fiber quality production of a cotton crop established from a poor quality seed lot might differ from that established from a superior quality seed lot, when similar final stand counts were maintained. In addition, Barradas and López-Bellido (2007) identified genotypic differences in field emergence and seed vigor index but only used one seed lot for each of the individual genotypes. Because few of these studies investigated varying quality seed lots from different genetic backgrounds, it is unclear if a genotype by seed quality interaction might exist for seedling emergence, yield, and other aspects of cotton growth and development.

Previous research has demonstrated that improved yield production can be achieved by planting earlier than has traditionally been considered the optimum planting window for the Mississippi Delta (Pettigrew, 2002). Early planting also presents a challenge for stand establishment due to placement of the seed in a stressful environment (possible colder and wetter conditions), leading to the need for slightly higher seeding rates (Pettigrew and Johnson, 2005). An even greater premium must be placed upon utilizing high quality seed when planting under cooler conditions common with early planting than when planting in more traditional planting windows (Smith and Varvil, 1984).

Balancing the risks and rewards of an early planting system, producers must make planting decisions every growing season while taking into account climatic conditions during the intended time of planting. Although the best quality seed should be used when planting early, that option does not always present itself every growing season. Will a producer achieve acceptable yields with early planting by either increasing the seeding rate of poor quality seed or by blending a superior and a poor seed lot together, compared to that achieved with superior quality seed? The objectives of this research were to determine how cotton growth and development, lint yield, yield components, and fiber quality were affected by variations in seed quality or by blending two seed lots together of varying quality when planted at both an early planting date and a normal planting date. Seed lots of varying quality from multiple varieties will be tested for evidence of an interaction between genetic background and seed quality.

MATERIALS AND METHODS

Field studies were conducted from 2002 through 2004 on a Bosket fine sandy loam soil (fine-loamy, mixed, active, thermic Mollic Hapludalfs) near Stoneville, MS. Twelve seed lots were planted at both an early and a normal planting date each year (Table 1). Within these 12 seed lots were seven cultivars, ‘CT 120’ (Seed Source Inc.; Stoneville, MS); ‘DPL 555BR’ (Delta and Pine Land Co.; Scott, MS); ‘FiberMax 966’ (FM 966) (Bayer CropScience; Research Triangle Park, NC); ‘GA 161’ (May et al., 2001); ‘PayMaster 1218BR’ (PM 1218) (Delta and Pine Land Co.; Scott, MS); ‘Phytogen PSC 355’ = (PSC 355) (Dow AgroSciences; Indianapolis, IN); and ‘SureGrow 747’ (SG 747) (Delta and Pine Land Co.; Scott, MS). Seed lots of two varying standard germination levels (high or low) were utilized with FM 966, PSC 355, and SG747. Low germination seed lots of the selected cultivars were produced by delaying harvest and thereby exposing the open bolls to prolonged weathering, while the high germination seed lots were obtained from the seed companies. Averaged across years, the standard germination rates were 81% for the high and 54% for the low germination seed lots of FM 966; 88% for the high and 53% for the low germination seed lots of PSC 355; and 92% for the high and 57% for the low germination seed lots of SG 747. In the FM 966 background, an additional seed lot (blend) was also created by blending the low and high germination seed lots together. Within the PM 1218BR background, two seed lots of varying seed size (large and small) were utilized. The different seed size lots of PM 1218BR were produced by different N fertility levels (Pettigrew and Adamczyk, 2006). The seed index of the seed lots of varying seed size in the PM 1218BR background averaged across years were 112 mg $seed^{-1}$ for the large seed size and 106 mg $seed^{-1}$ for the small seed size. To minimize stand establishment as a factor influencing growth and yield, seeding rates of each seed lot were adjusted to result in similar numbers of surviving seedlings based upon the standard germination of each seed lot and assumptions made about seedling survival for each planting date to achieve a goal of 50 surviving seedlings per 6.1 m of plot row or approximately 80,000 plants ha^{-1}. Assumptions were made that 80% of the germinating seeds planted at the normal planting time would emerge and survive and that 70% of the germinating seeds planted early would emerge and survive.

Table 1. Twelve seed lots planted at both an early and a normal planting date during 2002 through 2004 at Stoneville, MS. Can a number be associated with the terms High and Low?

