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GERMINATION OF COTTONSEED AS AFFECTED BY SOIL DISTURBANCE AND MACHINE PLACEMENT OF FERTILIZER

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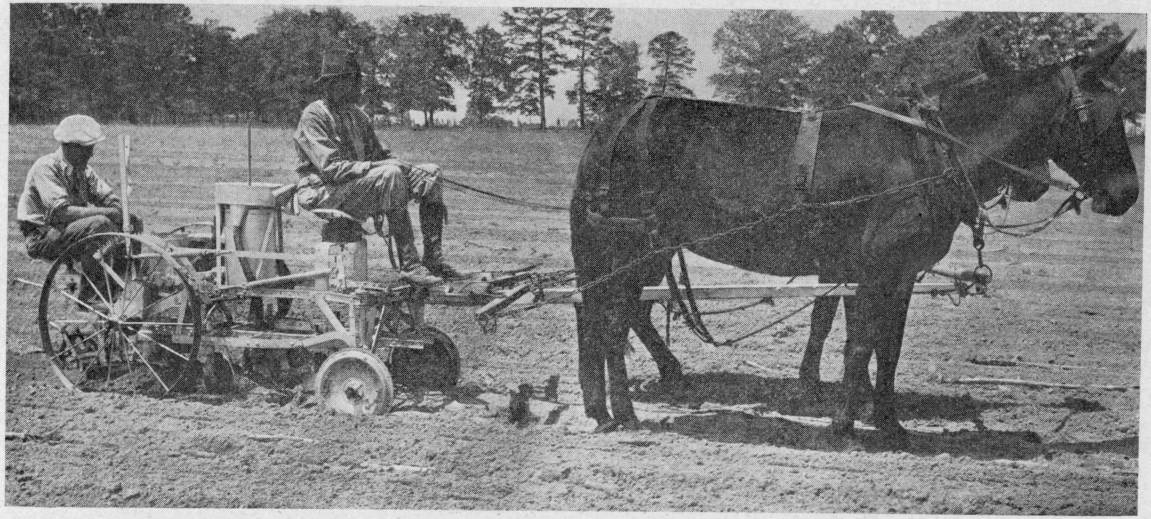


Figure 1. Side view of combination cotton planter and fertilizer distributor, designed and built by the Bureau of Chemistry and Engineering of the U. S. Department of Agriculture.

Experiments were conducted at College Station and Nacogdoches for a five-year period, 1936 to 1940, inclusive, to determine the effect of machine placement of fertilizer and the effect of soil disturbance on the germination of cottonseed.

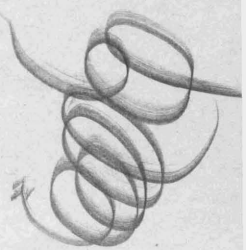
When a 4-12-4 commercial fertilizer was placed under the seed at depths of one, two, and three inches below the seed, there was an increase in the percentage of emergence and yield as the depth increased. Fertilizer placed directly under the seed at the time of planting injured the root system and in most cases stopped the development of tap roots at the level of the band of fertilizer.

When only the soil was disturbed directly under and at the several depths below the seed the percentage of germination decreased with the depth of the disturbance. Where fertilizer was not applied normal tap roots developed.

The best emergence and stands were obtained when the fertilizer was placed two inches to each side and one and two inches below the seed level. As the fertilizer was placed deeper and farther below the seed level than two inches there was a slight decrease in the percentage of emergenc indicating that when fertilizer is placed to the sides of the seed so that the roots of the cotton seedling do not come in contact with the fertilizer, yet close enough for them to get some plant food in the sprouting stage, the fertilizer is beneficial in obtaining better stands. In all of the side placement tests the root systems of the young seedlings were not injured and normal tap roots developed.

When only the soil was disturbed two inches to each side of the seed and one, two, and three inches below the seed level, but no fertilizer applied there was very little difference in the percentage of emergence.

The percentage of emergence when the soil was disturbed at the side in unfertilized tests was higher than when the soil was disturbed under the seed in all cases at both locations except the three-inch depth at Nacogdoches. Therefore, the results of these studies show that the best germination and emergence is obtained when cottonseed are planted on a firm, undisturbed soil, and that better stands are obtained when fertilizer is placed two inches to the sides of the seed and one or two inches below the seed level.



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GERMINATION OF COTTONSEED AS AFFECTED BY SOIL DISTURBANCE AND MACHINE PLACEMENT OF FERTILIZER

By

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A well prepared and firmly settled seedbed is essential for good germination of cottonseed. In many sections of the Cotton-belt, farmers follow the practice of preparing the seedbed for cotton, long enough before planting time, so that rain will occur in suffcient amounts to wet, settle, and firm the soil. The data presented in this bulletin confirm this practice and also show the effect on germination of cottonseed when the fertilizer was placed under and to the side of the seed at various depths and the effect of disturbing the soil at the same placements and depths.

In studies on machine placement of fertilizer of cotton by Collins, (1) Cummings, (2), and (3), and Smith (4) unfertilized checks were not used for each separate placement of fertilizer. In this study an unfertilized test or check was planted for each placement of fertilizer.

DESCRIPTION OF EXPERIMENTS

Scope of Experiments: These studies covered a five-year period and were made at College Station and Nacogdoches. The tests were planted in three replicated blocks. In each block a 100-foot row was divided into two 50-foot sections and data collected from each section. The analysis of variance, however, was calculated on the basis of the three replications.

Fertilizer: Throughout the experiments a 4-12-4 commercial fertilizer was applied at the rate of 500 pounds to the acre.

Variety of Cotton: Startex cottonseed grown at College Station was used at both locations each year for the experiments. The planting depth and the calibrated number of seed dropped for each 50 feet are shown in Table 1.

Fertilizer Placement Machine: The machine used in these experiments shown in Figure 1, was designed and built by the Bureau of Agricultural Chemistry and Engineering of the U. S. Department of Agriculture and is fully described in Texas Station Bulletin No. 548, "Machine Placement of Fertilizer for Cotton."

*Credit is due Dr. J. C. Gaines of the Division of Entomology for his assistance in the statistical analysis of the data contained in this Bulletin.

Interpretation of Data: Analyses of variance were made using the different criteria, even though, the plats were not truly randomized in each block. It was a systematic arrangement in that each fertilizer plat or row was always adjacent to an unfertilized plat. This arrangement may have caused a biased error but analyses are presented in an effort to improve the interpretation of the results.

Homogeneity tests of the error variance of the several experiments indicated heterogeneity, which means that a common error is not valid to test the treatment variance in the combined analyses. In some cases this combined error would be too low and others it would be too high. By comparing the treatment variance to the high interaction variance, it is safe to assume that the significance found was not due to chance alone, but due to certain treatments being consistantly better than others throughout the period.

Table 1. Planting depth and calibrated number of cottonseed dropped in 50 feet.

Year	College Station		Nacogdoches	
	Planting depth in inches	Seed in 50 feet	Planting depth in inches	Seed in 50 feet
1936	1¼	500	1	500
1937	1¼	550	1	550
1938	1¼	700	1	675
1939	1¼	600	1	586
1940	1¼	575	1	575

Rainfall and Seasonal Conditions: The temperature and moisture conditions at the time of planting and immediately following have considerable effect on the germination of cottonseed and the emergence of seedlings. Table 2 shows the average mean temperature of the air for five days before planting and ten days after planting. Each year as the tests were planted the temperature of the soil was determined at the planting depth (Table 2). The total rainfall during the five days before and ten days after planting is also shown in Table 2. Very little rain fell just before and after planting in 1937 and 1939. In 1939 at College Station the moisture in the soil was insufficient for germination where the soil was disturbed under or near the seed. The seed remained in the dry soil from April 20 until May 16 before rainfall was adequate for germination.

