April 18, 1939.

To the Committee on Graduate Study:

I am submitting to you a thesis written by Dwight McBryde Simpson entitled "Behavior of Cottonseed of Various Germination Percentages under Field Conditions". I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

O. W. Dynes
Major Professor

We have read this thesis
and recommend its acceptance:

S. B. F. Boler

Eric Winters

Accepted for the Committee

L. C. Smith
Dean of the Graduate School

BEHAVIOR OF COTTONSEED OF VARIOUS GERMINATION PERCENTAGES UNDER FIELD CONDITIONS

A THESIS

Submitted to
the Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Dwight McBryde Simpson

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INTRODUCTION

Seed from cotton which has been exposed to rain or humid conditions in the field is likely to be of lower germination than seed from cotton harvested during periods of dry weather.[1] Adverse weather frequently occurs over large areas in the Cotton Belt during the picking season and causes shortages of planting seed of high germination. Seed dealers seldom offer for sale cottonseed of less than 80 percent germination, and agricultural authorities hesitate to recommend the planting of seed of low germination percentage. Supplies of seed of satisfactory quality and purity usually are limited and when these supplies are further reduced by poor germination, the acreage planted with gin-run seed is increased.

More information is needed regarding the behavior under field conditions of cottonseed of low germination so that the greatest possible use may be made of the available supplies of pure seed. Stroman[2] showed differences in seedling vigor between cotton progenies, and

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1 Simpson, D.M. and Stone, B.M. Viability of cottonseed as affected by field conditions. Jour. Agr. Res. 50: 435-447. 1935.

2 Stroman, G.N. Cotton breeding investigations, 1928 to 1932. N. Mex. Agr. Expt. Sta. Bul. 217: 1-39, 1934.

Harris[1] showed the differentiation of varieties and species with respect to their capacity to produce seedling stands of cotton. Neither of these authors demonstrated whether the differences were due to hereditable characters or to the physical condition of the seed stocks used in their experiments.

The experiments described in this paper have been conducted to determine the behavior of different types and varieties of cottonseed under field conditions and to measure the relative vigor of the seedlings produced by seed lots differing in percentage of germination and with varying seed treatments. The results presented here are from field and laboratory experiments conducted at Knoxville and Jackson, Tenn. from 1935 to 1938, inclusive.

GERMINATION TESTS WITH FIELD DETERIORATED SEED

Over a period of several years, the behavior of seed of low germination percentage was observed by the writer in connection with cotton experiments in the Coastal section of South Carolina. Weather conditions in that section are particularly adverse for the production of seed of high germination percentage and the continued propagation of certain strains of upland cotton frequently required the planting of seeds which had laboratory germinations as low as 30 percent. The laboratory germination percentage of locally produced seed was seldom higher than 70 percent.

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1 Harris, J. Arthur, Harrison, George J., and Lockwood, Edna K. A criterion of the differentiation of varieties or of experimental areas with respect to their capacity to produce seedling stands of cotton. Jour. Agr. Res. 38: 601-621. 1929.

Despite the low viability of the seed available for planting, fair stands usually were obtained by increasing the rate of seeding to compensate for the lower germination percentage of the seed. In those seasons in which poor stands were obtained, such results were attributable to lack of moisture or other unfavorable conditions at planting time. The results outlined above were with seed that had been damaged in the field by adverse weather conditions and the seed were not more than one or two years old. It is uncertain whether equally good results would have been obtained with seed the germination of which had been impaired by causes other than weather damage in the field. Cases were noted in which seed that had deteriorated in longtime storage were germinable but produced seedlings lacking in vigor. Such seeds required optimum conditions for germination and for the survival of the weak seedlings.

Since much of the damage to planting seed in the Southeastern States can be attributed to rainy and humid weather during the harvesting period, a study of the behavior of seed affected by this type of deterioration should give information applicable to much of the seed of low germination which otherwise may be desirable for use in planting.

In 1934, four lots of seed of the Tidewater variety of cotton were collected at Charleston, S.C. These lots of seed had laboratory germination percentages of 65, 64, 42, and 26, respectively. In the laboratory germination tests no especial evidence of disease was noticed in any of the seed lots. Field plantings were made with these seeds at Knoxville, Tenn. in the spring of 1935, to study the relative behavior of the four lots of seed under the adverse conditions of early

spring as well as under more favorable conditions later in the season. Plantings were made at three dates, April 17 and 27, and May 22. In preparation for planting, the seeds of each lot were divided into three groups. Group 1 was retained as normal fuzzy seed without treatment, group 2 was delinted with sulphuric acid, and group 3 was delinted with sulphuric acid and treated with Ceresan[1]. Five 100-seed samples of each group of each seed lot were planted at each of the three dates indicated above. In planting, 5 seeds were placed together in hills, hills six inches apart on the row.

The data from this experiment are summarized in Table 1. In the seed lots of low average germination, the germinable seeds apparently were as vigorous and as effective in producing healthy seedlings as the viable seeds in lots of higher germination. This was true under the cool conditions of middle April as well as under more favorable conditions later in the spring. Seedling mortality was no higher in the low germination lots than in those of higher germination percentage. Under the conditions of this experiment, higher germinations were obtained from acid-delinted seeds than from normal fuzzy seeds of the same lot. Delinting generally increased the rapidity and regularity of the germinations. Delinting slightly increased the percentage of plants which survived the seedling stage. The treatment of delinted seeds with Ceresan was of no particular benefit under the conditions of this experiment. The experiment did not include undelinted seeds treated with Ceresan.

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1 Ceresan is the trade name of a seed disinfectant prepared in dust form. The active ingredient in this commercial preparation is ethyl mercury chloride.

