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Influence of Unfilled Cotton Seed Upon Emergence and Vigor[1]

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ABSTRACT

The influence of cottonseed fullness upon emergence and seedling growth was studied under a minimal temperature of 17 C ± 1. Seeds of Acala SJ-1 (*Gossypium hirsutum* L.) were sorted by X-ray photography into four classes, or degrees of seed filling (50, 75, 90, and 100%).

Completely filled seeds were superior to partially filled seeds for total emergence, seedling survival, and early growth. Emergence and seedling survival were related more to seed fullness than to seed weight in this study. These data indicate that grading of planting seed based upon weight or size is not adequate to remove many inferior seeds.

Additional key words: **Seed classes, X-ray photograph, Seedling survival, *Gossypium hirsutum*.**

IT is essential to obtain and maintain the desired population of healthy seedlings for efficient cotton (*Gossypium hirsutum* L.) production. Replanting, for any reason, is far more costly than indicated by seed price. Precision operations, before and after the actual planting, are vitally altered. The soil tilth of the seed bed and furrow shaping are adversely affected in most cases in which cotton must be replanted. The effectiveness of preplant herbicides, soil fumigants, and fungicides is often lost or diminished by replanting.

Seed quality is most important when plantings are made in cool, moist soil. Until recent years growers depended largely upon the reputation of the variety and official germination information printed on the seed certification tag as their criterion for judging seed quality. Such information is good, but inadequate to predict the degree of performance needed for progressive farmers who strive for greater precision. Slightly deteriorated seeds generally will germinate under optimum conditions in a laboratory germination test but fail to emerge under adverse field conditions.

The potential seedling emergence needs to be determined. Currently, it is difficult to estimate the extent of damage that seedling diseases and irregular plant populations cause when weak seedlings emerge. Techniques need to be developed that can give rapid and reliable information on the potential emergence and vigor of cotton seed.

We conducted this study to determine the influence of seed fullness (as measured by X-ray photography) upon emergence and vigor of cotton seedlings when planted under minimal temperature conditions.

REVIEW OF LITERATURE

Seedling emergence and vigor have received considerable attention in recent years. Investigations by Bowen (3) clearly indicated that soil temperature, soil moisture, physical impedance, and soil aeration each have an effect upon emergence. Since those climatic and physical variables may all be factors in a given field planting, it is rare for any seed to provide the rate and percentage of emergence that laboratory data indicate. Leinweber (10) found that water uptake and soil temperature greatly influenced cotton seedling emergence. The importance of factors affecting early stage growth and development upon final productivity in cotton was shown by Wanjura et al. (14).

El-Zik et al. (7) reported that the ability of cottonseed to germinate at low temperatures is heritable. They also found significant differences in the rate of seedling emergence between temperature levels and a temperature × strain interaction. Leach (9), using seeds of several vegetable crops, found that the severity of preemergence infection of various diseases was influenced by growth rate of both the seedling and the pathogen at different temperatures.

Mechanically damaged cottonseeds have been studied by various investigators. Germination studies

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by Douglas (6) showed a reduction in germination from damaged seeds. Varieties, type of machine harvester, and plant population influenced the extent of mechanical damage. According to Helmer (8), the type of processing affects mechanically damaged seeds. Acid-delinting seeds that had mechanical damage reduced emergence under field conditions; but no reduction occurred from use of flame delinting.

Gravity grading of cottonseed by size has been tried by some processors, and studied by Arndt (1). Porterfield and Smith (11) found that a higher percentage of the medium-sized seeds emerged in a field test than did either the small or large seeds.

Christiansen (4) reported two types of chilling injury to germinating cottonseed. Recently, Christiansen has shown that cottonseed can be rendered insensitive to chilling at the time of planting by elevating the seed moisture to levels exceeding 13% and storing temporarily at high humidity (5).

Tupper (13) approached the problem of cotton planting seed quality by measuring seed density. He found seed density to be more closely related to emergence and vigor than either seed weight, diameter, volume, or length.

PROCEDURES AND MATERIALS

X-ray photography, such as used by Singh and Banerjee (12, 2) with other crop seeds, was found suitable for use with cottonseed. At Shafter, we have used X-ray photography to detect mechanically damaged and unfilled seeds. We used the Faxitron 804 X-ray machine[3] and 203 × 254-mm type M film. One hundred seeds were placed on holders and exposed at 20 KVP for 2 min. After processing, the negatives were placed on a backlighted box with a frosted glass top. In about 5 min both the damaged seeds and the extent that the embryos filled the cavities were determined.