Cultivar	Germination Rate	Seed Size
CT 120	---	---
DPL 555BR	---	---
FiberMax 966	Blend	---
FiberMax 966	High	---
FiberMax 966	Low	---
GA 161	---	---
PayMaster 1218BR	---	Large
PayMaster 1218BR	---	Small
Phytogen PSC 355	High	---
Phytogen PSC 355	Low	---
SureGrow 747	High	---
SureGrow 747	Low	---

The field study utilized a randomized complete block design with a split-plot treatment arrangement and six replicates. Planting dates were the main plots and seed lots were the sub-plots. Plots were planted on 5 April 2002; and 1 April 2003 and 2004 for the early planting and 1 May 2002 and 2003; and 3 May 2004 for the normal planting. Plots consisted of 4 rows spaced 1-m apart and 6.1 m in length. To facilitate seedling disease suppression and early season insect control, 0.87 kg ha^{-1} PCNB (pentachloronitrobenzene), 0.22 kg ha^{-1} etridiazole (5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole), and 0.87 kg ha^{-1} disulfoton (O,O-diethyl S-[2-(ethylthio) ethyl] phosphorodithioate) were applied in-furrow during planting. Emergence counts were made each year approximately 25 to 30 days after each planting date. Following emergence counts for each planting date, plots within each respective planting date were then thinned to 6 plants m^{-2} or approximately 65,000 plants ha^{-1}. Plants were preferentially thinned to generate approximately equi-distance within-row spacing between the plants. The experimental area was subsoiled each fall after cotton stalk destruction. Each year, 112 kg N ha^{-1} was applied preplant to the experimental area as urea-ammonium nitrate solution (32% N). Furrow irrigation was applied when needed to minimize moisture deficit stress. Recommended insect and weed control measures were employed as needed throughout the growing season.

Dry matter harvests were performed during 8-15 July, 2002; 7-11 July 2003; and 29 June-1 July 2004. One of the inner plot rows was designated for use in the dry matter harvests. On each harvest date, the aboveground portions of plants from 0.3 m of row were harvested and separated into leaves, stems and petioles, and reproductive structures. Leaf area index (LAI) was determined by passing the leaves through a LI-3100 leaf area meter (Li-Cor, Lincoln, NE), and the main stem nodes were counted. Samples were dried for 48 h at 60 ºC, and dry weights were recorded.

Yield was determined by hand-harvesting the center 4.6 m of row length from one of the inner plot rows that was not used in the dry matter harvest, avoiding the ends of the row. Four hand-harvests were made each year of the study. The number of bolls harvested per plot were counted on each harvest date. Boll mass was determined by dividing the seed cotton harvested per plot by the number of bolls harvested per plot. Average seed mass was determined from 100 nondelinted seeds per plot.

After ginning, lint samples were sent to Starlab Inc., (Knoxville, TN) for determination of various fiber quality parameters. Fiber bundle strength and fiber elongation were determined with a stelometer. Micronaire was determined with a micronaire device. Span lengths were measured with a digital fibrograph. Fiber maturity and perimeter were calculated from arealometer measurements.

Data were subjected to analysis of variance (PROC MIXED, SAS Institute, 1996). For traits where year interacted with seed lots or planting dates and environmental effects associated with year were identified, the results were presented by year. When the seed lot or planting date differences for a trait were consistent across years, the seed lot or planting date means were averaged across years, and the year interactions with seed lot or planting date were considered a random source of error. F-tests were performed for a set of orthogonal contrasts to check for significant effect of variables (planting date, germination rate, seed size, etc..). These F-tests were then followed with specific mean comparisons using LSD at the 0.05 level.

RESULTS AND DISCUSSION

Different yearly weather conditions during this study represented three distinct growing environments (Table 2). The early spring was cooler and wetter in 2004 compared to the other years, whereas 2002 tended to be wet later in the season. The 2004 growing season also tended to be slightly cooler during the principle months of flowering and boll development (July and August). These diverse growing conditions across years offered a good platform for testing the concept that variations in seed quality and physical seed parameters might impact subsequent growth and development of yield of the established crop.

Analyses of variance indicate significance among the planting date and cultivar main effects for many of the traits (Table 3). Some significant interactions between the main effects, and interactions between years and the two main effects were also detected. Generally, the f values for these interactions were small relative to the f values for the main effects. When the interactions were detected, it was usually due to differences in the magnitude of the response for a given trait rather than a flip-flop in the response. Therefore, unless otherwise indicated, means for a main effect were averaged across years and the other main effects.