Table 1.- Germination of normal fuzzy, acid-delinted, and acid-delinted-Ceresan-treated cottonseed, in 1935.

Seed lot	Seed treatment	Laboratory germination	1st planting (4/17)		2d planting (4/27)		3d planting (5/22)	
			Seedling emergence	Seedling mortality	Seedling emergence	Seedling mortality	Seedling emergence	Seedling mortality
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
1	Normal fuzzy	65	43	19	59	8	50	10
	Acid-delinted	68	60	5	70	2	65	4
	Acid-delinted + Ceresan	72	60	7	67	4	65	2
2	Normal fuzzy	64	42	14	46	7	46	6
	Acid-delinted	69	49	9	68	4	59	3
	Acid-delinted + Ceresan	70	59	9	68	4	61	3
3	Normal fuzzy	42	28	15	29	5	27	10
	Acid-delinted	50	37	6	46	3	45	3
	Acid-delinted + Ceresan	58	41	10	48	4	43	3
4	Normal fuzzy	26	15	15	25	19	19	12
	Acid-delinted	40	30	8	34	10	32	4
	Acid-delinted + Ceresan	38	32	7	39	7	32	9

The low percentage of viable seeds in the seed lots used in this experiment was attributable to adverse weather conditions during the harvesting period. The seeds were comparatively free of disease. With seeds of this type it appears that good stands of healthy and vigorous seedlings may be obtained if the seeding rate is increased to compensate for the fewer number of viable seeds in the lots of low average germination.

GERMINATION TESTS WITH IMMATURE SEED

In the continuation of this study in 1936, three lots of seed of the Stoneville 2A variety of cotton were obtained for field study. These lots were from the 1st, 2d, and 3d pickings made at the U.S. Cotton Field Station at Knoxville in 1935. Laboratory germinations of these seeds were 96, 82, and 34 percent, respectively. These seed lots differed from those used in 1935 in that the deterioration of the seeds of the 2d and 3d pickings was due largely to frost damage and immaturity rather than to wet weather during the harvesting period. The immature seeds were observed readily after delinting since they were generally shrivelled and had light or straw-colored seed coats.

In preparation for planting, each seed lot was thoroughly mixed, then divided into four parts and the parts treated as follows:-

1. Normal fuzzy seed.
2. Normal fuzzy seed treated with Ceresan.
3. Acid-delinted seed.
4. Acid-delinted seed treated with Ceresan.

Field plantings were made with these seed lots at three dates, namely, April 15, May 7, and June 9. Each planting consisted of six replications

of each seed group, the plots being randomized in such a way as to allow a statistical analysis of the data by the variance method. Each plot or row of the test consisted of 20 hills, five seeds to the hill, hills six inches apart. Mean germination percentages from the three plantings of these twelve seed groups are given in Table 2.

Following heavy rainfall in March which totalled 9.43 inches for the month, frequent rains in early April kept the soil in a moist condition until after the April 15 planting. 4.62 inches of rain were recorded from April 1 to 12, inclusive. For the period April 15 to April 30, the mean maximum soil temperature was 79.7 and the mean minimum soil temperature was 52.6 degrees F. Rainfall of .30 inches was recorded on April 23. Germinations of all seed lots planted April 15 were relatively slow, the first seedlings beginning to show above ground on April 26. In general, the delinted seeds germinated one to two days earlier than those not delinted. Germination continued slowly and all seed lots had about reached their maximum germination percentages on May 11. From the data on mean germinations of the several seed lots, Table 2, it is apparent that the differences in field germination between seeds of the 1st, 2d and 3d pickings were highly significant; that the treatment of seeds with mercury dust did not appreciably increase the germination percentage; and that seeds delinted with sulphuric acid, in general, gave significantly higher germinations.

At the time of the 2d planting the soil had become relatively dry on the surface and was further dried by the operation of planting. While

Table 2.-Mean field germination percentages from seed of the first, second, and third pickings of Stoneville 2A cotton; planted on April 15, May 7, and June 9, 1936.

Seed lot	Seed treatment	Laboratory germination	Mean field germination		
			Planting date		
			April 15	May 7	June 9
		Percent	Percent	Percent	Percent
1st picking	Normal untreated	96	74	71	79
	Normal + Ceresan	97	76	70	77
	Acid-delinted	94	80	73	80
	Acid-delinted + Ceresan	98	83	73	83
2d picking	Normal untreated	82	48	55	62
	Normal + Ceresan	68	49	48	53
	Acid-delinted	84	67	64	71
	Acid-delinted + Ceresan	79	62	62	65
3d picking	Normal untreated	34	10	12	17
	Normal + Ceresan	27	7	14	16
	Acid-delinted	28	13	19	23
	Acid-delinted + Ceresan	38	18	18	27
Least significant difference between variables at odds of 19 to 1			6.8	6.8	7.5

many seeds came up promptly, initial germinations were irregular and incomplete due to differences in soil moisture in the different rows. Maximum and minimum soil temperatures for the period May 7 to May 20 averaged 97.0 and 65.9 degrees F.,respectively. Initial counts of germination were made on May 13. The number of seedlings gradually increased until May 20, after which date, due to dry weather, few additional newly emerged seedlings were recorded until after the rains of June 8 and 9. Approximately 40% of the germinable seed did not sprout until after these rains. Total germinations from which the means of the various seed lots were calculated, included all seeds which had germinated up to and including June 16. The final results as to seed lots and treatments of the May 7 planting were in accord with those of the April 15 planting.