All seeds that showed mechanical damage were discarded. This eliminated approximately 10% of the seeds on each holder. Identifying seeds that were *(1)* 50% filled, *(2)* 75% filled, *(3)* 90% filled, and *(4)* 100% filled (see photograph) was relatively easy. Only seeds that closely approximated one of the four classes (degree of filling) were used in this study. After sufficient seeds were classified, a second X-ray was made to verify the accuracy of seed class for each seed. Only a very few seeds were discarded as borderline cases.

Three lots of 'Acala SJ-1' planting seed were used in this experiment. (A lot is any quantity of seed derived from the same grower at one time of ginning, not exceeding 10 tons.) The choice of these seed lots was made on the basis of inspections conducted by the Califirnia Planting Cotton Seed Distributors. In their quality-control program for multiplication and distribution of Acala planting seed, the X-ray technique is used to estimate the mechanical damage and seed filling of all lots at harvest time. Their inspections of 1970 planting seed showed a range of from 8 to 28% in the percentage of unfilled seeds as examined in the fuzzy seed stage.

The three lots we chose for this study represented (a) low percentage (8%), (b) medium percentage (14%), and (c) high percentage (26%) of unfilled seeds. All three lots had given 90% or better official germination. We collected, at random within each lot, a 35-7-kg sample of fuzzy seed. Previous to the X-ray determinations we acid-delinted the seeds and also conducted a greenhouse test for emergence. Under ideal temperatures, and with the use of sterilized sand in 30 × 40-cm flats, all three lots gave excellent emergence, indicating that a very high percentage of seeds was capable of rapid emergence under optimum temperatures.

Thirty seeds of the 50% filled class and 20 seeds of the other classes from each of the three seed lots were identified for use in each of four replications. A total of 270 cups, considered as a replication, was the maximum capacity of the climate control chamber.

[3] Mention of commercial products does not imply endorsement by the US Department of Agriculture.

The temperature in the control chamber was set at 17 C ± 1. This was chosen to approximate the 46-year mean daily temperature at Shafter in the period from March 15 to April 10. The same chamber was used for four plantings of seeds prepared in the same manner. Twelve hours of light (11,750 lumens) and 12 hours of darkness were used in the box. Each seed was weighed, treated with fungicide, and planted at a depth of 2 cm in sterilized soil in a 142-g (5-oz) plastic cup. The cups were wetted with 21-C water before being placed in the control chamber.

Rate of emergence, expressed as mean emergence period (M.E.P.), was the calculation of the sum of each daily emergence increase × days since planting divided by total plants emerged. The day of emergence for each seedling was recorded when the hypocotyl crook was seen above soil level.

Total emergence differed from survival in that some seedlings emerged but died within a few days. Survival refers to the percentage of total seeds from which seedlings survived 18 days after emerging from the soil. Each seedling was then removed from the chamber and both shoot and root were removed from the soil and dried for 24 hours at 100 C to obtain dry weight. This dry weight was used as the measure of vigor.

RESULTS AND DISCUSSION

Emergence and survival of seedlings from the half-filled (50% class) seeds were below 10% in all replications. This extremely poor performance made it quite evident that such seeds were inferior in all respects. Therefore, this class of seeds was not considered in the analyses of data collected.

The initial analysis used a split-plot design in order to obtain the best possible estimate of differences between seed classes and class × lot interactions. Finding no significant differences for either lots or the class × lot interaction, we pooled the lots for the data as shown in Table 1. This provided 35 degrees of freedom, with 22 for the error term.

No significant differences are shown for rate of emergence (M.E.P.), indicating that the partially filled seeds that emerge are able to do so as rapidly as well-filled seeds. The major differences between classes were in emergence and in survival of seedlings. The 75% class of seed was significantly lower for both emergence and survival than the 90% and 100% classes. The 90% class was also significantly less than the completely filled (100%) seeds for seedling survival. It is obvious that even the well-filled seeds provided a low percentage of surviving seedlings under the conditions of this experiment. This, however, should be expected when we recognize that cottonseed planted in cool soil frequently produced seedlings from only 50% of the total seeds planted.

An extremely small amount of dry matter was produced in the 18 days following emergence. There was a significant gain in dry weight for the 100% class over seeds only 75% filled. Some of this difference, however, could be due to initial differences in embryo weight.

Data for seed weight indicate significant differences between each of the seed classes. This is, to a large

Table 1. Mean values for emergence measurements and seedling vigor for three classes of seed fullness.

