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Cotton (*Gossypium hirsutum* L.) Yield, Stand, and Bolls per Plant as Influenced by Seed Class and Row Width[1]

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ABSTRACT

Unsorted seed of 'Deltapine 45A' and seed separated into almost equal lots of light, medium, and heavy seed (seed classes) were planted in 102-cm (regular) and 25-cm (narrow) rows (row widths) at the rate of six seed per 30.5 cm.

Plants from the light seed class were taller 75 days after emergence than were plants from any other seed class regardless of row width. Lint yield was not affected by row width or seed classs. The interaction between row widths and seed classes was significant and, in regular-width rows, plants from unsorted seed produced more lint than did plants from the heavy seed class.

Unsorted seed produced more barren plants than did other seed classes. This result was apparently due to the larger number of plants produced from the unsorted seed in narrow rows.

Unsorted, light, and medium seed classes produced more 1-boll plants than did the heavy seed class. As plant population increased, there was an increase in the number of 1-boll plants. Seed class had no effect on the number of 2-boll plants; however, regular-width rows produced significantly more 2-boll plants than did narrow rows. The medium seed class produced fewer 3-boll plants than other seed classes regardless of row width, and regular-width rows produced more 3-boll plants than did narrow rows. Due to an interaction between row width and seed class, unsorted seed produced more 3-boll plants than the light, medium, or heavy seed class in regular-width rows. Seed planted in regular-width rows produced more plants with more than three bolls than in narrow rows. Under the conditions of this test there were no advantages from either seed sorting or narrow rows.

Additional index words: Seed density, Seed blower, Seed sorting.

CONSIDERABLE research has been conducted to determine the relationship between various cottonseed characteristics and seedling performance, but many areas of confusion still exist, especially with respect to the influence of the characteristics of planting seed on the resulting crop. Upland cotton (*Gossypium hirsutum* L.), as normally grown in 96- to 102-cm rows throughout the Cotton Belt of the United States, is an indeterminate fruiting plant with the fruit initiated over a period of several weeks. Under these conditions adequate yields of lint are produced

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from a wide range of plant spacings within the row.

However, techniques to improve the uniformity of field emergence might increase the efficiency of lint production. In typical emergence patterns seedlings emerge over a 2- to 3-week period after the first seedlings appear, resulting in a wide range in age, development, and number of bolls per plant. Wilkes and Hobgood (19) reported 50% of the seedlings emerging within a 2- to 3-day period after emergence began followed by an additional 10 to 20% of the seedlings emerging over a 2-week period. The final stand at harvest usually consisted of strong, healthy plants that produced the greater percentage of the yield, and weak, unthrifty plants that produced few, if any, bolls. A random-replicated sampling of three varieties (unnamed) of cotton with populations of 86,450 plants/ha showed that about 50% of the total yield was produced on only 25% of the plants (18, 19), with no bolls found on 7.5% of the plants.

Wilkes and Hobgood (19), Reid (15), and Porterfield and Smith (12) reported yield increases when improvements were made in planter components such as openers, seed press wheels, and covering devices, either singularly or in combination. Yield increases were attributed to more uniform and earlier stand establishment.

Kunze et al. (11) found that the seed index of cottonseed, from sized seed within a variety, correlated well with the seedling emergence within selected time periods after planting. The heavier seed within a variety showed earlier emergence, more vigor, and greater total emergence. Wilkes et al. (18) reported a direct correlation between cottonseed density and rate of emergence and total emergence. Tupper et al. (16) found that seed weight and seed density were the two physical characteristics most closely related to germination and seedling growth.

The present study was initiated to determine the effect of seed class and row width on the number of bolls per plant and the number of barren plants in Upland cotton.

MATERIALS AND METHODS

The test was conducted at Experiment, Ga., on a Lloyd sandy loam soil of moderate fertility. Fertilizer (672 kg/ha 4-5.3-10) was broadcast and disked into the top 10 to 15 cm of soil 6 weeks before planting. Trifluralin at the recommended rate was incorporated 2 weeks before planting.