In the 3d planting made immediately following the rains recorded on June 8 and 9, the seeds gave prompt and complete germination in a short time. There were practically no increases in germination percentages in any of the seed lots after June 17. Maximum and minimum soil temperatures for the period June 9 to June 17 averaged 107.5 and 71.7 degrees F.,respectively. The germinations obtained from the 3d planting were generally higher than from the 1st and 2d plantings. This result would be expected since conditions of soil moisture and temperature were more favorable for seed germination. As in the 1st and 2d plantings, significant differences were obtained between the germination of the seed of the 1st, 2d,and 3d pickings; in general the treatment of seed with 2% Ceresan had no influence on germination, and sulphuric acid delinted seeds were significantly higher in germination than those not delinted.

In order to summarize the results of the three plantings, a combined analysis (table 3) was made of the mean germination percentages obtained at the three planting dates. This analysis and the means for seed lots, treatments, and planting dates show; (1) the differences in germination between the seed lots were highly significant, (2) treatment of the seeds with Ceresan did not appreciably influence the germination of either normal or acid-delinted seeds, (3) significantly higher germinations were obtained from acid-delinted seeds than from those not delinted.

The "F" value[1] for interaction of seed lots by treatments indicates that the seed lots were significantly different in their response to treatments. In Table 2 it may be observed that acid-delinting was particularly beneficial on the seed of the 2d picking group at all three planting dates. There was no significant interaction between planting dates and treatments.

From field observations it was apparent that during the early stages of growth the seedlings from the seed of the 3d picking were less vigorous than those from the two earlier pickings. This was particularly true of the April 15 planting. During the latter stages of growth no differences in plant vigor were apparent.

The average laboratory germination for the seed of the 1st picking for all treatments was 96.2 percent. The average field germination of these same seeds was 76.6 percent, thus 79.6 percent of the viable seeds in this seed lot germinated in the field. Of the 2d picking group, 75.0 percent of

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1 Snedecor, George W. Statistical Methods. Ames, Iowa: Collegiate Press, Inc., 1937. (Ref. p. 173.)

Table 3.-Analysis of variance and mean germination percentages of seed lots, treatments, and planting dates, from three plantings of seed of various germinations and treatments, in 1936.

	Degrees of freedom	Sum of squares	Mean Square	Standard error	"F" value Found	"F" value Required at 1%	"F" value Required at 5%
Total	35	24450.03					
Seed lots (SL)	2	23188.85	11594.43		2531.53	6.93	3.88
Treatments (T)	3	608.29	202.76		44.27	5.95	3.49
Planting date (PD)	2	257.79	128.90		28.14	6.93	3.88
Interactions:-							
SL X T	6	188.27	31.38		6.85	4.82	3.00
PD X T	6	33.88	5.65		1.23	4.82	3.00
SL X PD	4	118.05	29.51		6.44	5.41	3.26
Error	12	54.90	4.58	2.14			

		Mean Germination	Least sig. diff. between variables at odds of 19 to 1
		Percent	Percent
Seed lots:	1st picking Stoneville 2A	76.6	3.2
	2d " " "	58.7	
	3d " " "	16.1	
Treatments:	Normal	47.3	3.7
	Normal + Ceresan	45.3	
	Acid-delinted	54.6	
	Acid-delinted + Ceresan	54.5	
Planting dates:	April 15	48.9	3.7
	May 7	49.9	
	June 9	54.2	

the viable seed germinated in the field, and of the 3d picking, 50.6 percent of the viable seed germinated in the field. This decreased percentage of field germination in relation to laboratory germination for seed of the 2d and 3d pickings is not in accord with the results obtained in 1935 with seed grown at Charleston, S.C., the deterioration of which was due to adverse moisture conditions in the field during the harvesting season. The deterioration of the seed used in 1936 was due principally to immaturity.

The foregoing experiments indicate that the viable seeds in seed lots of different laboratory germination percentages may or may not be equal in ability to produce healthy seedlings in the field. The type of deterioration must be taken into consideration.

VARIETAL DIFFERENCES IN GERMINATION AND SEEDLING VIGOR

In order to obtain information on a wide range of varieties and seed lots having different germination percentages, further experiments were conducted in 1936 and 1937 to measure relative laboratory and field germinations and seedling vigor. These experiments included plantings in 1936 and 1937 of 20 representative cotton varieties or strains.

The planting plans were arranged to allow an analysis of the data by the variance method. The randomized arrangement provided ten replications of each seed lot at each planting date. The plots consisted of single rows, 10 feet long, and 20 hills with 5 seeds per hill were planted in each plot. All seeds were delinted with sulphuric acid in order to remove as much of the external seed contamination as possible. Plantings

were made at two dates each year; namely, April 15 and May 7 in 1936, and April 16 and May 4 in 1937.

Laboratory and Field Germination in 1936.

After the seeds were delinted with sulphuric acid and thoroughly washed and dried, all lots were sampled and standard laboratory germination tests were made on each sample. The laboratory germinations of the 20 seed lots ranged from 99 percent for Trice 2339 to 58 percent for Oklahoma Triumph. Complete data on laboratory and field germination of these seed lots (table 4) show that varietal lots having practically the same laboratory germination percentages may differ widely in field germination. In the graph (fig. 1) it may be observed that the field germinations of the individual varieties were nearly the same at both planting dates. This indicates that the differences in field germination between the several varieties were due to qualities or factors within the seeds and not to soil or climatic conditions. It is also evident from these data that the standard germination technique[1] in current use fails to give an accurate measure of the field efficiency of the seeds.

Laboratory and Field Germination in 1937.