Table 2. Monthly weather summary for 2002 to 2004 at Stoneville, MS.[z]

Month	2002	2003	2004
		Precipitation (cm)	
April	8.3	9.6	10.5
May	7.2	6.5	18.4
June	10.5	18.5	31.6
July	8.4	6.2	7.8
August	7.0	3.9	5.5
September	19.6	12.5	0.1
October	17.9	10.1	18.1
		Thermal Units[y]	
April	135	114	107
May	214	245	249
June	319	288	317
July	397	375	362
August	378	392	315
September	309	248	275
October	116	127	203
		Solar Radiation (MJ m^{-2})	
April	437	474	671
May	506	482	663
June	523	656	644
July	581	692	672
August	522	641	657
September	378	598	571
October	253	476	380

[z] All observations made by NOAA, Mid-South Agric. Weather Service, and Delta Research and Extension Center Weather, Stoneville, MS.

[y] [(Max. temp + Min. temp.)/2] - 15.5 C.

Cooler, wetter conditions associated with the early planting dates clearly impacted stand establishment as the number of emerged and surviving plants observed at approximately 30 days after planting (DAP) was reduced 16% with the early planting compared to the normal planting date (Table 4). Because the emerged and surviving population densities for each planting date exceeded our seedling survival goal, the assumptions made regarding germination, emergence, and survival for the planting dates were undoubtedly too low for the seeding rate adjustments made to individual seed lots. Stand establishment differences were also detected among the seed lots of multiple cultivars. Although these cultivar differences might imply genetic variability in stand establishment, stand differences among the seed lots of various cultivars could not be solely attributed to genetics because these seed lots were produced in different environments.

Stand emergence and survival differences were detected among the varying germination rate seed lots of the cultivars FM 966, PSC 355, and SG 747 (Table 5). Approximately 40% more seedlings were observed from the low germination seed lots of each cultivar than from the high germination seed lot. Although this observation seems counterintuitive, the results can be understood when considering the seeding rate adjustments made to individual seed lots based upon their standard germination rates in an unsuccessful effort to produce similar stand establishment. Apparently, our standard germination of low germination seed lots underestimated the actual germination for these seed lots resulting in higher than expected numbers of seedlings. The large size seed lot of cultivar PM 1218BR also had 17% more seedlings than the small sized seed lot, which is consistent with earlier studies (Ferguson and Turner, 1971; Turner and Ferguson, 1972). Following stand counts, all plots were thinned to the same population density to ensure all subsequent measurements across the different seed lots were equivalent in terms of stand establishment.

Differences were detected in the dry matter partitioning components among planting dates and cultivars (Table 6). Due to the additional thermal units for growth, plants from the early planting date were more advanced in development than plants from the normal planting date. Plants that were planted early were 17% taller, had 18% more nodes, produced 29% more leaf area and 68% more total dry matter, and had a 5% greater specific leaf weight (SLW) during mid-June. The 277% greater harvest index is indicative of the advanced reproductive growth for the early planting relative to the normal planting, in as much as the early plants were in the early bloom stage whereas the normal planting were only in the squaring (fruiting bud formation) phase. These dry matter partitioning differences between planting dates are similar to those previously reported (Pettigrew, 2002; Pettigrew and Adamczyk, 2006). Cultivar dry matter partitioning differences were generally, but not exclusively, related to crop maturity differences. Examples of these maturity differences are PM 1218BR, which is an early maturity cultivar, and DPL 555BR, which is a late maturity cultivar that also produces a large amount of vegetative growth.

Table 3. Analysis of variance table containing sources of variation, degrees of freedom, and f values for cotton lint yield and yield components.

