EFFECTS OF PLANTING SEED SIZE ON PERFORMANCE OF TWO CULTIVARS AT SEVEN LOCATIONS

C. O. Gwathmey
University of Tennessee
Jackson, TN
N. R. Benson
University of Arkansas
Keiser, AR
W. D. Caldwell
Louisiana State University
Bossier City, LA
K. D. Howard and T. A. Kerby
Delta and Pine Land Co.
Scott, MS
B. J. Phipps
University of Missouri
Portageville, MO

Abstract

Various size fractions separated from a commercial seed lot of cotton may differ in emergence, seedling vigor, and yield performance. Objectives of this study were to evaluate the performance of seed size fractions of two cultivars, relative to their original (composite) seed lots, in a range of field environments. Commercial seed lots of Deltapine DP 458 B/RR and Paymaster PM 1220 BG/RR were sized with slotted screens. The five size classes and the original seed lots of the two cultivars were planted in a RCB design in seven states (AR, AZ, LA, MO, MS, SC, TN) in 1999. Stand counts, seedling vigor (height-to-node ratio), and yield data were collected. Emergence percentage generally improved as seed size increased, but emergence response was influenced by the edaphic environment. Size effects were minimal in sandy soils but more pronounced on silty or clayey soils. Emergence of the largest sizes may have been hindered by soil crusting in some locations. The study was inconclusive regarding seed size effects on seedling vigor measured as height-to-node ratio. Across cultivars and locations, yields differed by size class, with the medium and larger sizes yielding slightly more than smaller sizes. Results suggest that planting larger sizes can improve emergence and yield performance in some environments, but additional information is needed on vigor and earliness effects.

Introduction

The size of cotton planting seed varies within and between cultivars. Much of the size variation within a seed lot of a cultivar is due to differences in when and where bolls are produced on the parent plants, due to indeterminate fruiting (Leffler, 1986). Seed produced in bolls on lower fruiting branches and at first-position sites tend to be larger than those produced at distal positions and on higher fruiting branches (Kerby and Ruppenicker, 1989).

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Tupper et al (1971) found that cotton seed germination and seedling vigor depend more on seed density than on weight or size. While seed weight influences growth rate, seed density has a strong influence on earliness of germination. Higher density is associated with a greater proportion of seed weight in the embryo, indicating greater maturity. Hess (1977) pointed out, however, that higher density seed fractions were smaller in size and weight than lower density fractions. King and Lamkin (1979) suggested that the inverse relationship between seed density and size would result in an intermediary "compensation point," beyond which reduced seed volume would negate the advantages of higher density. Porterfield and Smith (1956) indicated that germination and field emergence were greater for intermediate size seed than for either small or large diameter seed.

Commercial grading of cotton planting seed normally includes the removal of some low density fractions by gravity or air separation methods (Delouche, 1986). While commercial cultivars differ in mean specific seed weight (or seed/bag), any seed lot of cotton contains a range of seed sizes and weights. Do different seed sizes perform differently in terms of emergence, seedling vigor, and lint yield? This question is of contemporary importance because the increasing cost of planting seed raises the possibility of packaging seed by number instead of by weight, as in certain other crops such as corn (e.g., Garst Seed Co., 1999). In this instance, the stated goals of corn seed sizing were uniformity of stand and improved plantability with planters that require specific seeds/pound or specific bag weights. For cotton, however, interest in seed sizing has arisen in part from the use of Roundup Ready varieties and relatively expensive seed treatments. Uniform sizing would allow an equal amount of seed treatment to be placed on each seed. Planting of sized seed may also produce seedlings of relatively similar age and size, which would be advantageous in the Roundup Ready system.

The objectives of this study were to evaluate the performance of cotton seed size fractions of two contrasting cultivars, relative to the natural composite of these fractions in their original seed lots, in different field environments across the U.S. cotton belt.