Acid-delinted seed of 'Deltapine 45A' were separated into almost equal lots of light, medium, and heavy seed classes by the use of a South Dakota seed blower, series D.[4] The proportions of light, medium, and heavy seed obtained were 1.0:1.2:1.2, respectively. All seed that were caught in the upper chamber of the seed blower column in 1 min at a setting of 6.5 units were considered light seed (8.73 g/100 seed). Of those remaining in the bottom chamber, all caught in the upper chamber of the column in 1 min at a setting of 9.0 units were considered medium seed (9.02 g/100 seed). Those seed remaining in the bottom chamber after the seed separation were considered heavy seed (9.42 g/100 seed). Thus, seed sorted into three classes and unsorted seed (9.19 g/100 seed) were available for field plot planting.

Seed from each class plus the unsorted seed were planted in 1966 in a randomized complete block split-plot with six replications. Row widths, narrow-row (25-cm) and regular-row (102-cm), were the main plots, and seed classes, the subplots. Each subplot consisted of 124 m^2 with either two rows 102 cm apart or eight rows 25 cm apart.

Fungicide-treated seed from each seed class were drilled at the rate of six seed per 30.5 cm in the regular rows and planted by hand at the same linear rate in the narrow rows. Thus, the seeding rate per unit area was four times higher in the narrow rows than in the regular rows. Planting date was June 8, 1 month later than the normal planting date for this area. The regular-width rows were cultivated once, and all plots were hand-weeded. Weed control was good except for sicklepod (*Cassia* spp.) and morningglory (*Ipomoea* spp.). Seed cotton was harvested from all plants by hand on Dec. 12 and 13.

The year was not a particularly good one for cotton production. Rainfall During May, June, and July totaled 34.06 cm and was not well distributed; both June and July were deficient. During the period from May through September the plots received 59.28 cm of rainfall. In addition, average temperatures during May and June were lower than normal. Minimum temperatures were as low as 7.22 C on June 2 and were not consistently above 15.6 C until after June 23. A temperature of —3.89 C on November 3 resulted in the loss of many green bolls. In all the data reported on bolls per plant, only the open bolls were counted and harvested.

[4] Mention of trade names does not imply endorsement or preferential treatment of the product by the U.S. Department of Agriculture or the University of Georgia.

RESULTS AND DISCUSSION

Stand

The number of plants per hectare was significantly influenced by seed class and row width (Table 1). Considering only seed class means, more plants grew to maturity from unsorted seed than from other seed classes. In addition, the unsorted seed produced more plants than other seed classes within the narrow rows. Since four times as many seed were planted per unit land area in the narrow rows than in the regular-width rows, the significant difference between row width means was expected.

Plant Height

Emergence was excellent on all plots from all seed classes. Visual observations indicated that the heavy seed class produced seedlings that were slightly taller than seedlings from other seed classes 14 days after emergence. These results agree with previous research (2, 6, 7, 10). However, Colwick (4) found that field emergence of medium classes of acid-delinted cottonseed was significantly better than the emergence of either small or large seed classes.

The apparent initial advantage in plant height from the heavy seed class in our test had disappeared 75 days after emergence (Table 2). Both row width and seed class affected plant height and the interaction between row width and seed class was significant. Plants from the light seed class in regular-width rows were taller than plants from any other seed class (Table 2). When only seed class means were considered, plants from the light seed class were taller. The additional height of plants from the light seed class was not due to stand since more plants grew to maturity from un-

Table 1. The effect of seed class and row width on final stand of cotton.

Seed class	Row width		
	Regular	Narrow	Means
	plants/ha		
Unsorted	18,488 a*	634,666 a	407,577 a*
Light	167,577 a	508,109 b	377,842 b
Medium	178,875 a	550,205 b	364,540 b
Heavy	158,297 a	516,178 b	337,239 b
Means	171,309 b*	552,290 a	361,800

* Numbers within an array followed by the same letter do not differ significantly at the 0.05 level according to Duncan's Multiple Range Test.

sorted seed than from the light seed class. These findings contradict the results obtained by Ganesan (6), who found that plants from large seed classes were superior to medium, and medium to small, in plant height.

Yield

Many workers (1, 3, 4, 5, 14) generally recommend about 98,800 cotton plants/ha for 96- to 102-cm rows and report little difference in yield from 74,100 to 172,900 plants/ha. There has been a belief among some cotton researchers for several years that even higher plant populations may be desirable under some conditions (9, 13, 14, 17, 20). Ray and Hudspeth (13) pioneered in the use of narrow-row culture, and reported yield increases ranging from 6 to 11% with ultra-high populations of 494,000 plants/ha planted in 18- to 25-cm row spacings. In addition, they found that the cost of producing a pound of lint was reduced 27% by narrow-row culture. Wanjura and Hudspeth (17) reported that an early-maturing stormproof variety, drill planted in 18- to 25-cm rows and irrigated, yielded 33% more than the same variety grown in 102-cm rows. On the other hand, Wilkes and Hobgood (20) reported that cotton yields were significantly lower from broadcast plantings than from the same variety planted in 102-cm rows. Yields were not different from the same variety planted in 102- and 36-cm rows in a different test. As pointed out by Ray et al. (14), close spacing should afford the young plants more fruiting points on a unit land area basis, which should provide a more rapid set of bolls.