The plantings of 1937 were similar to those of 1936 in plan and in seed stocks except that Trice W-2-1-2-1 was substituted for Trice W-2-1-2,

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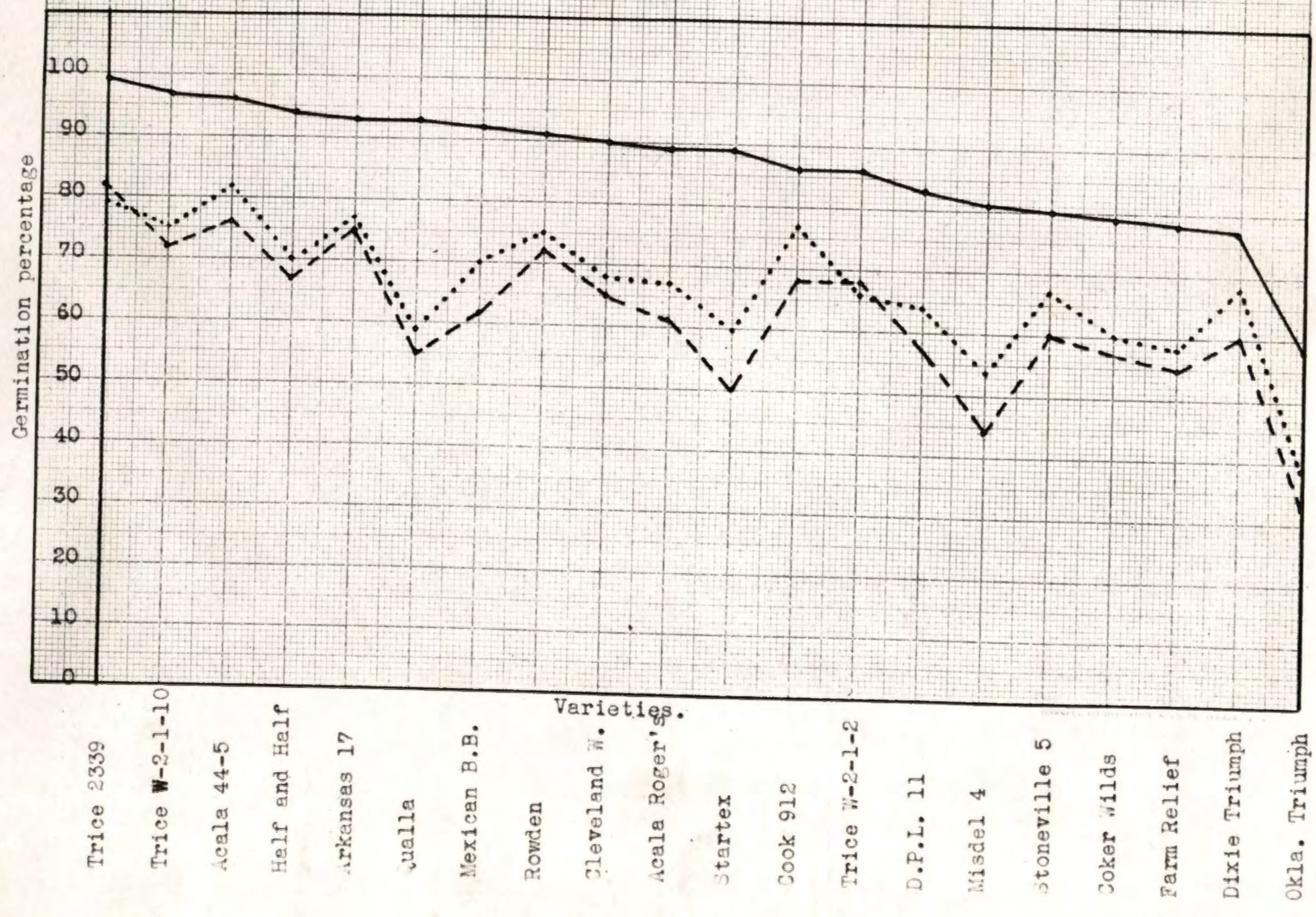
1 Del Curto, J.M. The germination of cottonseed. Tex. Dept. of Agr. Bul. 86: 1-20, 1927.

Table 4.-Laboratory and field germination percentages and dry weight per plant of 20 varieties of cotton in seedling vigor test, in 1936.

Variety	Laboratory germination	Field germination		Dry weight per plant	
		Planting		Planting	
		1st (4/15)	2d (5/7)	1st	2d
	Percent	Percent	Percent	Grams	Grams
Trice 2339	99	82.0	79.1	.2438	.2220
Mexican Big Boll	92	62.1	70.4	.2146	.2160
Arkansas 17	93	74.9	76.8	.2108	.2017
Farm Relief	78	55.0	58.2	.2073	.2179
Acala 44-5	96	75.8	81.5	.2064	.1950
Rowden 2088	91	71.6	74.6	.1923	.2002
Half and Half	94	67.1	69.8	.1872	.1615
Dixie Triumph	77	60.0	68.1	.1870	.1962
D. and P.L. 11	83	57.3	64.0	.1864	.1929
Coker Wilds	79	57.1	59.7	.1841	.2205
Trice W-2-1-10	97	72.2	75.3	.1804	.1838
Trice W-2-1-2	86	68.1	66.0	.1802	.1658
Cleveland (Wann.)	90	64.8	68.3	.1703	.1923
Qualla	93	55.3	59.3	.1679	.1980
Misdel 4	81	43.8	54.4	.1659	.1704
Oklahoma Triumph	58	33.2	38.5	.1608	.1870
Cook 912	86	68.2	77.1	.1602	.1961
Roger's Acala	89	61.3	66.6	.1597	.1922
Startex	89	49.6	51.9	.1503	.1658
Stoneville 5	80	59.9	67.4	.1383	.1748
Least significant difference between--any two varieties		6.1	6.6	.0238	.0329