Materials and Methods

Commercial seed lots of two cotton cultivars, Deltapine DP 458 B/RR and Paymaster PM 1220 BG/RR, were fractioned by size, using slotted screens that differed by 1/64-inch increments. Each cultivar was separated into five size classes. The size classes of PM 1220 BG/RR were 1/64 inch larger than the corresponding classes of DP 458 B/RR. Size and germination characteristics of the seed size fractions, and of the original (composite) seed lots, are summarized in Table 1.

The five size classes and the original seed lots of the two cultivars constituted 12 treatments in field studies conducted in seven locations in 1999: Bossier City LA, Casa Grande AZ, Hartsville SC, Jackson TN, Keiser AR, Portageville MO, and Scott MS. Treatments were arranged in a RCB with four replications at each location. Individual plots were two rows wide and 30 to 60 feet long, using standard plot length and row spacing for each location. A seeding rate representative of the area was used for all treatments at each location. Soil types, planting dates, and temperatures at planting at the seven locations are summarized in Table 2.

During emergence, sequential stand counts were taken in a 10-ft row segment of each plot row at 2- to 3-day intervals, until counts stabilized. At approximately 4- and 8-node stages, plant height and node count data were collected from 10 consecutive plants in each plot row. These data were used to calculate average height-to-node ratios (HNR) for each plot. Plots were managed for optimum yields, and they were spindle picked to determine seedcotton yields. An average gin turnout for each variety was applied to the seedcotton weight from each plot to calculate lint yields.

Data were statistically analyzed by treating cultivar and seed size class as factors in a multi-location factorial RCB design.

Results and Discussion

Emergence percentages of the five seed size classes, and of the original (composite) seed lots of the two cultivars across locations, are shown in Table 3. Emergence of PM 1220 BG/RR was higher than DP 458 B/RR, consistent with the germination data provided for the two cultivars (Table 1). Across cultivars, emergence differed by seed size, with the medium and two larger size classes producing higher emergence than the two smaller classes (Table 3). Significant cultivar-size interaction is attributed to lower emergence of the small (11/64") size class of PM 1220 BG/RR, and of the smallest (<9/64") size class of DP 458 B/RR, relative to other sizes. This result may be associated with lower germination of small seed of PM 1220 BG/RR, but a similar association is less evident in the case of DP 458 B/RR. Emergence of the composite was similar to all size classes except the smallest DP 458 B/RR, and the small PM 1220 BG/RR seed.

There was no significant interaction between time of observation and size, indicating that size classes did not differ in rate of emergence with time between 13 and 30 DAP.

Emergence percentage also differed by location, and there were significant location-cultivar, location-size, and location-cultivar-size interactions (Table 4). Relatively low emergence rates were observed at Hartsville SC and Scott MS, where minimum air temperatures indicate relatively cool conditions at planting (Table 2). Much of the cultivar interaction is attributable to Hartsville SC, where emergence of DP 458 B/RR was slightly higher than that of PM 1220 BG/RR, unlike the other six locations (Table 4). The Hartsville test was planted into a dry seedbed, and later rains may have caused soil crusting problems. Some location-size interaction may also be attributed to TN, MO, AR and MS, where the largest size fractions had slightly lower emergence percentages than the large size fraction, unlike the other three locations. The greatest response to seed size was on a clay soil in AZ. The least response to seed size was found in LA and SC on sandy loams, which may have offered less physical resistance to cotyledonary emergence. Lower emergence percent of the largest fractions in TN and MO may be attributed to slight crusting of those silt loams interfering with cotyledonary emergence. Data from these sites generally support the findings of Phipps et al (2000), and Porterfield and Smith (1956), in that field emergence was higher for intermediate size seed relative to the smallest or largest seed fractions. There were no significant interactions of location-cultivar-time or location-size-time, indicating that rate of emergence with time did not differ at various locations for different seed sizes or cultivars (Table 4).