Procedure: At both locations the seedbed was prepared by listing and throwing up ridges or beds with a two-mule walking middlebuster plow. This was done three or four weeks before the date of planting so that rains could settle and firm the soil in the ridges. It appeared best to

Table 2. Temperature and rainfall during the period 5 days before to 10 days after planting.

Year	College Station							Nacogdoches						
	Planting date—April	Average mean temperature—°F.			Soil temperature at planting	Total rainfall—in.		Planting date—April	Average mean temperature—°F.			Soil temperature at planting	Total rainfall—in.	
		5 days before planting	10 days after planting	Average for the 15 days		5 days before planting	10 days after planting		5 days before planting	10 days after planting	Average for the 15 days		5 days before planting	10 days after planting
1936	26	63.7	75.2	71.4	72	1.10	1.33	24	62.6	71.2	68.4	65	1.25	.99
1937	22	74.8	72.8	73.4	66	.48	.20	19	71.6	68.8	69.7	68	.00	1.00
1938	19	72.7	72.2	72.3	67	.73	2.65	15	62.1	70.5	67.7	67	.00	.72
1939	20	64.3	70.2	68.2	68	.11	.00	18	65.8	64.8	65.1	57	1.65	.14
1940	17	59.9	68.4	65.6	76	.00	.59	16	56.5	65.5	62.5	67	.53	.95
Ave.		67.1	71.8	70.2	70	.48	.95		63.7	68.2	66.7	65	.69	.76

have alternate fertilized rows so that if the plants fed from row to row, conditions would be equal for all the unfertilized plants. For each fertilizer placement test, an unfertilized test was planted having the same soil disturbance as the fertilized test.

EFFECT OF FERTILIZER

The major objective in these studies was to determine the effect of machine placement of fertilizer and the effect of soil disturbance on the germination of cottonseed. Tests were planted with the fertilizer placed one, two, and three inches below and directly under the seed. Other tests were planted with the fertilizer placed two inches to each side of the seed and one, two, and three inches below the seed level. In one test all fertilizer was placed two inches to one side and two inches below the seed level. The unfertilized test for each placement was planted with the same planter adjustments as the fertilizer test.

The fertilizer placements under the seed were in a single narrow band 1.75 inches wide.

Effect of Under the Seed Placement of Fertilizer on Percentage Emergence and Yield

When fertilizer is placed under cottonseed at the time of planting, the furrow opener for the fertilizer should open a furrow at least two inches deeper than that opened for the seed. After the fertilizer has been deposited in the bottom of the furrow and covered, the seed opener opens a furrow in this soil and the cottonseed are planted in the loose soil directly above the fertilizer. The distance between the seed and the fertilizer depends upon the adjustment of the fertilizer and seed furrow openers. The soil thrown on the seed to cover them is loose around the seed, even though press wheels are used to partially press and firm the soil over the seed. Moisture evaporates rapidly from loose soils, often down to or below planting depth. Such a condition may delay germination of seed several days, or until rain occurs.

Percentage of Emergence: The data in Table 3 show that when fertilizer was placed at depths of 1, 2, and 3 inches under the seed the average percentage of emergence for both locations was 59.3, 70.9, and 71.9 percent, respectively. This indicates that better germination and emergence was obtained when the fertilizer was placed deeper and farther below the cottonseed. This is shown graphically in Figure 2.

Different results were obtained for the unfertilized tests, that is, the percentage of seed germinating and emerging as seedlings decreased as the soil was disturbed deeper under the seed (Table 3 and Figure 2). When only the soil was disturbed at depths of 1, 2, and 3 inches under the seed the average percentage of emergence was 76.5, 72.9, and 70.7, respectively. Figures 3, 4, and 5 show growth of cotton roots seven days after planting for the three depths of fertilizer when placed under

the seed. Figure 6 shows growth of cotton roots where no fertilizer was applied under the seed.

In figure 3, it is seen that, when the fertilizer was placed one inch directly under and below the seed, the root of the germination cottonseed extended only down to the fertilizer. The fertilizer was so close

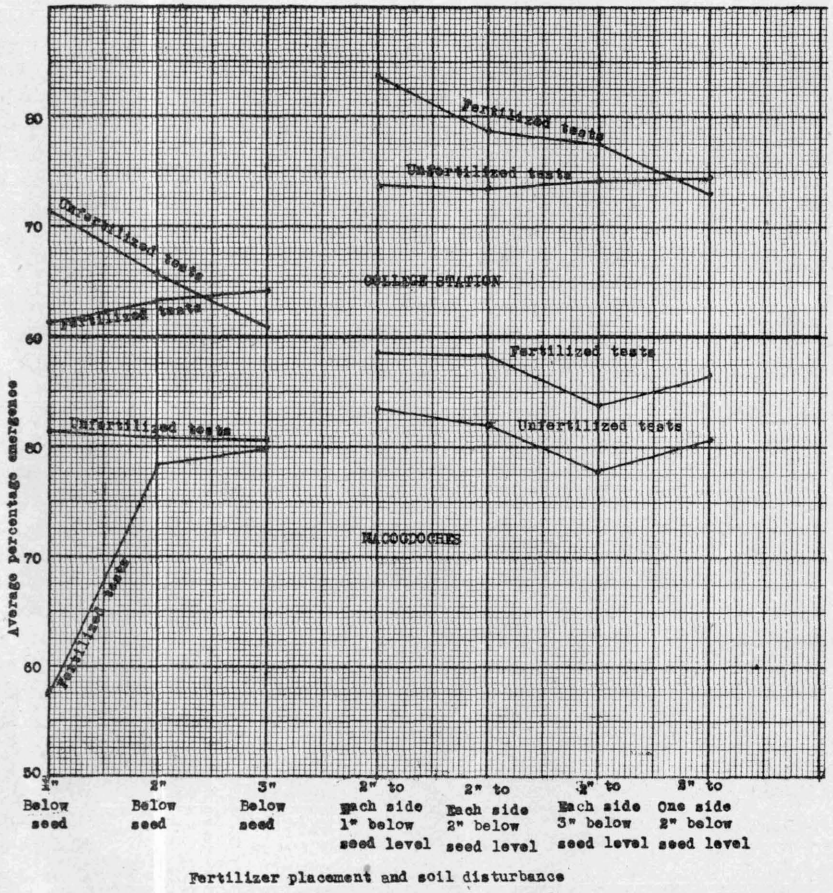

Figure 2. Graph showing percentage of germination of cottonseed for the fertilized and unfertilized tests at College Station and Nacogdoches.

to the seed that as soon as the seed sprouted and root growth started the root immediately came in contact with the band of fertilizer. The roots being young and tender were stunted and growth of the plant was slowed down, thus delaying emergence of the seedlings. In many cases the germinating seeds were so badly affected that they died in the sprouting stage, and this resulted in a lower stand count than on tests where fertilizer was placed two and three inches below the seed. Placing

Table 3. Average percentage of emergence of cotton seedlings in 50 feet of row when the fertilizer was placed under and to the side of the seed and the soil was disturbed on the unfertilized tests.