We found no significant differences in yield due to row width or seed class (Table 3). However, the interaction between row width and seed classes was significant. Plants from unsorted seed produced significantly more lint cotton than plants from the heavy seed class in regular-width rows. Porterfield and Smith (12) found that lint yields among progenies from various seed sizes were significantly different, that the seed sizes that gave the highest emergence also gave the highest lint yields, and that plants from medium seed sizes yielded more lint than plants from either large or small seed. These findings confirm the opinion held by Tupper et al. (16) that the modal size seed have the highest germination and seedling vigor and produce highest-yielding plants.

Innes (10), Brixhe (2), and Gillham (7) found that early growth differences in favor of large seed were not reflected in yield. Harper and Obeid (8) reviewed the literature for different crops, and concluded that larger embryos and greater growth rate from large seed did not necessarily culminate in greater yield under the "normal crowded conditions of crop growth where production is more often limited by environmental resources than by the potential growth rates of the individuals."

Innes (10) pointed out that varieties that mature over a short period are more likely to show yield differences between sized and unsized seed. Deltapine 45A is a variety that continues to produce bolls over a relatively long period. It appears that at some stage during this relatively long period of boll production, environmental conditions became favorable for boll retention, and that the advantage gained from early growth rate of plants from the heavy seed class was negated. Perhaps the advantage of plants from the heavy seed class would have been reflected in increased yield had there been no competition. However, few crop plants are grown without interplant competition. Therefore, it is not surprising that differences in seed class, which conferred advantages to the seedlings, were not reflected in yield. In addition, the late planting date and early frost might have acted to equalize the yields.

Plants With No Bolls (Barren Plants)

When only seed class means were considered, unsorted seed produced more barren plants than other seed classes (Table 4). Within regular-width rows seed class had no effect on the number of barren

Table 2. The effect of seed class and row width on height of cotton plants 75 days after emergence.

Seed class	Row width: Regular	Row width: Narrow	Means
	cm		
Unsorted	100.6 b*	85.3 d	92.9 b*
Light	112.8 a	94.5 bc	103.6 a
Medium	88.4 cd	91.4 c	89.9 b
Heavy	100.6 b	88.4 cd	94.5 b
Means	100.6 a*	89.9 b	95.2

* Numbers within an array followed by the same letter do not differ significantly at the 0.05 level according to Duncan's Multiple Range Test.

Table 3. The effect of seed class and row width on lint yield.

Seed class	Row width: Regular	Row width: Narrow	Means
	kg/ha		
Unsorted	579 a*	439 ab	508 a*
Light	432 ab	487 ab	460 a
Medium	457 ab	524 ab	491 a
Heavy	421 b	451 ab	437 a
Means	473 a*	475 a	474

* Numbers within an array followed by the same letter do not differ significantly at the 0.05 level according to Duncan's Multiple Range Test.

Table 4. The effect of seed class and row width on number of bolls per plant.

Seed class	Row width: Regular	Row width: Narrow	Means
	Plants/ha with 0 bolls/plant		
Unsorted	116,065 a*	563,654 a	339,860 a*
Light	110,821 a	432,660 b	271,740 b
Medium	118,622 a	463,728 b	291,175 b
Heavy	106,516 a	450,412 b	278,464 b
Means	113,006 b*	477,614 a	
	Plants/ha with 1 boll/plant		
Unsorted	28,511 a	54,468 a	41,491 a
Light	25,016 a	57,830 a	41,422 a
Medium	29,455 a	72,087 a	50,771 a
Heavy	24,747 a	48,417 a	36,581 b
Means	26,932 b	58,200 a	
	Plants/ha with 2 bolls/plant		
Unsorted	17,485 a	10,087 a	13,786 a
Light	18,157 a	10,490 a	14,324 a
Medium	16,947 a	10,490 a	13,718 a
Heavy	14,390 a	10,895 a	12,642 a
Means	16,745 a	10,490 b	
	Plants/ha with 3 bolls/plant		
Unsorted	10,357 a	4,036 a	7,196 a
Light	6,993 b	3,767 a	5,380 a
Medium	6,052 b	1,882 a	3,967 b
Heavy	6,726 b	4,303 a	5,514 a
Means	7,532 a	3,497 b	
	Plants/ha with over 3 bolls/plant		
Unsorted	8,069 a	2,421 a	5,245 a
Light	6,590 a	3,362 a	4,976 a
Medium	7,800 a	2,018 a	4,909 a
Heavy	5,918 a	2,151 a	4,034 a
Means	7,094 a	2,488 b	