Seedling vigor, measured as height-to-node ratio (HNR) of seedlings at approximately the 4- and 8-node stages, is shown in Table 5. Because seed size-location interaction was not significant, HNR data from individual locations are not shown. Although HNR increased between the first and second observations, analyses of variance produced similar results in both cases. The vigor of seedlings grown from the composite seed lot was similar to that of the medium and larger fractions. The larger seed size classes tended ($P = 0.088$) to produce greater HNRs at the first observation, but this difference disappeared ($P = 0.654$) by the second observation (Table 5). In TN, seedlings of larger seed sizes were taller and had more nodes than those from smaller fractions, although HNRs did not differ significantly (data not shown). In MO, the most vigorous seedlings grew from the large (but not the largest) seed size fractions that also produced the best stands (Phipps et al, 2000). PM 1220 BG/RR exhibited higher HNR across locations than did DP 458 B/RR, although there were significant location and cultivar-location effects. The latter was mainly due to the lack of difference in HNR between the two cultivars in SC (data not shown). Interactions of cultivar-size, location-size, and location-cultivar-size were not significant.

Mean lint yields of the various size classes of the two cultivars are shown in Table 6. Because seed size-location interaction was not significant, yield data from individual locations are not shown. Across cultivars and locations, yields differed by size class, with the medium and two larger sizes yielding slightly more than the two smaller sizes. Yield trends associated with seed size were more apparent in DP 458 B/RR than in PM 1220 BG/RR, although cultivar-size interaction was not significant. In DP 458 B/RR, the composite tended to yield less than the larger seed size fractions. In PM 1220 BG/RR, yields from the composite seedlot were similar to all but the small (11/64") fraction, which also had low germination and emergence.

Results from the first year of this study suggest that sizing of cotton seed can produce differences in field emergence and yield among different size fractions. Emergence percentage generally improved as seed size increased, but emergence response was influenced by the edaphic environment. Size effects were minimal in sandy soils but more pronounced on silty or clayey soils. Emergence of the largest sizes may have been hindered by crusting in some silt loams, and possibly in one sandy loam soil. The 1999 data were inconclusive regarding seed size effects on seedling vigor as measured by HNR. It appears that the higher lint yields of the larger seed size fractions were influenced by more than emergence, perhaps involving differences in growth rate and earliness that did not produce large differences in HNR. Another possible factor affecting yield is the effect of seed sizing on plant size uniformity. Additional study is planned to address these questions.

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Table 1. Size and germination characteristics of seed lots tested in 1999.†

Cultivar	Seed Size	Size Class	Seed/lb.	Fraction of seed lot	Germ. 4 d	Germ. 9 d
	64ths inch		count	%	----- %	-----
DP 458 B/RR		composite	6115		68	76
	<=9	smallest	6645	15	64	72
	10	small	6450	31	61	68
	11	medium	5910	37	70	83
	12	large	5130	15	71	82
	>12	largest	4405	2	57	81
PM 1220 BG/RR		composite	4270		88	95
	<=10	smallest	4875	7	81	88
	11	small	5025	19	80	85
	12	medium	4295	40	86	91
	13	large	3900	30	87	92
	>13	largest	3520	3	82	94

† Data source: Delta and Pine Land Co.

Table 2. Soil types, planting dates, and temperatures at seven test locations in 1999.

Location	Soil type	PlantingDate	Hi / Lo temp's at planting: Air	Soil
			degrees F	
Bossier City, LA	Caplis Very Fine Sandy Loam	5/7/99	79/50	78/60
Casa Grande, AZ	Ginland Clay	5/1/99	96/58	88/76
Hartsville, SC	Sandy Loam	5/5/99	81/51	77/66
Jackson, TN	Calloway silt loam	5/11/99	81/64	79/63
Keiser, AR	Tunica silty clay	5/12/99	83/58	73/67
Portageville, MO	Tiptonville silt loam	5/14/99	69/58	76/62
Scott, MS	Silty Clay Loam	4/28/99	80/56	81/67

Table 3. Emergence of five seed size classes and of original seed lots of two cultivars across seven locations, and statistical analyses of main effects and interactions. Percentages represent means of three observations at 13-15, 20-21, and 23-30 DAP in 1999.