Fertilizer placement and soil disturbance	Test No.	College Station, Lufkin fine sandy loam						Nacogdoches, Norfolk sandy loam						Ave. of both locations
		1936	1937	1938	1939	1940	Ave.	1936	1937	1938	1939	1940	Ave.	
Bands 1.75 inches wide														
1 inch below seed	1	77.0	20.9	71.3	58.7	78.3	61.2	66.5	52.7	60.7	39.8	67.5	57.4	59.3
Unfertilized—soil disturbed	2	85.3	48.2	79.8	68.9	74.2	71.3	76.9	73.3	82.7	89.2	86.7	81.7	76.5
2 inches below seed	3	79.1	40.6	60.8	61.6	74.7	63.4	79.2	79.8	75.8	68.0	89.3	78.4	70.9
Unfertilized—soil disturbed	4	80.0	41.6	61.7	77.0	66.1	65.3	77.6	72.2	89.3	73.8	89.8	80.5	72.9
3 inches below seed	5	78.6	50.9	51.0	69.6	70.4	64.1	82.5	85.1	86.3	59.5	85.2	79.7	71.9
Unfertilized—soil disturbed	6	73.2	43.2	45.8	75.4	67.2	61.0	82.7	78.4	81.0	76.3	83.6	80.4	70.7
Bands 2 inches to each side														
1 inch below seed level	7	89.8	62.9	93.3	88.4	83.7	83.6	86.4	96.6	87.9	81.1	92.1	88.8	86.2
Unfertilized—soil disturbed	8	78.2	46.1	86.1	84.2	73.9	73.7	77.3	85.4	85.0	85.3	84.3	83.5	78.6
2 inches below seed level	9	91.6	52.6	85.7	83.9	80.4	78.8	82.0	92.6	91.6	79.0	97.0	88.4	83.6
Unfertilized—soil disturbed	10	83.6	53.2	80.5	78.3	71.4	73.4	74.0	85.7	83.1	81.9	85.9	82.1	77.8
3 inches below seed level	11	86.7	44.6	85.8	82.0	86.5	77.1	77.4	84.8	96.0	72.1	88.8	83.8	80.5
Unfertilized—soil disturbed	12	81.6	46.7	80.0	85.7	76.7	74.1	76.7	78.4	79.3	73.5	81.1	77.8	76.0
In band all on one side of seed														
2 inches below seed level	13	87.4	41.0	78.1	78.3	80.1	73.0	86.3	93.3	86.0	80.6	84.7	86.2	79.6
Unfertilized—soil disturbed	14	81.7	58.4	75.3	75.5	79.1	74.0	75.6	92.4	76.8	77.4	82.0	80.8	77.4
Difference required between any two means for significance at the 5 per cent level							8.90						7.57	9.09

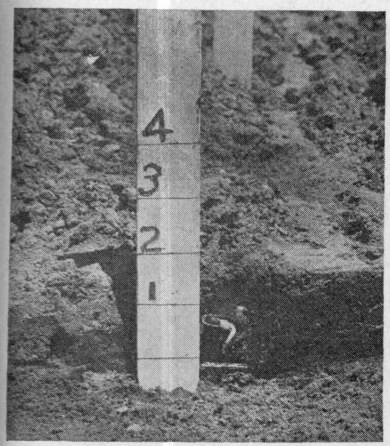

Figure 3. Typical root development of cotton seedlings 7 days after planting when fertilizer was placed 1 inch directly below seed. Roots extended only down to the fertilizer.

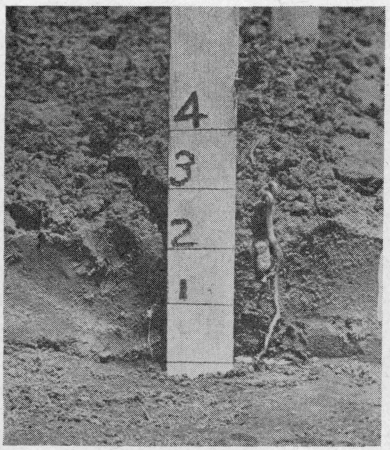

Figure 4. Root development of cotton seedling 7 days after planting when fertilizer was placed 2 inches directly below the seed. Roots extended down to the fertilizer with only a few passing through it.

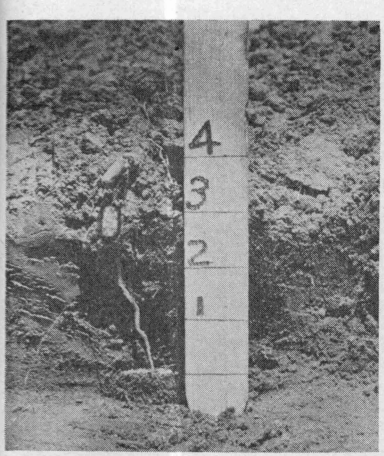

Figure 5. Root development of cotton seedling 7 days after planting when fertilizer was placed 3 inches directly below the seed. The roots extended down to the fertilizer with only a few passing through it.

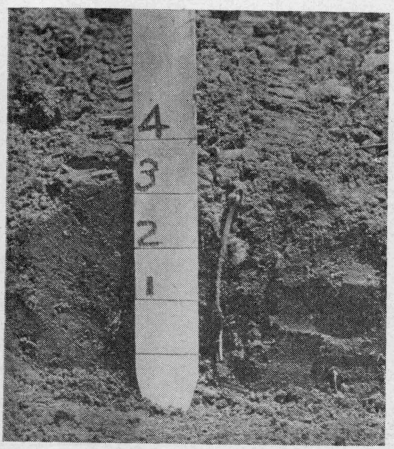

Figure 6. Root development of cotton seedling 7 days after planting when soil was disturbed 1 inch directly below seed but no fertilizer applied. Compare with Figure 3.

the fertilizer deeper and farther below the seed permitted more development of the plant before the roots reached the fertilizer, resulting in

Table 4. Analyses of variance of percentage emergence in experiments at College Station and Nacogdoches.

Source of variation	DF	Mean squares pertaining to— College Station 1936	1937	1938	1939	1940	Nacogdoches 1936	1937	1938	1939	1940
Blocks	2	12.08	50.72	273.06	215.31	68.88	1.28	58.24	30.75	60.08	274.83
Treatments	13	83.55†	293.81*	594.98	235.96†	106.69*	81.02†	385.25	214.70†	455.51†	134.79†
Error	26	16.69	100.82	83.89	41.49	38.80	7.92	17.91	9.61	29.83	8.87
Total	41	37.66	160.81	255.17	116.88	61.80	30.78	136.35	75.67	166.27	61.77

Conbined analyses

Source of variation	DF	Mean squares College Station	Nacogdoches
Blocks	10	150.61†	85.04†
Treatments	13	726.27†	844.27†
Years	4	8321.42†	829.33
Treatments × years	52	147.18†	106.75†
Error	130	56.34	14.83
Total	209	283.31	108.24

Source of variation	DF	Mean squares, College Station and Nacogdoches combined
Blocks	20	117.83†
Tests	13	1305.55†
Years	4	3805.46†
Location	1	9846.82†
Treat × years	52	117.05†
Treat × location	13	266.24†
Location × years	4	5259.33†
Years × location × treatment	52	136.57†
Error	260	35.58
Total	419	218.84

*Significant.
†Highly significant.

better stands than where the fertilizer was placed close to the seed (Fig. 3, 4, 5, and 6). Figures 7, 8, and 9 show root development of fully matured plants at harvest time. Note absence of tap roots where fertilizer was placed under the seed and presence of long tap roots where no fertilizer was applied.

When analyses of variance were applied to the detail data the variance for treatment was significant in every year at each location indicating the treatments significantly affected the percentage of germination (Table 4).

Thus, it appears, that both the shallow placement of fertilizer and the deep disturbance of the soil under the seed at planting time will affect and reduce the germination of cottonseed and the emergence of seedlings.

Rate of Emergence. The data in Table 5 shows a definite delay in germination when the fertilizer was placed one inch under the seed at Nacogdoches and seedlings did not emerge as rapidly as where the fertilizer was placed at the deeper depth. When the fertilizer was placed one inch under the seed, the average stand at the first, second and third counts was 31, 105, and 331 plants, respectively, but when the fertilizer was placed three inches under the seed the average stand for each of the three counts was 97, 322, and 460 plants, respectively.

At College Station this same trend is indicated for each year except 1938. In 1938 a .42 inch rain fell just after planting was completed, and a .77 inch rain on the following day. Also a 1.42 inch rain fell on the day the first count was made. This much rain occurring so soon after planting may have dissolved the fertilizer and diluted the salts sufficiently to reduce the effects of the fertilizer salts on the cottonseed.