* Numbers within an array followed by the same letter do not differ significantly at the 0.05 level according to Duncan's Multiple Range Test.

plants. However, within narrow rows unsorted seed produced significantly more barren plants than other seed classes. The effect of seed class in the two row widths was different. This differential response was apparently due to the total number of plants produced from unsorted seed in the narrow rows. Regular-width and narrow rows averaged 66 and 86% barren plants, respectively. The average for both row widths and all seed classes was 82% barren plants. This percentage is considerably higher than that reported by Wilkes et al. (18) in Texas. Our test averaged 361,800 plants/ha; theirs averaged 86,450 plants/ha. However, the total number of plants/ha with one or more bolls in the two tests was comparable: 79,966 in their test; 66,483 in ours.

Plants With One Boll (1-Boll Plants)

Row width and seed class significantly affected the number of 1-boll plants (Table 4). Unsorted, light, and medium seed classes produced more 1-boll plants than the heavy seed class. As plant population increased, there was a trend toward an increase in the number of 1-boll plants. About 16% of the plants in regular-width rows and 11% of the plants in narrow rows produced one boll.

Plants With Two Bolls (2-Boll Plants)

Only row width affected the number of 2-boll plants (Table 4). Regardless of seed class, seed planted in regular-width rows produced more 2-boll plants than seed planted in narrow rows. The significance associated with regular-width rows was primarily due to the total number of plants. About 10% of the plants in regular-width rows and 2% of the plants in narrow rows produced two bolls.

Plants With Three Bolls (3-Boll Plants)

The medium seed class produced fewer 3-boll plants than other seed classes (Table 4). The significance associated with regular-width rows was primarily due to the total number of plants. Unsorted seed produced significantly more 3-boll plants than did the light, medium, or heavy seed class in regular-width rows. There was no effect of seed class within the narrow rows. In regular-width rows 4% of the plants had three bolls; in narrow rows 0.6% of the plants had three bolls.

Plants With More Than Three Bolls (Over 3-Boll Plants)

Seed in regular-width rows produced more plants with more than three bolls than did narrow rows (Table 4). Four percent of the plants in regular-width rows, and 0.4% of the plants in narrow rows produced more than three bolls. Considering all seed classes and row widths, only 1% of the population had more than three bolls. As the plant population increased, plants in the population with more than three bolls decreased.

CONCLUSIONS

Results show that the higher the plant population, the higher the number of barren plants and plants with one boll. This finding substantiates the opinion, held by many, that within a normal population of cotton there is a large percentage of plants that set few, if any, bolls. Within the population range studied (158,297 to 634,666 plants/ha) the percentage of barren plants increased as population increased, so that the yield remained approximately the same regardless of the population.

Yield should increase as number of bolls per plant increases within a finite population. However, these results suggest that regardless of the number of fruiting points per unit area, only so many bolls can be obtained per unit area under limitations of variety and environment. Multiple correlations in this study indicated that plants producing more than three bolls were contributing very little to yield. The highest simple correlation ($r = 0.5461$), based on the individual plot values, was obtained between yield and plants with one boll. This suggests that further yield increases in narrow-row culture must be obtained through boll production (at least one boll per plant) on barren plants. Cotton plants usually have been selected as spaced plants and apparently do not yield well when subjected to the crowded conditions encountered in high populations. The method of selection could account for the large number of field-grown plants that produce no yield. This suggests that we should change our method of selection of plants when the objective is for plants to be grown in populations exceeding 223,000 plants/ha.

In addition, it is probable that variety and environment are important in deciding whether there is an advantage to be gained from sorting cottonseed. Under the conditions of this test, there was no advantage from either seed sorting or narrow rows.

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