Source of Variation[z]	df	Lint Yield	Boll Number	Boll Mass	Lint Percentage	Seed Mass	Seed Number	Lint Index
Year	2	9.93 (0.01)[y]	10.37 (0.01)	2.53 (0.11)	39.9 (0.01)	3.00 (0.08)	1.96 (0.17)	11.86 (0.01)
Planting	1	59.10 (0.01)	46.01 (0.01)	5.92 (0.02)	9.22 (0.01)	1.60 (0.22)	0.12 (0.72)	9.21 (0.01)
Cultivar	6	19.98 (0.01)	39.18 (0.01)	79.06 (0.01)	44.81 (0.01)	203.69 (0.01)	14.69 (0.01)	38.13 (0.01)
germ(cultivar)	4	1.16 (0.33)	2.25 (0.06)	0.45 (0.77)	0.67 (0.62)	1.60 (0.17)	0.47 (0.76)	1.26 (0.28)
size(cultivar)	1	4.26 (0.04)	4.14 (0.04)	0.12 (0.73)	0.55 (0.46)	0.15 (0.70)	0.58 (0.45)	0.55 (0.46)
planting*cultivar	6	2.89 (0.01)	3.78 (0.01)	3.42 (0.01)	2.06 (0.06)	0.46 (0.83)	2.13 (0.05)	1.48 (0.18)
planting*germ(cultivar)	4	0.63 (0.64)	0.05 (0.99)	1.77 (0.13)	0.35 (0.84)	1.07 (0.37)	1.95 (0.11)	0.84 (0.50)
planting*size(cultivar)	1	0.67 (0.41)	2.15 (0.14)	2.85 (0.09)	0.16 (0.69)	0.45 (0.50)	2.82 (0.09)	0.01 (0.94)
year*planting	2	4.15 (0.03)	9.70 (0.01)	3.75 (0.02)	1.53 (0.22)	0.14 (0.87)	2.89 (0.06)	0.08 (0.93)
year*cultivar	12	4.63 (0.01)	2.22 (0.01)	3.39 (0.01)	3.31 (0.01)	4.26 (0.01)	1.74 (0.06)	3.77 (0.01)
Year*germ(cultivar)	8	1.80 (0.08)	0.92 (0.50)	1.77 (0.08)	0.28 (0.97)	0.80 (0.61)	1.24 (0.27)	0.15 (0.99)
year*size(cultivar)	2	0.26 (0.77)	0.24 (0.79)	0.01 (0.99)	0.11 (0.89)	1.08 (0.34)	0.43 (0.65)	0.50 (0.61)
year*planting*cultivar	12	1.50 (0.12)	1.37 (0.18)	0.96 (0.49)	1.16 (0.31)	1.11 (0.35)	0.71 (0.74)	1.51 (0.12)
year*planting*germ(cultivar)	8	0.51 (0.85)	1.13 (0.34)	0.89 (0.52)	0.27 (0.98)	0.53 (0.83)	1.27 (0.26)	0.31 (0.96)
year*planting*size(cultivar)	2	0.93 (0.40)	1.05 (0.35)	1.19 (0.31)	0.17 (0.84)	0.12 (0.89)	1.13 (0.32)	0.15 (0.86)

[z] Random effects used in this model were rep(year) and rep*planting(year). Nested effects denoted with parentheses (i.e. germ(cultivar) denotes germination within cultivar).

[y] Values with parentheses represent P > F. Values < 0.01 were rounded up to 0.01.

Table 4. Emerged cotton plants counted at approximately 30 days after planting as affected by varying planting dates and cultivars. Planting date means were averaged across cultivars and years. Cultivar means were averaged across planting dates and years.

Planting Date	Cultivar	Emerged Plants
		plants m^{-2}
Early		9.12
Normal		10.87
LSD 0.05		0.61
	CT 120	7.76
	DPL 555BR	9.24
	FM 966[z]	10.38
	GA 161	9.53
	PM 1218BR	9.91
	PSC 355[z]	9.59
	SG 747[z]	7.36
	LSD 0.05	0.86

[z] The high germination seed lots of these cultivars were utilized for these cultivar comparisons

Table 5. Emerged cotton plants counted at approximately 30 days after planting as affected by seed lots of varying standard germination for multiple cultivars and by seed lots of varying seed size for the cultivar PM 1218BR. Seed lot means were averaged across planting dates and years.

Cultivar	Germination	Seed Size	Emerged Plants
			plants m^{-2}
FM 966	Blend		11.29
FM 966	High		10.38
FM 966	Low		13.92
LSD 0.05			0.86
PSC 355	High		9.59
PSC 355	Low		13.08
LSD 0.05			0.86
SG 747	High		7.36
SG 747	Low		13.29
LSD 0.05			0.86
PM 1218BR		Large	10.67
PM 1218BR		Small	9.15
LSD 0.05			0.86

Table 6. Cotton dry matter partitioning data as affected by varying planting dates and cultivars. Planting date means were averaged across cultivars and years. Cultivar means were averaged across planting dates and years.