Yield: At College Station the yield for each of the placements under the seed was 205 pounds of lint per acre for the one-inch depth; 270 pounds for the two-inch depth, and 284 pounds for the three-inch depth (Table 7 and Fig. 10). The yields increased as the fertilizer was placed deeper. The average for all three depths was 253 pounds against 165 pounds of lint per acre for the three unfertilized tests receiving the soil disturbance. The three fertilized tests yielded 88 pounds per acre more than did the three unfertilized tests.

At Nacogdoches, the yields for the one-, two-, and three-inch depths was 346, 391, and 407 pounds of lint per acre, respectively (Table 7). As at College Station the yield increased as the fertilizer was placed deeper. The average for the three unfertilized tests was 134 pounds of lint per acre. The three fertilized tests at Nacogdoches gave a yield of 247 pounds of lint per acre more than the unfertilized tests.

Table 8 shows the yield of seed cotton per 100 feet of row on which the analyses of variance were calculated. The same ratio of differences appear in Tables 7 and 8 though one is calculated to show acre yield of lint and the other yield of seed cotton per plat. The yield graphs in

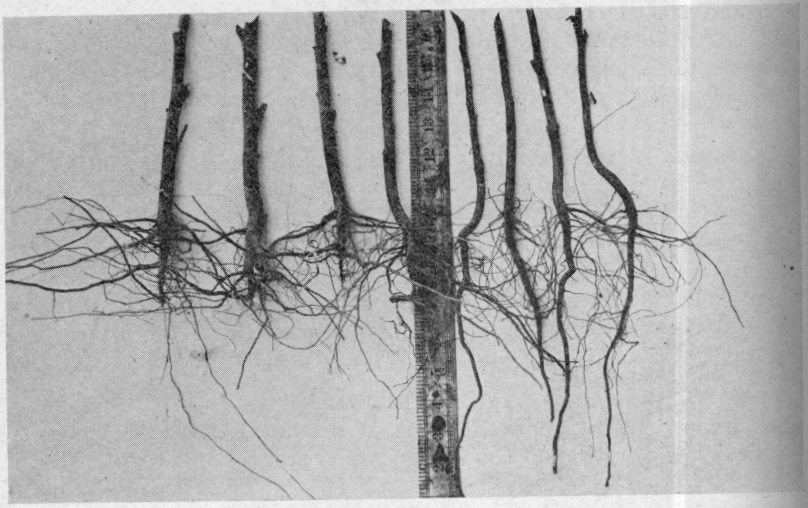

Figure 7. The four cotton roots on left show effect of fertilizer when the fertilizer was placed 1 inch directly below the seed at the time of planting. The four roots on right are from unfertilized test having the same soil disturbance as those on left.

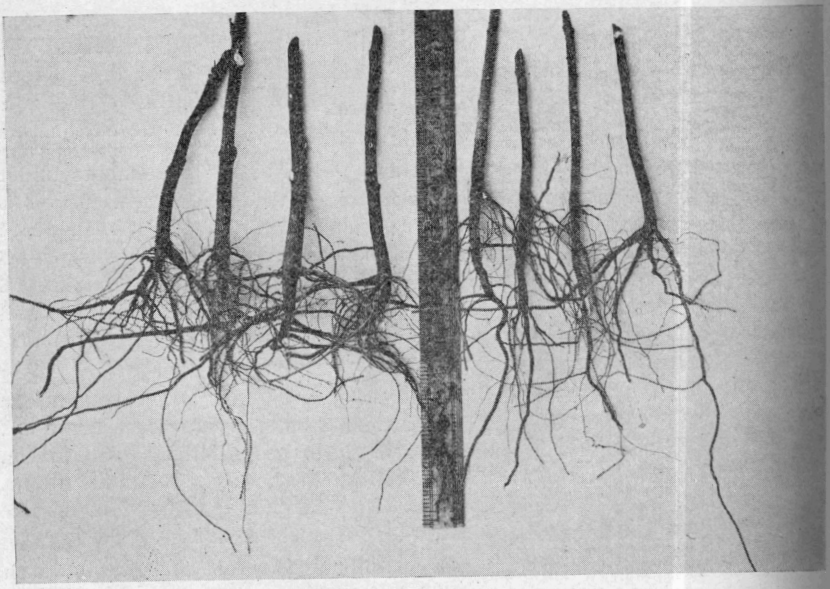

Figure 8. The four cotton roots on the left show effects of fertilizer when fertilizer was placed 2 inches directly below the seed. The four roots on the right are from unfertilized test having the same soil disturbance as those on the left.

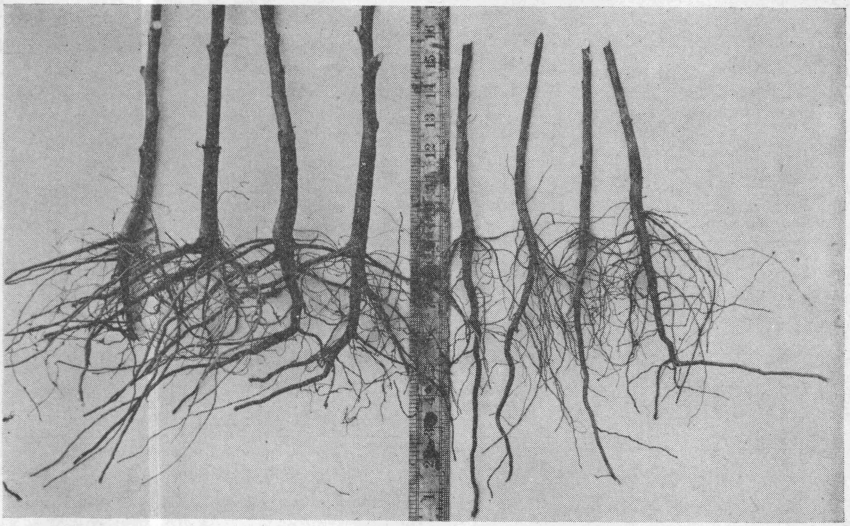

Figure 9. The four cotton roots on the left show effects of fertilizer when fertilizer was placed 3 inches directly below the seed. The four roots on the right are from unfertilized test having the same soil disturbance as those on the left.

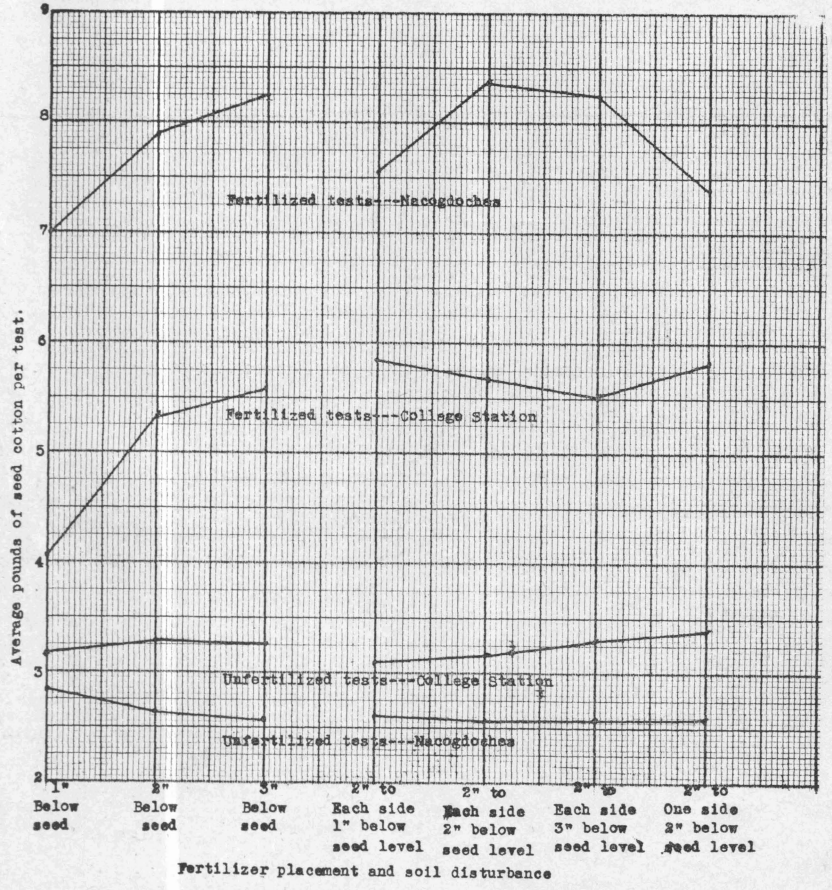

Figure 10. Graph showing average pounds of seed cotton harvested from the fertilized and unfertilized tests, at College and Nacogdoches.