Size Class	Cultivar: DP 458 B/RR	PM 1220 BG/RR	Mean
	-------------- %	---------------	
Composite	56.2	72.8	64.5
Smallest	50.5	73.0	61.7
Small	56.9	65.9	61.4
Medium	56.0	71.9	63.9
Large	57.5	74.7	66.1
Largest	56.3	73.2	64.8
Mean	56.7	71.4	63.7
Source of Variance		***P*-value**	**LSD 0.05**
Cultivar		<0.001	1.1
Size Class		0.002	1.8
Cultivar*Size		<0.001	2.6
Time of obs.		<0.001	1.3
Time*Size		0.994	n.s.
Time*Cultivar*Size		0.994	n.s.

Table 4. Emergence of five seed size classes and of original seed lots of two cultivars at seven locations, and statistical analyses of main effects and interactions. Percentages represent means of three observations at 13-15, 20-21, and 23-30 DAP in 1999.

	LA	AZ	SC	TN	AR	MO	MS
Size class	---------------------------			%			----------------------------
Composite	88.2	71.7	35.0	63.9	74.2	75.9	42.4
Smallest	89.5	68.1	43.0	57.8	68.0	58.8	47.0
Small	81.4	65.5	42.8	55.1	72.6	73.2	38.9
Medium	89.5	68.2	35.2	64.3	73.5	68.3	48.5
Large	88.0	77.3	35.8	70.4	75.6	72.2	43.6
Largest	88.7	77.6	45.6	58.5	72.4	68.6	42.1
Cultivar							
DP 458 B/RR	78.8	58.1	42.4	51.5	65.8	57.8	34.6
PM 1220	96.3	84.7	36.8	71.8	79.7	81.2	52.9
Mean	87.6	71.4	39.6	61.7	72.7	69.5	43.8

Source of Variance	*P*-value	LSD 0.05
Cultivar	<0.001	1.1
Location	<0.001	2.0
Cultivar*Location	<0.001	2.8
Location*Size	<0.001	4.9
Location*Cultivar*Size	<0.001	6.9
Location*Cultivar*Time	0.997	n.s.
Location*Size*Time	0.999	n.s.

Table 5. Height-to-node ratio of seedlings grown from five seed classes and from original (composite) seed lots of two cultivars across seven locations in 1999, and statistical analyses of main effects and interactions.

	1st Obs. (4-node stage)	2nd Obs. (8-node stage)
	---------- in./node ------------	
Size class		
Composite	1.09	1.26
Smallest	1.07	1.23
Small	1.05	1.22
Medium	1.08	1.24
Large	1.10	1.26
Largest	1.11	1.25
Cultivar		
DP 458 B/RR	1.00	1.17
PM 1220 BG/RR	1.17	1.31
Source of Variance	***P*-value 1st Obs.**	***P*-value 2nd Obs.**
Cultivar	<0.001	<0.001
Size Class	0.088	0.654
Cultivar*Size	0.203	0.483
Location	<0.001	<0.001
Location*Cultivar	<0.001	<0.001
Location*Size	0.867	0.626
Loc*Cultivar*Size	0.461	0.357

Table 6. Lint yield of cotton grown from five seed size classes and from original (composite) seed lots of two cultivars across seven locations in 1999, and statistical analyses of main effects and interactions.

	Cultivar		
SizeClass	DP 458 B/RR	PM 1220 BG/RR	Mean
	-------------- lb./acre ---------------		
Composite	740	976	858
Smallest	758	960	859
Small	751	905	828
Medium	789	992	891
Large	792	983	887
Largest	826	980	903
Mean	776	966	871
Source of Variance		**P-value**	**LSD 0.05**
Cultivar		<0.001	16.3
Size Class		0.003	28.2
Cultivar*Size		0.287	n.s.
Location*Size		0.359	n.s.
Location*Cultivar		<0.001	43.0
Location*Cultivar*Size		0.596	n.s.