Planting Date	Cultivar	Height	Main Stem Nodes	Leaf Area Index	Specific Leaf Weight	Total Dry Weight	Harvest Index [z]
		cm	nodes plant^{-1}		g m^{-2}	g m^{-2}	
Early		81.3	19.4	2.24	54.7	320	0.177
Normal		69.3	16.4	1.74	51.9	190	0.047
LSD 0.05		2.7	0.3	0.15	2.1	19	0.013
	CT 120	77.1	17.2	1.73	55.7	247	0.114
	DPL 555BR	82.4	19.5	2.20	50.0	264	0.078
	FM 966 [y]	60.1	17.5	1.77	53.3	208	0.114
	GA 161	74.2	18.4	2.18	52.3	267	0.102
	PM 1218BR	78.0	17.7	2.01	54.3	276	0.158
	PSC 355 [y]	74.2	17.8	1.94	54.0	253	0.127
	SG 747	76.9	17.0	1.98	54.7	269	0.121
	LSD 0.05	4.0	0.6	0.27	2.3	34	0.026

[z] Harvest Index = Reproductive dry weight / Total dry weight.

[y] The high germination seed lots of these cultivars were utilized for these cultivar comparisons.

Few dry matter partitioning differences were detected among the varying germination seed lots of the cultivars FM 966, PSC 355, and SG 747 (Table 7). A few exceptions to this generalization included the reduced plant height of the FM 966 high germination seed lot compared to either the low or blended germination seed lots, and the 5% reduced SLW and the 15% reduced total dry matter production of the SG 747 low germination seed lot compared to its high germination seed lot. In addition, the high germination seed lot of PSC 355 had a 26% greater harvest index than its low germination seed lot counterpart. Varying the seed size of seed lots within the PM 1218BR cultivar did not alter any of the dry matter partitioning traits.

As previously documented, early planting increased lint yield 14 % (Pettigrew, 2002; Pettigrew and Adamczyk, 2006) relative to that of normal planted cotton (Table 8). This lint yield increase was brought about by the production of 10% more bolls m^{-2} that were 2% larger in mass. Bolls from the early planting also had a 1% greater lint percentage due to the production of 3% more lint per seed (lint index). A larger percentage of the total harvested was gathered during the first hand harvest for the early planting than for the normal planted cotton indicating its advanced maturity on that date relative to the normal planted cotton.

Cultivars also differed in lint yield performance (Table 8). DPL 555BR demonstrated its superior yield potential relative to the other cultivars by producing a lint yield that was 285 kg ha^{-1} greater than it closest competitor and 445 kg ha^{-1} greater than the lowest yielding cultivar. This superior yield for DPL 555BR comes about by the production of more bolls m^{-2} and a greater lint percentage for bolls produced. A negative yield component associated with DPL 555BR was its extremely small seed mass, which leads to a reduced overall production in seed yield per hectare for this cultivar (data not shown).

Planting seed lots of varying germination rates within individual cultivars had essentially no impact on lint yield production (Table 9). The blending together of high and low germination seed lots for FM 966 also yielded similarly to both the high and low germination seed lots of that cultivar. In addition, with the exception of 10% increased boll number production by the SG 747 low germination seed lot compared to its high germination counterpart, the varying germination rates among seed lots did not affect any of the yield components for any of the cultivars tested. Lint yield differences were detected among the seed lots of varying seed size for the cultivar PM 1218BR. The large size seed lot produced 7% more lint yield than the small size seed lot due primarily to the production of 7% more bolls m^{-2}. No other yield components were affected by varying the seed size.

Table 7. Cotton dry matter partitioning data as affected by seed lots of varying standard germination for multiple cultivars and by seed lots of varying seed size for the cultivar PM 1218BR. Seed lot means were averaged across planting dates and years.