Figure 10 are based on the data in Table 8. Table 9 shows the analyses of variance of yield in the experiments at College Station and Nacogdoches.

Table 5. Average rate of emergence of cotton seedlings in 50 feet of row when fertilizer was placed under and below the seed and the soil was disturbed under and below the seed.

Fertilizer placement and soil disturbance	Test No.	Germination counts*	College Station — Lufkin fine sandy loam — 5 year Ave.	Nacogdoches — Norfolk sandy loam — 5 year Ave.	Ave. of both locations
Bands 1.75 inches wide					
1 inch below seed	1	first	47	31	40
		second	173	105	139
		third	352	331	342
Unfertilized—soil disturbed	2	first	97	81	89
		second	282	343	312
		third	418	473	446
2 inches below seed	3	first	32	87	60
		second	204	268	236
		third	369	462	410
Unfertilized—soil disturbed	4	first	51	90	70
		second	221	348	284
		third	380	447	414
3 inches below seed	5	first	51	97	74
		second	222	322	272
		third	370	460	415
Unfertilized—soil disturbed	6	first	49	103	76
		second	202	345	274
		third	353	462	408

*At College Station the average interval between date of planting and first, second and third counts was 6, 9, and 20 days, respectively, while at Nacogdoches the average interval was 6, 9, and 17 days, respectively.

Effect of Side Placement of Fertilizer on Percentage Emergence and Yield

In this series of tests the fertilizer was placed in furrows made with disks set to open furrows two inches to each side of the seed and one, two, and three inches below the seed level. This left a strip of firm soil some four inches wide undisturbed on which to plant the cotton-seed. One test was planted where all the fertilizer was placed two inches to one side and two inches below the seed level. For each fertilized test planted an unfertilized test was also planted. Both sets of tests received the same soil disturbance.

Percentage of Emergence: Table 3 shows that as the fertilizer was placed deeper below the level of the seed, there was a decrease in the percentage of the total number of seedlings emerging. When the fer-

tilizer was placed one, two, and three inches below the seed level the average percentage of emergence for both locations was 86.2, 83.6 and 80.5 percent, respectively. The percentage of emergence for the unfertilized tests with the same soil disturbance was 78.6, 77.8 and 76.0, percent, respectively. For all three depths of fertilizer placement and soil disturbance the fertilizer tests gave a higher percentage of germination and a larger number of seedlings emerging than the unfertilized tests (Fig. 2).

Thus it appears that when fertilizer is placed far enough from the seed to prevent injury to the germination, yet close enough for young seedlings to get some plant food, the fertilizer is beneficial, and increases the number of cotton seedlings emerging.

The data in Table 3 also show that when the soil is not disturbed directly under the seed or too close to the sides and no fertilizer applied there is little change in the percentage of emergence of seedlings as the soil is disturbed deeper below the seed level.

The percentage of emergence and the total number of seedlings were slightly lower when all of the fertilizer was placed on one side than when it was divided and equal amounts placed on each side at the same depth.

Placing the fertilizer to the sides of the seed did not retard the development of tap roots of young cotton seedlings (Figs. 11, 12, 13 and 14). Root development of fully matured cotton plants taken from rows where the fertilizer was placed to the side is shown in Figures 15, 16 and 17.

Placing all of the fertilizer on one side of the plants at the time of planting appears to induce greater root development on the side of the plant next to the fertilizer. This is shown in Figure 18.

Difference in growth of plants on the fertilized tests at Nacogdoches is shown in Figures 19 and 20.

When analyses of variance were applied to the detail data on the side placement of fertilizer and soil disturbance, it is seen from a study of the data, that at College Station the treatments did not affect the germination in exactly the same manner (Fig. 2) but the variance for treatments was significant when compared to the significant interaction (treatment vs. years). This was likewise true at Nacogdoches. In the combined analysis for all years at both locations all interactions were significant and the variance was significant when compared to the interaction (treatment vs. years). Apparently the percentage emergence was high on tests, 7 and 9, where the fertilizer was placed 2 inches to each side and two inches and three inches below the seed level. This was consistant throughout the 5-year period at both locations (Table 3).

Rate of Emergence: Fertilizer placed to each side of the seed and below the seed level at the various depths did not delay emergence as much as when the fertilizer was placed below and directly under the

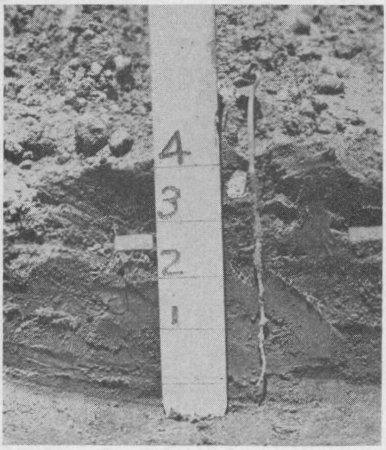

Figure 11. Root development of cotton seedling 7 days after planting when fertilizer was placed 2 inches to each side and 1 inch below soil level.

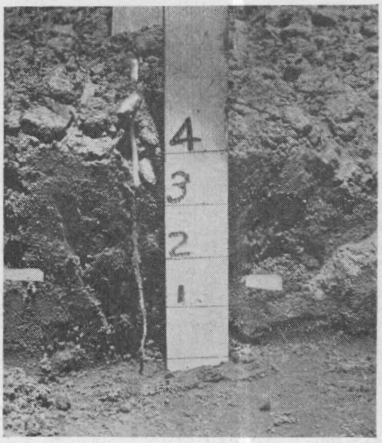

Figure 12. Root development of cotton seedling 7 days after planting when fertilizer was placed 2 inches to each side and 2 inches below seed level.

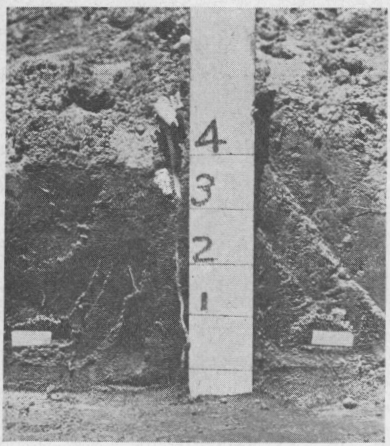

Figure 13. Root development of cotton seedling 7 days after planting when fertilizer was placed 2 inches to each side and 3 inches below seed level.

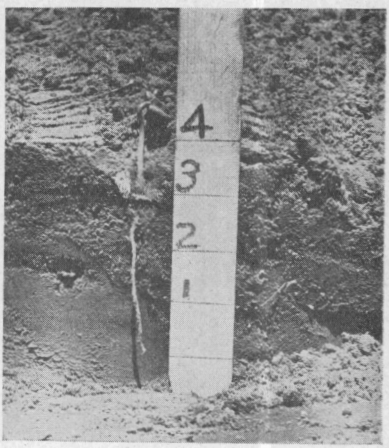

Figure 14. Root development of cotton seedling 7 days after planting when soil was disturbed 2 inches to each side and 2 inches below seed level.

seed (Tables 5 and 6). Table 6 shows that there was a slight delay in emergence when the fertilizer was placed one inch bleow the seed level as compared with the two- and three-inch depths, yet the total emergence for the one-inch depth was slightly higher than the deeper depths.