Figure 1.-Comparisons of laboratory and field germination percentages of twenty varieties of cottonseed at Knoxville, Tenn. 1936. Solid line indicates laboratory germinations; broken line indicates field germination, 1st planting; dotted line, field germination 2nd planting.



and Trice W-2-1-2-2 was substitued for Trice W-2-1-10. Plantings were made at two dates, namely April 16 and May 4. In general, the relation between laboratory and field germinations were the same as in 1936. The average field germinations were 25% lower than the average laboratory germinations, but there were wide differences in the behavior of the individual seed lots.[1] Complete data on laboratory and field germinations are given in Table 5 and graphically presented in Figure 2.

Seedling Vigor - 1936 Experiments.

Differences in seedling vigor were apparent between seed lots in the early stages of seedling development and particularly in the seedlings of the 1st planting when air and soil temperatures were generally low. To obtain a definite measurement of seedling vigor or growth, the dry weight per plant was obtained from each plot of each seed lot at thinning time. All plants which were removed from the rows at thinning time were counted, oven-dried at 100 degrees C. for 24 hours and the dry weight per plant calculated for each plot. Thinning of the 1st planting was done on May 23, 38 days after planting. The 2d planting was thinned on June 4, 28 days after planting. The mean dry weight per plant for seedlings of each seed lot from the 1936 tests is given in Table 4. The data on dry weight per plant were analyzed for variance and the least significant difference between seed lots is indicated in the table.

Significant differences in dry weight per plant are indicated by these data. The results at the two planting dates are in general agreement

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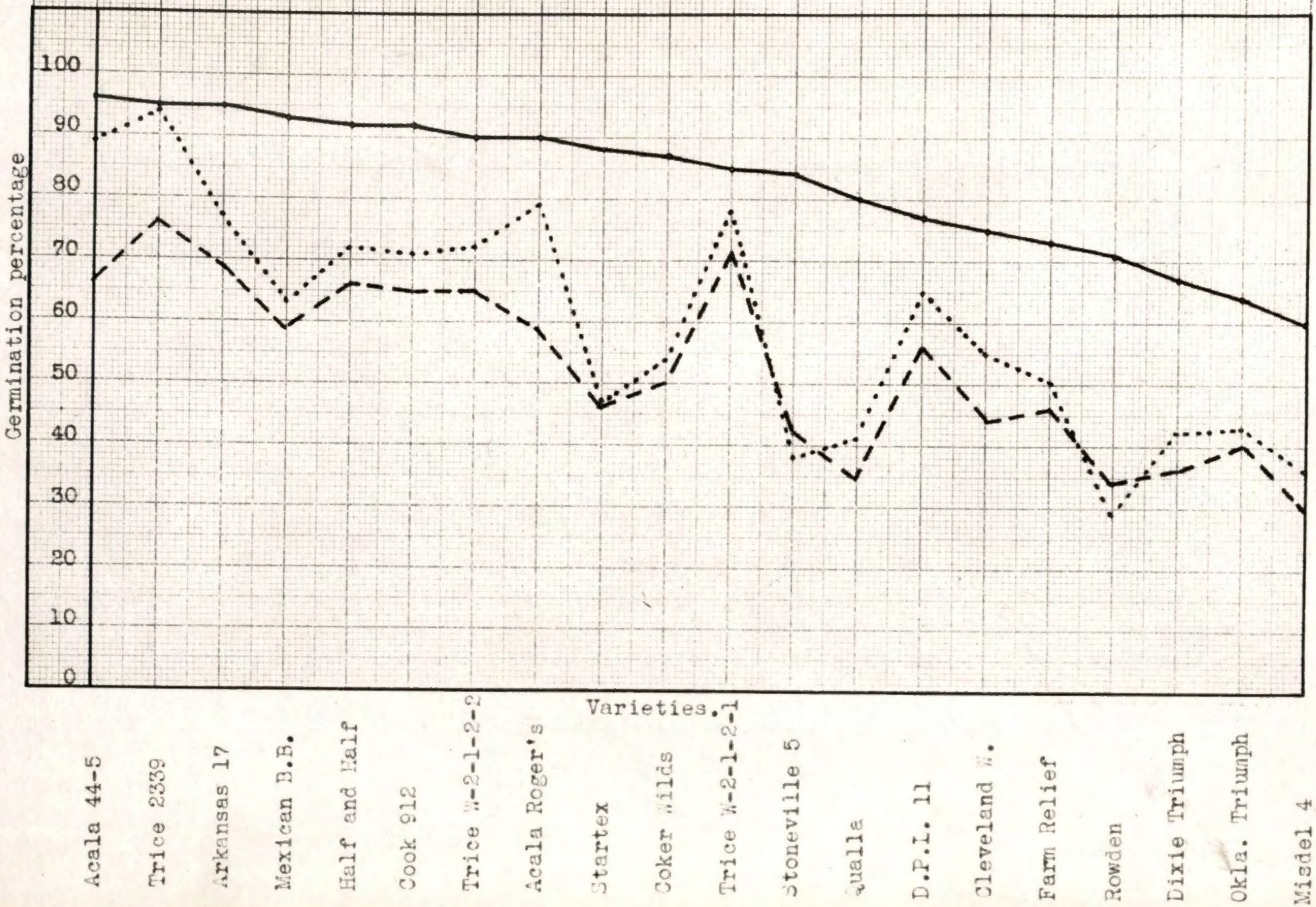
1 Toole, Eben H. and Drummond, Pearl L. The germination of cottonseed. Jour. Agr. Res. 28: 285-296, 1924.