Cultivar	Germination	Seed Size	Height	Main Stem Nodes	Leaf Area Index	Specific Leaf Weight	Total Dry Weight	Harvest Index [z]
			cm	nodes plant^{-1}		g m^{-2}	g m^{-2}	
FM 966	Blend		64.7	17.9	1.91	53.7	229	0.095
FM 966	High		60.1	17.5	1.77	53.3	208	0.114
FM 966	Low		65.8	17.8	1.87	54.8	221	0.098
LSD 0.05			4.0	ns [y]	ns	ns	ns	ns
PSC 355	High		74.2	17.8	1.94	54.0	253	0.127
PSC 355	Low		78.1	17.7	2.18	52.9	271	0.101
LSD 0.05			ns	ns	ns	ns	ns	0.026
SG 747	High		76.9	17.0	1.98	54.7	269	0.121
SG 747	Low		74.7	17.4	1.80	52.2	229	0.106
LSD 0.05			ns	ns	ns	2.3	34	ns
PM 1218BR		Large	78.5	17.6	2.04	55.0	286	0.170
PM 1218BR		Small	77.4	17.7	1.97	53.6	266	0.146
LSD 0.05			ns	ns	ns	ns	ns	ns

[z] Harvest Index = Reproductive dry weight / Total dry weight.

[y] ns = not significantly different at the $P > F$ level of 0.05.

Table 8. Cotton lint yield and yield components as affected by varying planting dates and cultivars. Planting date means were averaged across cultivars and years. Cultivar means were averaged across planting dates and years.

Planting Date	Cultivar	Lint Yield	% 1st Harvest	Boll Number	Lint Percentage	Boll Mass	Seed Mass	Seed Number	Lint Index
		kg ha^{-1}	%	bolls m^{-2}	%	g boll^{-1}	mg seed^{-1}	seed boll^{-1}	mg seed^{-1}
Early		1494	35.9	76	41.1	4.84	98	29	68
Normal		1310	6.0	69	40.6	4.76	97	29	66
LSD 0.05		51	2.8	2	0.3	0.08	ns [z]	ns	1
	CT 120	1346	22.6	67	41.5	4.88	96	29	68
	DPL 555BR	1700	13.3	89	44.0	4.39	79	31	62
	FM 966 [y]	1391	20.1	63	40.3	5.52	110	29	74
	GA 161	1255	19.7	69	39.5	4.67	96	29	63
	PM 1218BR	1415	29.8	70	39.9	5.07	106	28	71
	PSC 355 [y]	1296	23.0	77	39.4	4.27	96	26	63
	SG 747 [y]	1367	21.6	69	41.2	4.85	97	29	69
	LSD 0.05	93	2.7	5	0.7	0.19	2	1	3

[z] ns = not significantly different at the $P > F$ level of 0.05.

[y] The high germination seed lots of these cultivars were utilized for these cultivar comparisons.

Both planting date and cultivar affected certain fiber quality traits (Table 10). Early planting decreased fiber elongation, 2.5% span length, and 50% span lengths all by 1%. In contrast, the micronaire for fiber from the early planting increased 1% relative to that from the normal planting. These planting date induced fiber quality differences are similar to those reported previously (Pettigrew, 2002; Pettigrew and Adamczyk, 2006). Considerable variability was detected among cultivars for the fiber quality traits. Most striking among these differences was the reduced fiber length uniformity of DPL 555BR compared to all the other cultivars. Lower length uniformity is reflective of increased short fiber content and is apparently an unfortunate tradeoff that comes with the superior lint yield production demonstrated by DPL 555BR.

Table 9. Cotton lint yield and yield components as affected by seed lots of varying standard germination for multiple cultivars and by seed lots of varying seed size for the cultivar PM 1218BR. Seed lot means were averaged across planting dates and years.

Cultivar	Germination	Seed Size	Lint Yield	% 1st Harvest	Boll Number	Lint Percentage	Boll Mass	Seed Mass	Seed Number	Lint Index
			kg ha^{-1}	%	bolls m^{-2}	%	g boll^{-1}	mg seed^{-1}	seed boll^{-1}	mg seed^{-1}
FM 966	Blend		1407	18.8	64	40.5	5.50	111	29	76
FM 966	High		1391	20.1	63	40.3	5.52	110	29	74
FM 966	Low		1358	17.4	62	40.2	5.48	112	29	76
LSD 0.05			ns [z]	ns	ns	ns	ns	ns	ns	ns
PSC 355	High		1296	23.0	77	39.4	4.27	96	26	63
PSC 355	Low		1306	22.4	76	39.8	4.33	98	26	65
LSD 0.05			ns	ns	ns	ns	ns	ns	ns	ns
SG 747	High		1367	21.6	69	41.2	4.85	97	29	69
SG 747	Low		1455	18.0	76	40.9	4.74	96	29	67
LSD 0.05			ns	3.1	5	ns	ns	ns	ns	ns
PM 1218BR		Large	1463	30.3	73	40.1	5.05	106	28	71
PM 1218BR		Small	1366	29.3	68	39.8	5.09	106	28	70
LSD 0.05			93	ns	5	ns	ns	ns	ns	ns

[z] ns = not significantly different at the *P* > *F* level of 0.05.