The rate of emergence on the unfertilized tests varied in a similar manner as did the fertilizer tests. The number of seedlings was slightly lower for the unfertilized tests than for the fertilized tests.

Table 6. Average rate of emergence of seedlings in 50 feet of row when the fertilizer was placed to the side and below the seed level and the soil disturbed to the side and below the seed level.

Fertilizer placement and soil disturbance	Test No.	Germination counts*	College Station Lufkin fine sandy loam 5 year Ave.	Nacogdoches Norfolk sandy loam 5 year Ave.	Ave. of both locations
Bands 2 inches to each side					
1 inch below seed level	7	first	139	131	135
		second	320	378	349
		third	492	513	502
Unfertilized—soil disturbed	8	first	108	120	114
		second	271	376	324
		third	435	483	459
2 inches below seed level	9	first	143	150	146
		second	266	386	326
		third	463	509	486
Unfertilized—soil disturbed	10	first	128	108	118
		second	266	387	326
		third	431	455	443
3 inches below seed level	11	first	139	153	146
		second	244	391	318
		third	454	491	472
Unfertilized—soil disturbed	12	first	129	112	120
		second	271	344	308
		third	430	449	440
All on one side of seed					
2 inches below seed level	13	first	123	153	138
		second	274	386	325
		third	428	497	462
Unfertilized—soil disturbed	14	first	116	127	122
		second	284	384	334
		third	431	466	448

*At College Station the average interval between date of planting and the first, second, and third counts was 6, 9, and 20 days, respectively, while at Nacogdoches the average interval was 7, 9, and 17 days, respectively.

Yield: At College Station the yield for the fertilizer placement of two inches to each side and one, two, and three inches below the seed level was 320, 287, and 281 pounds of lint per acre, respectively, with an average of 296 pounds of lint per acre (Table 7 and Fig. 10). The three unfertilized tests gave an average yield of 162 pounds of lint per acre. The three fertilized tests yielded 134 pounds of lint per acre more than the unfertilized tests.

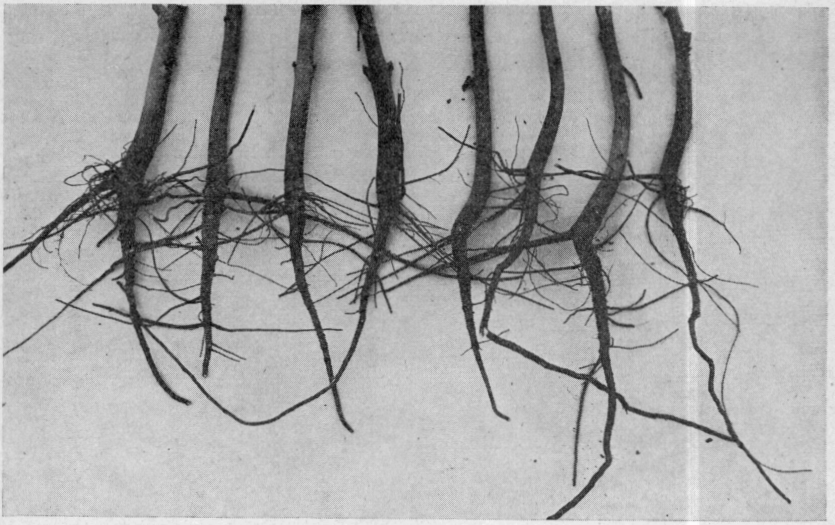

Figure 15. The four cotton roots on the left show root development when fertilizer was placed 2 inches to each side and 1 inch below seed level. The four on right are from unfertilized test having the same soil disturbance as those on left.

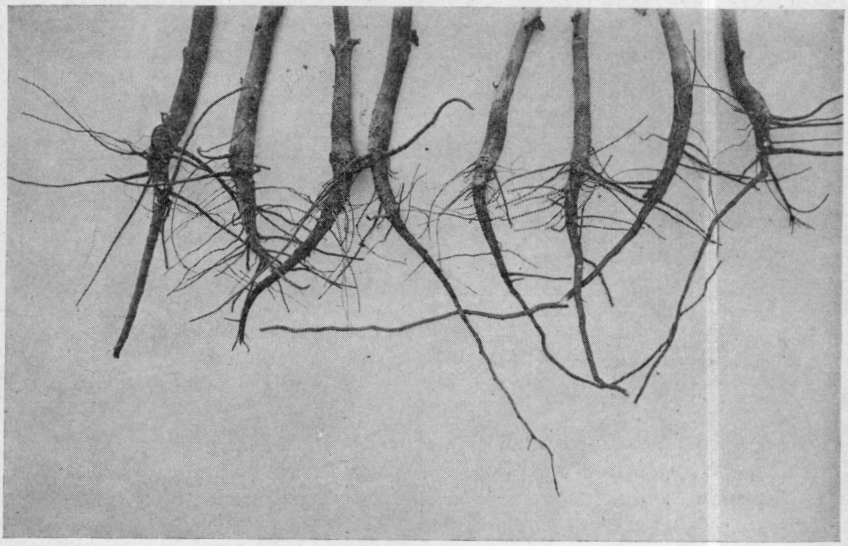

Figure 16. The four cotton roots on the left show root development when fertilizer was placed 2 inches to each side and 2 inches below seed level. The four roots on the right are from unfertilized test having the same soil disturbance as those on left.

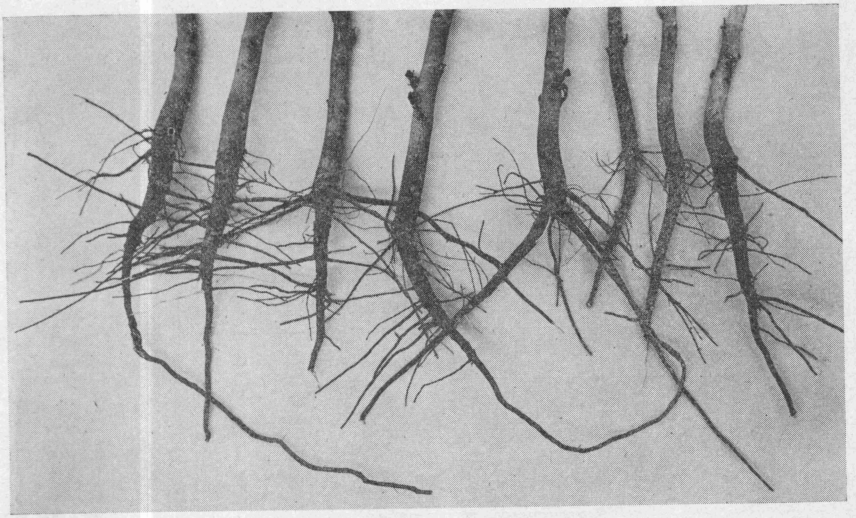

Figure 17. The four cotton roots on the left show root development when fertilizer was placed 2 inches to each side and 3 inches below seed level. The four on right are from unfertilized test having the same soil disturbance as those on left.