Table 5.-Laboratory and field germination percentages and dry weight per plant of 20 varieties of cotton in seedling vigor test, in 1937.

Variety	Laboratory germination	Field germination		Dry weight per plant	
		Planting		Planting	
		1st (4/16)	2d (5/4)	1st	2d
	Percent	Percent	Percent	Grams	Grams
Trice 2339	95	75.9	93.6	.2187	.3567
Mexican Big Boll	93	59.1	63.1	.2130	.2974
Arkansas 17	95	68.6	76.7	.1829	.2394
Farm Relief	73	46.0	50.0	.1581	.2298
Acala 44-5	96	65.9	88.7	.1744	.2449
Rowden 2088	71	33.7	28.6	.1571	.1723
Half and Half	92	65.6	71.7	.1535	.2364
Dixie Triumph	67	35.8	42.3	.1309	.1971
D. and P.L. 11	77	55.6	64.5	.1723	.2192
Coker Wilds	87	50.4	54.3	.1976	.2636
Trice W-2-1-2-2	90	65.3	72.2	.1421	.2197
Trice W-2-1-2-1	85	71.3	78.4	.1227	.1903
Cleveland (Wann.)	75	44.7	55.0	.1338	.1700
Qualla	80	34.6	41.4	.1320	.1736
Misdel 4	60	30.3	36.2	.1361	.1741
Okla. Triumph	64	39.5	43.0	.1670	.1973
Cook 912	92	64.6	70.9	.1713	.2013
Roger's Acala	90	59.4	79.2	.1612	.2395
Startex	88	46.4	46.7	.1522	.1614
Stoneville 5	84	42.1	37.7	.1268	.1496
Least significant difference between any two varieties	--	6.8	6.1	.0235	.0352

Figure 2.-Comparisons of laboratory and field germination percentages of twenty varieties of cottonseed at Knoxville, Tenn. 1937. Solid line indicates laboratory germinations; broken line indicates field germination, 1st planting; dotted line, field germination 2nd planting.



although the differences are not as great in the 2d planting as in the 1st. This would be expected since factors of cold resistance and seedling hardiness would be more apparent under the conditions of the earlier planting. Of the six varieties or seed lots showing the most vigorous growth, five were selected and developed at locations in the northern portion of the Cotton Belt. Trice 2339 and Acala 44-5-2204 are Tennessee selections, Mexican Big Boll was developed in North Carolina, and Arkansas 17 and Rowden 2088 are from Arkansas.

While the differences in dry weight per plant are extremely small, the relative vigor of the seedlings could be observed by the eye in the field. On May 21, two days before the plants were collected for weighing, notes were made in the field on the 1st planting, recording the observed vigor of the seedlings in all plots. The rank of the varieties as determined by observation was in general agreement with the rank as determined by dry weight per plant for the 1st planting.

Seedling Vigor - 1937 Experiments.

Measurements of seedling vigor or growth were made in 1937 in the same manner as in 1936. The plots were thinned and determinations of dry weight per plant made on May 27 for the 1st planting and on June 2d for the 2d planting, this being 41 and 29 days after each planting, respectively. These data on dry weight per plant (table 5) show consistent and significant differences between seed lots in seedling growth. When the data on seedling vigor for both 1936 and 1937 are considered as a whole, there

are strong indications of varietal differences in vigor. Trice 2339, a Tennessee strain, definitely outgrew all other varieties at all four planting dates. Mexican Big Boll, Arkansas 17, Coker Wilds, Acala 44-5, and Farm Relief were other varieties showing more vigorous seedling growth. Stoneville 5, Startex, Trice W-2-1-2-1, Misdel 4, and Qualla were consistently slow in seedling growth.

Relation of Seedling Vigor to Field Germination Percentage.

A summary of the rank of each of the 20 varieties in laboratory germination, field germination, and dry weight per plant shows the relative standing of these varieties at each date of planting (Table 6). Considering the average rank of the several varieties, Trice 2339, Arkansas 17, and Acala 44-5 are high in both germination and seedling vigor. However, Mexican Big Boll, Coker Wilds, and Farm Relief, varieties with relatively low germinations, are high in seedling vigor. Trice W-2-1-10, and Half and Half had relatively high total germination percentages but were low in seedling vigor.

An indication of the possible effect of lowered germination on seedling vigor is shown by the behavior of Rowden 2088 at the four planting dates. In 1936, Rowden 2088 ranked relatively high in both germination and seedling vigor. In 1937, the Rowden 2088 seeds had deteriorated considerably since 1936 and in germination ranked 14th in the laboratory and 19th in the field. In seedling vigor, the variety ranked 5th and 6th for the two plantings in 1936 and 11th and 17th in 1937.

To obtain a statistical measure of the relation between seedling

Table 6.-Rank of 20 varieties of cotton in laboratory and field germination and dry weight per plant in seedling vigor tests, in 1936 and 1937.