Table 10. Cotton fiber quality traits as affected by varying planting dates and cultivars. Planting date means were averaged across cultivars and years. Cultivar means were averaged across planting dates and years.

Planting Date	Cultivar	Fiber Elongation	Fiber Strength	Span Length		Length Uniformity	Micronaire	Fiber Maturity	Fiber Perimeter
				2.5%	50%				
		%	kN m kg^{-1}	cm	cm	%		%	µm
Early		7.8	198	2.87	1.40	48.9	4.86	86.5	51.1
Normal		7.9	200	2.91	1.41	48.6	4.79	86.0	50.7
LSD 0.05		0.1	ns [z]	0.02	0.01	ns	0.06	ns	ns
	CT 120	8.8	187	2.91	1.45	49.9	4.94	85.8	52.2
	DPL 555BR	6.8	196	2.86	1.33	46.6	4.76	87.9	49.0
	FM 966 [y]	6.2	233	3.00	1.46	48.7	4.76	92.4	45.9
	GA 161	8.2	201	2.91	1.44	49.4	4.87	85.6	51.8
	PM 1218BR	7.6	190	2.78	1.37	49.1	4.74	82.8	52.7
	PSC 355 [y]	9.2	209	2.86	1.42	49.8	4.94	84.5	52.9
	SG 747 [y]	8.9	184	2.91	1.41	48.4	4.85	83.7	52.8
	LSD 0.05	0.3	5	0.03	0.02	0.6	0.13	1.7	1.1

[z] ns = not significantly different at the *P* > *F* level of 0.05.

[y] The high germination seed lots of these cultivars were utilized for these cultivar comparisons.

Most fiber quality traits were unaffected by varying germination rates or seed size among seed lots of the different cultivars (Table 11). Differences that were detected include an average 7% reduction in fiber elongation for the low germination seed lots of both PSC 355 and SG 747, but not FM 966. Although the 2.5% span length of the low germination seed lot of SG 747 was increased 1% compared to the high germination seed lot, the length uniformity of this low germination seed lot was reduced 2% relative to the high germination seed lot. Fiber from the high germination seed lot of SG 747 also had a 3% greater perimeter. None of the fiber quality traits were affected by growing seed lots with varying seed size of the same cultivar, PM 1218BR.

Table 11. Cotton fiber quality traits as affected by seed lots of varying standard germination for multiple cultivars and by seed lots of varying seed size for the cultivar PM 1218BR. Seed lot means were averaged across planting dates and years.

Cultivar	Germination	Seed Size	Fiber Elongation	Fiber Strength	Span Length		Length Uniformity	Micronaire	Fiber Maturity	Fiber Perimeter
					2.5%	50%				
			%	kN m kg^{-1}	cm	cm	%		%	µm
FM 966	Blend		6.1	230	2.96	1.44	48.6	4.70	92.8	45.3
FM 966	High		6.2	233	3.00	1.46	48.7	4.76	92.4	45.9
FM 966	Low		6.2	232	2.98	1.46	48.8	4.67	91.9	46.0
LSD 0.05			ns [z]	ns	0.03	ns	ns	ns	ns	ns
PSC 355	High		9.2	209	2.86	1.42	49.8	4.94	84.5	52.9
PSC 355	Low		8.9	208	2.87	1.42	49.5	5.01	85.6	52.5
LSD 0.05			0.3	ns	ns	ns	ns	ns	ns	ns
SG 747	High		8.9	184	2.91	1.41	48.4	4.85	83.7	52.8
SG 747	Low		8.0	182	2.94	1.40	47.5	4.75	84.7	51.4
LSD 0.05			0.3	ns	0.03	ns	0.6	ns	ns	1.1
PM 1218BR		Large	7.7	188	2.78	1.36	48.8	4.75	82.6	53.1
PM 1218BR		Small	7.6	192	2.77	1.38	49.3	4.73	82.9	52.3
LSD 0.05			ns	ns	ns	ns	ns	ns	ns	ns

[z] ns = not significantly different at the $P > F$ level of.