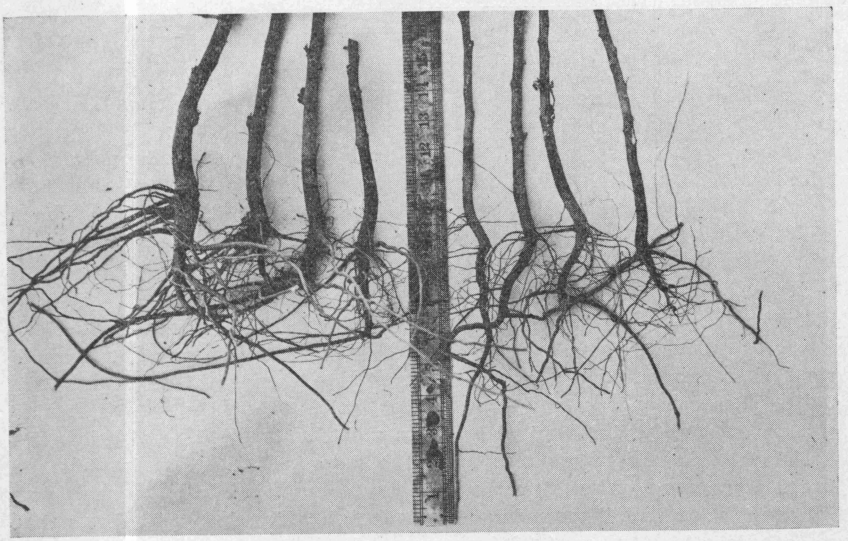

Figure 18. The four cotton roots on the left show root development when all of the fertilizer was placed on one side—2 inches to the side and 2 inches below the seed level. The four on the right are from unfertilized test having same soil disturbance as those on left.

Table 7. Average yield of lint per acre on 50 feet of row for all fertilizer placement and soil disturbance tests.*

Fertilizer placement and soil disturbance	Test No.	College Station Lufkin fine sandy loam 5 year Ave.	Nacogdoches Norfolk sandy loam 5 year Ave.	Ave. of both locations
Bands 1.75 inches wide				
1 inch below seed	1	205	346	276
Unfertilized—soil disturbed	2	162	142	152
2 inches below seed	3	270	391	330
Unfertilized	4	168	132	150
3 inches below seed	5	284	407	346
Unfertilized—soil disturbed	6	166	127	146
Bands 2 inches to each side				
1 inch below seed level	7	320	375	348
Unfertilized—soil disturbed	8	160	130	145
2 inches below seed level	9	287	414	350
Unfertilized—soil disturbed	10	162	126	144
3 inches below seed level	11	281	408	344
Unfertilized	12	165	128	146
All on one side of seed				
2 inches below seed level	13	295	365	330
Unfertilized—soil disturbed	14	172	128	150

*Calculations based on 290.4 part of acre per plat and 35 percent Lnt.

At Nacogdoches, the average yield for the fertilizer placement, of one, two and three inches below the seed level was 375, 414 and 408 pounds of lint per acre, respectively, with an average of 399 pounds of lint per acre (Table 7). The three unfertilized tests which received the same soil disturbance but no fertilizer gave an average yield of 128 pounds of lint per acre. The fertilized tests yielded 271 pounds of lint per acre more than the unfertilized tests.

When all of the fertilizer was placed two inches to one side and two inches below the seed level, the average yield was 295 pounds at College Station and 365 pounds of lint per acre at Nacogdoches. The average yield of the unfertilized tests was 172 and 128 pounds of lint per acre for College Station and Nacogdoches, respectively. When the average yields of the three under-the-seed placements and the three-side-and-below the seed level placements are compared, the data in Table 7 show that the latter placements gave higher yields by 43 pounds of lint per acre at College Station and 18 pounds at Nacogdoches. The data also shows that at both locations, when 4-12-4 commercial fertilizer was applied at the rate of 500 pounds per acre two inches to each side and at one inch and two inches below the seed level, slightly higher yields were obtained than

when the fertilizer was placed one and two inches below and under the seed. A study of Table 7 shows, however, that at both locations there was very little difference in the yield when the fertilizer was placed three inches below and under the seed and the side placement at the same depth below the seed level.

The variance due to treatments was significant in every year at each location, indicating that the treatment (fertilized vs. unfertilized) caused a significant difference in the yield (Tables 8 and 9). An examination of the yield graph (Fig. 10) shows that the treatment variance was caused by a high yield in all fertilized tests. Fertilizer applied in any manner increased the yield. Among the fertilized tests, the yields was low when the fertilizer was placed one inch directly under the seed, but this difference in yield was not significant.

Table 8. Average yield of seedcotton in 100 feet of row when the fertilizer was placed under and to the side of the seed and the soil was disturbed on the unfertilized tests.*

Fertilizer placement and soil disturbance	Test No.	College Station Lufkin fine sandy loam 5 year Ave.	Nacogdoches Norfolk sandy loam 5 year Ave.	Ave. of both locations
Bands 1.75 inches wide				
1 inch below seed	1	4.04	6.98	5.51
Unfertilized—soil disturbed	2	3.18	2.87	3.02
2 inches below seed	3	5.31	7.89	6.60
Unfertilized—soil disturbed	4	3.28	2.65	2.96
3 inches below seed	5	5.58	8.21	6.89
Unfertilized—soil disturbed	6	3.25	2.68	2.92
Bands 2 inches to each side				
1 inch below seed level	7	5.86	7.56	6.71
Unfertilized—soil disturbed	8	3.13	2.62	2.88
2 inches below seed level	9	5.69	8.36	7.03
Unfertilized—soil disturbed	10	3.17	2.56	2.87
3 inches below seed level	11	5.52	8.25	6.89
Unfertilized—soil disturbed	12	3.31	2.58	2.94
All on one side of seed				
2 inches below seed level	13	5.80	7.36	6.58
Unfertilized—soil disturbed	14	3.38	2.58	2.98
Difference required between any two means for significance at the 5% level		.66	.78	2.46

*Calculations based on 145.2 part of acre per plat.

Table 9. Analyses of variance of yield in experiments at College Station and Nacogdoches.

Source of variation	DF	Mean squares pertaining to— College Station 1936	1937	1938	1939	1940	Nacogdoches 1936	1937	1938	1939	1940
Blocks	2	1.87	4.58	1.34	3.03	4.84	.12	3.37	18.59	.22	5.79
Treatments	13	3.00†	3.33†	8.12†	4.11†	6.32†	14.22†	17.48†	28.60†	23.74†	30.34†
Error	26	.20	.39	.26	.74	.27	.08	.18	.54	.02	.24
Total	41	1.17	1.53	2.80	1.92	2.41	4.57	5.82	10.32	7.55	10.05

Conbined analyses

Source of variation	DF	Mean squares: College Station	Nacogdoches
Blocks	10	3.13†	5.62†
Treatments	13	21.59†	109.99†
Years	4	49.14†	39.07†
Treatment × years	52	.82†	1.10†
Error	130	.37	.21
Total	209	2.87	8.26

Source of variation	DF	Mean squares, College Station and Nacogdoches combined
Blocks	20	4.38†
Treatments	13	112.13†
Years	4	73.35†
Location	1	84.56†
Treatments × years	52	.47
Treatments × location	13	19.45†
Location × years	4	14.84†
Years × location × treatments	52	1.45
Error	260	.33
Total	419	5.75

†Highly significant.

EFFECTS OF SOIL DISTURBANCE

To place fertilizer in the soil at the same time cottonseed are planted, it is necessary to first open furrows and disturb the soil to place the fertilizer either below the seed or to the sides and below the seed level. It has been observed that cottonseed planted on a firm, well settled soil germinated more rapidly and gave better stands than when planted in a loose soil. It appeared, therefore, that all the differences in germination between different fertilizer placements and an average check could not be attributed to the effects of the fertilizer. Consequently, for each fertilizer test planted an unfertilized test was planted having the same soil disturbance as the fertilized test.

Effect of Disturbing the Soil Under Seed on Percentage Emergence and Yield

In the unfertilized tests the soil was disturbed one, two, and three inches directly under and below the seed as was done to place the fertilizer under the seed.

Figure 19. Field at Nacogdoches June 23, 1939, showing difference in growth of cotton plants on fertilized and unfertilized tests.

A. No fertilizer applied but soil disturbed at planting time two inches to each side and one inch below seed level. Test No. 8.

B. Fertilizer applied at the rate of 500 pounds per acre, two inches to each side and two inches below the seed level. Test No. 9.