Variety	Rank of variety									
	Laboratory germination		Field germination				Dry weight per plant			
			Planting				Planting			
			1936		1937		1936		1937	
	1936	1937	1st	2d	1st	2d	1st	2d	1st	2d
Trice 2339	1	2	1	2	1	1	1	1	1	1
Trice W-2-1-16*	2	5	4	5	6	6	11	15	14	9
Acala 44-5	3	1	2	1	4	2	5	10	5	4
Half and Half	4	4	8	8	5	7	7	20	12	7
Arkansas 17	5	2	3	4	3	5	3	5	4	6
Qualla	5	10	16	16	18	17	14	7	17	16
Mexican Big Boll	6	3	10	7	9	10	2	4	2	2
Rowden 2088	7	14	5	6	19	20	6	6	11	17
Cleveland (Wann.)	8	12	9	9	14	11	13	12	16	18
Acala Roger's	9	5	11	12	8	3	18	13	9	5
Startex	9	6	18	19	12	14	19	19	13	19
Cook 912	10	4	6	3	7	8	17	9	7	11
Trice W-2-1-2**	11	8	7	13	2	4	12	18	20	14
D. and P.L. 11	12	11	14	14	10	9	9	11	6	10
Misdel 4	13	17	19	18	20	19	15	17	15	15
Stoneville 5	14	9	13	11	15	18	20	16	19	20
Coker Wilds	15	7	15	15	11	12	10	2	3	3
Farm Relief	16	13	17	17	13	13	4	3	10	8
Dixie Triumph	17	15	12	10	17	16	8	8	18	13
Okla. Triumph	18	16	20	20	16	15	16	14	8	12

*W-2-1-2-2 in 1937
**W-2-1-2-1 in 1937

growth and field germination, the correlation coefficient between field germination and dry weight per plant was determined for these 20 seed lots at each planting date. These correlation coefficients were as follows:-

1936	1st planting	r = .572
"	2d "	r = .244
1937	1st "	r = .467
"	2d "	r = .679

The correlation coefficient required for significance at odds of 19 to 1 with 20 paired values is .444, and at odds of 99 to 1 is .561.

At three planting dates there is significant positive correlation between field germination percentage and dry weight of plants at thinning time; however, since varietal differences in vigor are strongly indicated by the data of Tables 17 and 18, and as these correlations are from data including several varieties, the validity of the correlations may be questionable.

EFFECT OF SEED TREATMENT ON SEEDLING VIGOR.

The foregoing experiments have shown that significant differences in seedling vigor exist between seed lots and that these differences in vigor may be correlated with field germination percentage. Varietal differences in seedling vigor also are apparent. Since improvement in field germination may be obtained by seed treatment, it is of interest to determine if seed treatments are effective in increasing the vigor of the seedlings. Information on this point was provided by experiments conducted in 1938 at Knoxville and Jackson, Tennessee.

These experiments included randomized plantings of eight lots of cottonseed that had been selected for study on the basis of their freedom from, or contamination with disease producing organisms. The seed lots varied in degree of contamination and in age. These seed lots were as follows:-

Variety	Year grown	Laboratory germination	Remarks
Acala - Calif.	1934	84	Relatively disease free
Farm Relief	1936	87	do
Dixie Triumph	1936	83	do
Dixie Triumph	1937	89	Contaminated with Glomerella
Farm Relief	1937	89	gossypii and Fusarium monili-
Carolina-Del	1937	89	forme
Mexican Big Boll	1937	88	
Acala - Okla.	1935	72	Bacterium malvacearum.

Plantings at Knoxville included Ceresan-treated and untreated seeds of each varietal lot. Plantings were made at two dates at Knoxville and on one date at Jackson. Records were maintained from all plantings of seedling stand before thinning, seedling root lesions at thinning, and green weight of plants at thinning time. Yield data were obtained from the two plantings at Knoxville.

These records, summarized in Table 7, show the improvement in performance of the seeds of the eight lots due to Ceresan treatment. These figures show that significant increases in the number of seedlings were obtained in six of the seed lots in all plantings as a result of Ceresan treatment. Significant decreases in seedling root lesions also were obtained in the disease contaminated seed lots. In spite of these highly significant differences in seedling survival and percentages of plants

Table 7.-Improvement in field performance of cottonseed treated with Ceresan as compared to untreated seeds of the same varietal lots, 1938.

Variety	Improvement in performance due to treatment with Ceresan										
	Knoxville, Tenn.								Jackson, Tenn. (4/28)		
	1st planting (4/25)				2d planting (5/6)						
	Increase in number of seedlings	Decrease in seedling lesions	Increase in weight per plant	Increase in mean yield per plot	Increase in number of seedlings	Decrease in seedling lesions	Increase in weight per plant	Increase in mean yield per plot	Increase in number of seedlings	Decrease in seedling lesions	Increase in weight per plant
	Percent	Percent	Grams	Pounds	Percent	Percent	Grams	Pounds	Percent	Percent	Grams
Dixie Triumph 1936	1.5	1.0	-.286	-.50	1.7	.3	-.045	-.47	14.7	4.2	.013
Farm Relief 1936	3.3	3.0	-.209	.17	9.1	9.2	.069	-.25	1.3	4.1	-.087
Acala-Calif. 1934	9.2	.0	-.306	.10	12.9	3.5	.238	.17	19.3	3.4	.315
Farm Relief 1937	12.6	10.7	.047	-.12	14.2	36.5	.325	.22	19.8	7.5	.022
Mexican B.B. 1937	14.6	14.5	.058	-.07	20.2	38.0	.578	.33	19.0	18.6	.192
Acala-Okla 1935	20.5	8.0	-.205	-.27	15.6	7.8	-.077	.15	13.5	3.2	-.340
Carolina-Del 1937	25.5	19.0	.371	.33	33.9	44.5	.301	.43	16.3	13.0	-.157
Dixie Triumph 1937	37.8	17.8	.667	.52	39.0	42.5	.740	.15	26.2	29.8	.129
Required for Sig. at odds of 19 to 1	7.2	4.7	.476	.65	6.0	9.7	.396	.52	7.1	10.2	.394

showing root lesions, differences in size of plants, as indicated by green weight, were significant in only 3 of the 24 individual cases. In other words, the surviving seedlings from untreated seeds were, in general, as vigorous as the seedlings from Ceresan treated seeds.