Few growth differences were detected among seed lots of varying germination for the different cultivars. The few dry matter partitioning differences detected between different germination seed lots were not consistent across cultivars and did not translate into any meaningful lint yield differences. No matter which genetic background was utilized, there were no yield differences between the different germination seed lots. This lack of important growth and yield differences was most likely due to the seedling rate adjustments for the individual seed lots to account for differences in germination among seed lots. Even within a low germination seed lot, there may be enough quality seed to generate an adequate stand if the seeding rate is increased. Although only three genetic backgrounds were evaluated, the consistency of the response suggests it might be a common phenomenon for most cultivars. Given the lack of a significant planting*germ(cultivar) interaction for yield, this principle of increasing the seeding rates of low germination seed appears to work under both early and normal planting environments. The seeding rate just needs to be increased even more with early planting. Blending of different germination seed lots together may also be an acceptable practice as long as the seeding rate is adjusted to account for the poor germination seed in the blended lot. This practice of blending could be particularly useful during years when the supply of high germination seed for the most desired varieties is low. However, this blending concept was only tested in one genetic background.

The lack of detrimental growth consequences from using poor quality seed beyond stand establishment is in contrast with prior research of Turner and Ferguson, (1972), Minton and Supak (1980) and Bourland et al. (1989). However, methodology differences among the studies may explain some of these contrasting results. The low germination seed lots in this study were generated by extended field exposure to natural weathering conditions, whereas Turner and Ferguson (1972) compared partially filled seeds to filled seeds within the same seed lot, while Minton and Supak (1980) examined seeds of varying density within the same seed lot, and Bourland et al. (1989) studied the effect of seed artificially deteriorated from two different methods. Bourland et al. (1989) also didn't report the use of any fungicide during planting, while this research included an in-furrow fungicide application during planting. Therefore, plants infected with seedling disease but still surviving might be more likely to occur in their plots than would be expected with our plots.

Seed size may be an additional tool for evaluating individual seed lots within a given cultivar, in addition to standard and cool germination rates. For the cultivar PM 1218BR, a larger seed size not only aided in stand establishment but it also led to the production of more bolls and an increase in lint yield compared to the smaller seed size. These results would appear to contrast with the results of Porterfield and Smith (1956) who found that medium size seed were the best performing. However, Porterfield and Smith (1956) hand planted and hill-dropped their plots whereas we mechanically planted our plots with a drill planter. In addition, we used an in-furrow fungicide while they didn't use fungicide. Therefore, the results from this research aren't directly comparable to the Porterfield and Smtih (1956) study. Beyond the influence on stand establishment and possible early seedling vigor (Ferguson and Turner, 1971; Turner and Ferguson, 1972), it is not physiologically clear why increased seed size would lead to increased boll and lint yield production. Nonetheless, the data from this limited evaluation indicate that it might be preferential to utilize larger size seed lots rather than small size seed lots when all other considerations are equal. However, further research is needed to confirm this phenomenon with additional cultivars and across multiple seed sizes before any definitive conclusions could be drawn.

Based upon the results from this study, it is clear that producers should use the best quality seed available when planting early. The cooler conditions make stand establishment more of a challenge with early planting. However, when excellent quality seed is not an option, a producer can still obtain adequate stand establishment and yield performance with poorer quality seed by adjusting the seeding rate based upon germination. To achieve desired population densities for cotton, Kerby et al. (1989) published equations to adjust seeding rates based upon standard and cool germination rates of the planting seed. Nevertheless, there is probably also a breaking-point as to how poor the germination rate can be, below which the seed lot should be avoided altogether. Although it is true that a surviving seedling disease infected plant may not perform as well as a healthy plant (Wanjura et al., 1969; Minton et al., 1982), modern seed- applied and in-furrow applied fungicides can help producers mitigate the seedling disease issue. However, common sense dictates that producers should avoid utilizing poorer quality seed or planting early into cool and wet conditions on fields with a past history of seedling disease or drainage problems.

DISCLAIMER

Trade names are necessary to report factually on available data; however the USDA neither guarantees nor warrants the standard of the product or service, and the use of the name by USDA implies no approval of the product or service to the exclusion of others that may also be suitable.

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