Seed class	Seed emergence		Seedling		Seed weight
	M. E. P.	Total	Survival	Vigor	
% filled	days	%	%	g/plant	g
75	15.75 a	23.8 a	21.5 a	.0029 a	.108 a
90	15.75 a	45.0 b	40.0 b	.0030 ab	.123 b
100	15.20 a	56.2 b	55.4 c	.0035 b	.129 c

* For each column of data, any two means not followed by the same letter differ significantly at the 5% level of probability by Duncan's New Multiple Range Test.

Table 2. Mean values for emergence and seedling vigor for seed classes having comparable seed weights.

Seed class	Seed weight	Emergence measurements			Vigor
		M. E. P.	Total emerged	Survived	
% filled	g	days	%	%	g/plant
75	.1138 a	16.1 a	35.9 a	35.9 a	.00348 a
90	.1150 a	15.1 a	48.4 b	41.9 a	.00296 b
100	.1155 a	15.9 a	54.5 b	50.0 b	.00374 a

* For each column of data, any two means not followed by the same letter differ significantly at the 5% level of probability by Duncan's New Multiple Range Test.

Table 3. Seedling survival for light and heavy seeds of the completely filled class.

Seed group	% survival by replication				Mean
	1	2	3	4	
Light (.0777 to .1299)	55.6	41.6	54.8	50.0	50.5
Heavy (.1300 to .1617)	60.6	65.7	55.2	57.0	59.6
					ns

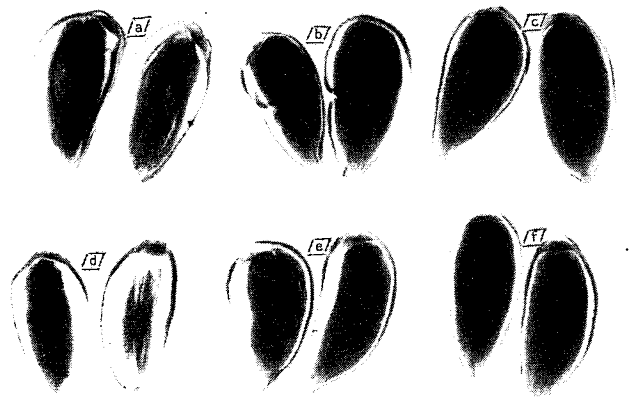

Fig. 1. X-ray picture of cracked seeds and seeds of three classifications of filling: a. Cracked underneath; b. Cracked on the side; c. No cracks; d. 50% filled; e. 75% filled; and f. 90% filled.

extent, due to embryo size as viewed in the X-ray classing. It does not, however, indicate that the seed classed by this technique is synonomous with seed weight. A review of the 1,080 individual seed weights reveals a wide range of seed weights within each class. For example, a large number of the 75% class seeds have weights equal to many in the 90% and 100% classes.

We were interested in whether a full seed was superior to a partially filled seed when seed weights were approximately equal. An analysis was made of the data for emergence and vigor, using only seeds that weighed .1100 to .1199 g in the three classes. Results are shown in Table 2. The analysis indicates that seeds in this regrouping show no significant difference between classes for seed weight. It is evident that the 100% filled seeds gave a significantly higher percentage of survival than the partially filled seed classes. This information strongly suggests that seed fullness is of more importance than weight per seed.

Another analysis was made, using only the completely filled seeds. A range in weight from .0777 to .1617 g per seed was obtained for the 100% filled seeds in this experiment. We assembled the measurements on emergence for the light (.0777 to .1299) versus the heavy seeds (.1300 to .1617). The results are given in Table 3. There was no significant difference for seedling survival between the two weight groups, even though mean values favor the heavier seed. This further confirms our thesis that seed fullness is more important than seed size, or weight, in predicting the ability to obtain stands of healthy cotton seedlings.

We recognize that factors other than seed fullness influenced the emergence data obtained under these minimum temperature conditions. Even our 100%-filled seeds, which gave more than 90% emergence under optimum laboratory and greenhouse conditions, were below 60% emergence in this climate control study. This difference could be attributed to a number of factors that have been investigated previously by cotton scientists.

Subjecting cottonseed to a substandard soil temperature places the germinating seed and emerging seedling under stress from a series of factors, such as shown in the literature review.

We measured the effects of seed filling *per se* upon emergence and vigor. The X-ray technique would not be expected to detect other factors affecting seed quality, except mechanically damaged seeds, which were removed in this case.

The findings of this study need confirmation in field experiments, where fruiting, yield, and quality of the fiber and seed can be evaluated. If final yields prove to be influenced by the fullness of the seed planted, it behooves scientists and processors to develop ways to remove partially filled seeds. Agronomists should pursue the genetic and cultural factors that contribute to the development of well-filled seeds.

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