Preceding experiments have shown that differences in seedling vigor may be correlated with field germination percentage. In this experiment, increases in field germination brought about by seed treatment did not result in corresponding increases in seedling vigor. These findings indicate that (1) vigor is largely an inherited character as shown by varietal differences, and (2) that differences in vigor are more likely to be the result of factors that weaken the embryo than by external disease organisms that attack the growing seedlings. It is quite possible that the failure of seed treatment to result in an increased average weight per plant is due to a natural selective process. Seeds having physiological weaknesses would be present in both treated and untreated varietal lots in approximately equal numbers. In the treated lots a large percent of these weak seeds might survive after germination and by their small size reduce the average weight per plant of the plants surviving to thinning time. In the untreated seed lots, however, it is quite possible that many of the weak seeds would succumb to the attack of disease organisms and only the stronger seedlings would survive to thinning time. These stronger seedlings, although having a higher percent of root lesions, might equal in size those from lots of treated seeds.

Although seedling stands were increased as much as 39 percent by

Ceresan treatment, sufficient seedlings remained in the untreated plots to have good stands of plants after thinning. The two tests conducted at Knoxville were continued beyond the seedling stage and yields of seed-cotton were obtained from them. As indicated by the yield data (table 7), increases in yield due to Ceresan treatment were not significant in any seed lot in this experiment. Since the stands of plants, after thinning, in treated and untreated plots were not greatly different and the seedlings were equally vigorous, yield differences would not be expected unless seasonal conditions were such as to favor the spread of infection from the root lesions to the mature plants and bolls.[1]

Under more adverse planting conditions, with untreated seeds, stands might be depleted to such an extent that yields would be decreased. Since seedling diseases are widespread in their distribution and are likely to be present in any lot of cottonseed, the use of Ceresan or other approved seed disinfectant may be considered as good insurance for the protection of seedling stands.

SUMMARY AND CONCLUSIONS

A series of experiments have been conducted at Knoxville, Tenn. and Jackson, Tenn. during the period 1935 to 1938 to study the field behavior of cottonseed of various germination percentages. Information

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1 Neal, David C. and Gilbert, W.W. Cotton diseases and method of control. U.S. Dept. of Agr. Farmer's Bul. 1745: p.34, 1935.

has been obtained upon the comparative efficiency of seeds of various germination percentages in producing seedlings under field conditions, and the differential effects of seed treatments upon germination and seedling vigor.

Previous observations at Charleston, S.C. had indicated that the viable seeds in lots of field deteriorated seeds, having low average germination percentage, were capable of producing healthy seedlings in the field and that good stands might be obtained from such seed lots by increasing the seeding rate. These observations were confirmed by experiments at Knoxville in 1935, using field deteriorated seeds collected at Charleston, S.C. in 1934.

In 1936, germination tests were conducted with three lots of seeds collected at Knoxville in the fall of 1935. These lots had average laboratory germination percentages of 96, 82, and 34, respectively, the latter two lots having many immature seeds. In field germination they averaged 76, 58, and 16 percent; thus indicating that the viable seeds in the immature lots were less effective in producing seedlings under field conditions.

Further experiments in 1936 and 1937 indicated that seeds from lots of low germination may or may not be effective in producing healthy seedlings in the field. It was evident that present laboratory methods of seed germination often fail to give an accurate measure of the field efficiency of the seeds, as seed weaknesses not detected in the laboratory may cause poor germination under adverse field conditions.

Studies of the vigor of the seedlings produced by good and poor germinating seed lots indicated that in general low germination was

correlated with low seedling vigor. However, varietal differences in vigor also were evidenced. Among the varieties tested, those developed along the northern portion of the Cotton Belt were among the most vigorous under the conditions at Knoxville.

Several of the experiments conducted during these studies included tests of the effect of sulphuric acid-delinting on field germination and seedling vigor. In general, slightly higher germination was obtained from acid delinted seeds than from normal fuzzy seeds, in most cases the increase being less than 10 percent. In a few instances some injury was caused by acid delinting. The emergence of the seedlings in the field was approximately two days quicker from acid delinted than from fuzzy seeds. Since only a relatively small increase in germination percentage can be expected as a result of acid delinting, benefits from the treatment usually do not justify the cost.

Under normal planting conditions at Knoxville, no particular benefit has been obtained from the treatment of cottonseed with Ceresan. Experiments with contaminated seed lots, however, showed that when such seed lots were used, seedling stands were considerably improved by Ceresan treatment. Although the stand of seedlings was increased, seedling vigor was not significantly affected by Ceresan treatment.

These series of experiments have indicated wide divergence between field behavior and laboratory germination of cottonseed. In general, seeds having high laboratory germination percentages have given superior stands and more vigorous seedlings than those with lower germination percentages.

However, viable seeds in lots of low average germination percent are capable of producing vigorous seedlings and in most cases, adequate stands can be obtained from such seed lots by increasing the planting rate.

Seeds of superior germ-plasm should be utilized for planting purposes if a reasonable percentage of the seeds are viable. With proper planting conditions and the use of approved seed disinfectants adequate stands of healthy seedlings usually can be obtained. Prejudice against the sale of planting seed of less than 80 percent should be discouraged, but regulations requiring certification of the germination percentage should be strictly enforced so that the farmer may be advised as to the seed value and planting rate. More intensive research is needed to improve laboratory germination methods so that the results of laboratory tests may be more closely correlated with actual field behavior.

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