C. No fertilizer applied but soil disturbed same as B. Test No. 10.

Percentage of emergence: The data in Table 3 shows that for College Station the percentage of seedlings emerging averaged 71.3, 65.3 and 61.0 percent for the one-, two-, and three-inch depths of disturbance under the seed, respectively. The difference between the one-and three-inch depth was significant. The results at Nacogdoches gave a similar trend but were not significant. That is, that as the soil was disturbed deeper the percentage of emergence decreased somewhat. The average for both locations was 76.5 for the one-inch depth, 72.9 for the two-inch depth, and 70.7 for the three-inch depth.

A study of the data for the unfertilized tests in Table 3 shows that when the soil is disturbed and left loose and cottonseed are planted in a loose soil, germination is affected and fewer seedlings emerge as the depth of the disturbance and the amount of loose soil increases.

It appears, therefore, that disturbing soil under the seed will reduce germination of cottonseed and the effect is increased with the depth of the soil disturbance.

Rate of Emergence: A study of the data in Table 5 and Figure 2, show that at College Station deep disturbance of the soil cause more delay in emergence than the shallow disturbance. At the first count an average of 97 plants had emerged for the one-inch depth, 51 for the two-inch depth and 49 for the three-inch depth. At Nacogdoches the average stand at the first count was 81 for the one-inch depth, 90 for the

Figure 20. Difference in growth of cotton plants on fertilized and unfertilized test at Nacogdoches September 17, 1940. Man at left is standing on row 3 where fertilizer was placed 2 inches directly under the seed. Man at right is standing on unfertilized row (row 4) which had the same soil disturbance as row 3. Row 5 at right in picture had fertilizer placed at 3 inches directly under the seed.

two-inch depth, and 103 for the three-inch depth. The difference in soil type probably accounts for the reversal in the results at the two locations. The Norfolk sandy loam soil, Nacogdoches, flowed back and filled the furrow opened in placing the fertilizer better than did the stiffer Lufkin soil at College Station. Consequently, the seed were not planted at as constant a depth as at Nacogdoches.

Yield: The average yield for all unfertilized tests where the soil was disturbed under the seed was 165 and 134 pounds of lint per acre for College Station and Nacogdoches, respectively (Table 7). The depth of soil disturbance did not significantly affect the yield when the unfertilized tests are compared with each other (Tables 7 and 8 and Fig. 10).

Effect of Disturbing the Soil to the Side of the Seed on Percentage Emergence and Yield

Soil was disturbed two inches to the sides of the seed at depths of one, two and three inches below the seed level.

Percentage Emergence: The data in Table 3 and Figure 1, show that for the unfertilized side disturbed soil tests the percentage of emergence was more uniform for the different depths at College Station than at Nacogdoches. Germination, however, was slightly better at Nacogdoches than at College Station. At College Station the average percentage of emergence was 73.7, 73.4, and 74.1 percent, respectively, for the one-, two-, and three-inch soil disturbance below the seed level. The average percentage of emergence at Nacogdoches was 83.5, 82.1 and 77.8 percent, respectively, for the three depths. None of these differences were significant at the 5 percent level.

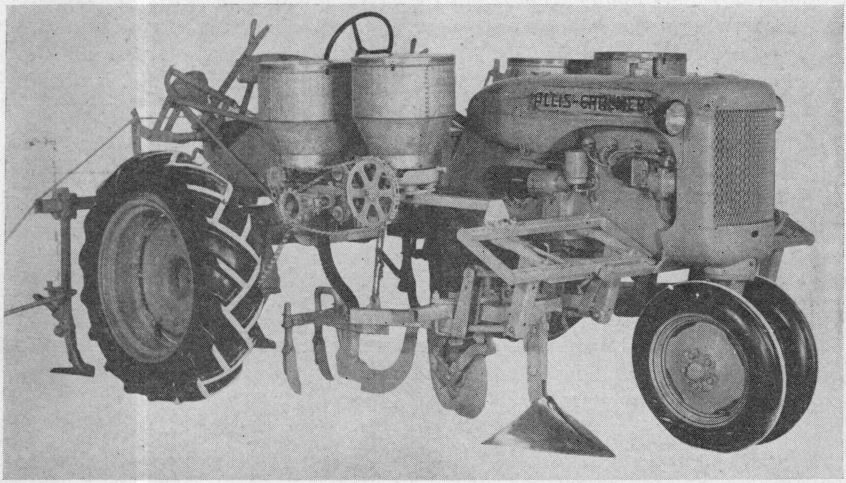

Figure 21. A commercial tractor mounted planter with fertilizer attachment for placing the fertilizer to the side and below the seed level.

Rate of Emergence: The data in Table 6 shows that disturbing the soil to the sides one, two, and three inches below the seed level and no fertilizer applied, had little effect on the rate of emergence of cotton seedlings. The average stand of plants at the first count for both locations, was 114 for one-inch depth, 118 for two-inch depth and 120 for the three-inch depth per 50 feet of row.

When the soil was disturbed only on one side, two inches below the seed level, the average stand was 122 plants for both locations.

Yield: The average yield for all of the unfertilized tests at College Station, where the soil was disturbed to the sides of the seed, was 162 pounds of lint per acre (Table 7). At Nacogdoches the yield was 128 pounds of lint per acre. The yield for the three tests at both locations was quite uniform, varying only 5 pounds of lint per acre at College Station and 8 pounds at Nacogdoches. The highest yield for each of the two locations was for the test where the soil was disturbed three inches below the seed level (Tables 7 and 8 and Fig. 10).

SUMMARY AND CONCLUSIONS

The experiments reported in this bulletin were conducted during the 5-year period (1936 to 1940 inclusive), at College Station on Lufkin fine sandy loam and at Nacogdoches on Norfolk sandy loam soil.

A 4-12-4 fertilizer was applied at the rate of 500 pounds per acre for all the fertilizer tests, and none was applied on the soil disturbance tests. Tests were planted when the fertilizer was placed one, two and three inches below and directly under the seed. Other tests were planted when the fertilizer was placed two inches to each side and one, two and three inches below the seed level. One test was planted when all of the fertilizer was placed on one side, two inches to the side and two inches below the seed level. For each fertilizer test planted an unfertilized test was also planted. Both sets of tests received the same soil disturbance.

The results show, that when the fertilizer was placed under the seed, there was an increase in the percentage of emergence and total stand as the fertilizer was placed deeper and farther below the seed.

When fertilizer was placed one inch under and below the seed, germination was both delayed and reduced more than when the fertilizer was placed two inches and three inches below the seed.

When the fertilizer was placed to the sides of the seed, the percentage of emergence and total number of seedlings emerging decreased as the fertilizer was placed deeper and farther below the seed level.

Fertilizer placed to the sides of the seed appeared to have a stimulating effect on the germination of cottonseed as more plants emerged on the fertilized tests than on the unfertilized tests and higher percentages of emergence were obtained for the side applications than for the under the seed applications.

The highest percentage of emergence and the best stand was obtained at both locations when the fertilizer was placed two inches to each side and one inch below the seed level.

The results obtained when all of the fertilizer was placed on one side compared closely with the divided placement at the same depth.

For the under-the-seed placement of fertilizer the yields increased as the the fertilizer was placed deper.

For the side of the seed placement of fertilizer the yields increased as the fertilizer was placed deeper at Nacogdoches, but decreased slightly at College Station.

The results show that when the soil is disturbed under the seed and cottonseed are planted in the loose soil, germination and the total number of seedlings emerging is reduced. The effect increases as the depth of the disturbed soil increases.

Disturbing the soil to the sides of the seed but not at the point where seed were placed in the soil did not appear to affect germination as the total emergence was very uniform for the different depths.

At College Station the highest yield was obtained when the fertilizer was placed two inches to each side and one inch below the seed level, while at Nacogdoches the highest yield resulted when the fertilizer was placed two inches to each side and two inches below the seed level. Fertilizer applied in any manner significantly increased the yield at both locations.

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