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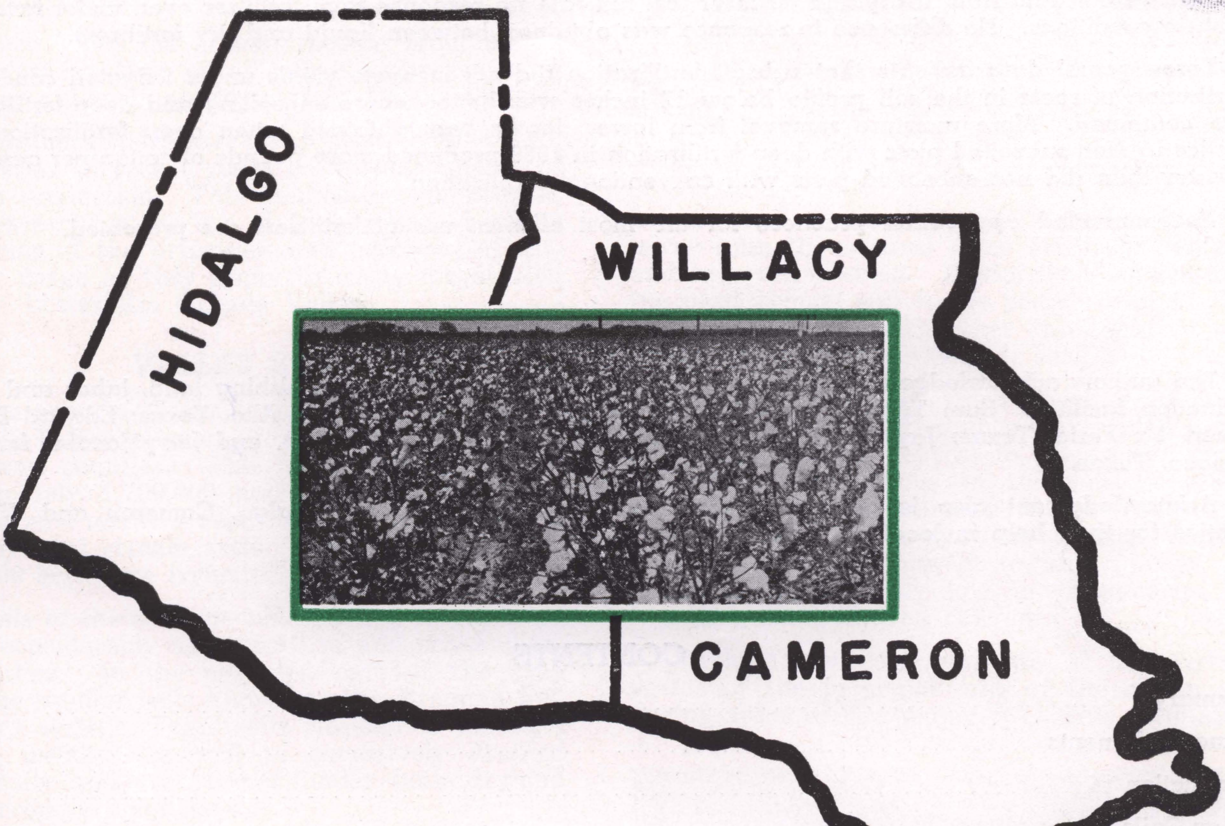
Fertilizing Cotton
IN THE LOWER RIO GRANDE VALLEY



TEXAS AGRICULTURAL EXPERIMENT STATION

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SUMMARY

Since the disastrous freezes of 1949 and 1951, which destroyed the major portion of the Valley's citrus industry, cotton has become a major crop in the Lower Rio Grande Valley, with an annual production of approximately 400,000 bales. The cotton industry is now the major source of agricultural income and has an annual value of approximately $75,000,000.

Four years' data are presented from cotton fertilizer tests conducted by the Lower Rio Grande Valley Experiment Station under irrigated conditions. These data indicate that irrigated cotton responds principally to nitrogen applications, with 60 pounds per acre accounting for most of the yield response. Smaller yield increases were obtained occasionally from an additional 60 pounds of nitrogen. Applications of phosphate and potash, alone or in combination with other fertilizers, failed to increase yields. Staple length and lint percentage were not affected by fertilizer treatment.

The addition of minor elements in conjunction with a fertilizer treatment of 120-120-60 resulted in significant yield increases in an irrigated test in 1958. This occurred on land leveled recently, where considerable top soil had been removed, and under highly alkaline conditions (pH 8.5). Further investigation revealed that the response was from zinc.

One year's data from a dryland fertilizer test indicate no response from fertilizer even under favorable moisture conditions. No difference in response was obtained between liquid and dry fertilizers.

Three years' data indicate that subsoil fertilization did not increase yields under irrigated conditions. Distribution of roots in the soil profile below 12 inches was better where subsoiling and deep fertilization were combined. More moisture removal from lower depths was obtained when deep fertilization was practiced. Non-subsoiled plots with deep fertilization in 1958 produced more pounds of cotton per acre-inch of water than did non-subsoiled plots with conventional fertilization.

Recommended application practices for the most efficient use of fertilizers are presented.

ACKNOWLEDGMENTS

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Fertilizing Cotton in the Lower Rio Grande Valley

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COTTON HAS BEEN GROWN for many years in the Lower Rio Grande Valley, but only recently has it become an industry of major importance. Cotton production in the Valley reached an all time high of more than 632,000 bales in 1951, the year immediately following the disastrous freeze that destroyed a major portion of the citrus trees. The average annual production since 1951 has been around 400,000 bales, which is approximately 10 percent of the cotton produced in Texas.

Since 1950, the annual income from cotton has exceeded that of all other crops, with an average value of approximately $75,000,000.

Considerable research has been conducted in the Valley in recent years on various phases of cotton production. This publication summarizes the research on the use of fertilizers and points out some of the principles and practices of fertilizer usage as they apply to cotton production in the Lower Rio Grande Valley.

VALLEY SOILS

The area of Texas known as the lower Rio Grande Valley is largely in Hidalgo, Willacy and Cameron counties. This area consists of approximately 1,700,000 acres of alluvial deltaic and marine terraces deposited by the Rio Grande and by local stream action. Of this area, some 700,000 acres are irrigated (6).

Soils of the area on which cotton is produced vary considerably as to texture and other characteristics. In the northern part of the area are the sandier soils known as the Brennan and Willacy series. These soils respond to management, usually are well to excessively drained internally and are farmed under both dryland and irrigated conditions.

Further south toward the Rio Grande are the medium and fine-textured soils of the Willacy, Raymondville and Hidalgo series. These soils mostly are irrigated, and management problems range from few to many as far as drainage conditions are concerned.

Alluvial deposits of the Rio Grande comprise most of the remaining major soil resources. Next to the river on the slightly elevated natural levee are soils such as the Rio Grande, Laredo and Cameron series. Soils on areas lower than the natural levee are finer textured and less well drained. In the first bottom land, the most typical soil is the poorly drained Harlingen clay along with other fine-textured soils of the Laredo and Rio Grande series.

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TABLE 1. FERTILITY STATUS OF SURFACE SOILS OF THE LOWER RIO GRANDE VALLEY

Soil series	Nitrogen	Phosphorus	Potash	Calcium	Organic matter	Cation exchange capacity, m.e. per 100 gm.
Harlingen, Cameron, Hidalgo, Raymondville	Low to medium	Low medium to high	High	High	Low to low medium	20 to 45
Willacy, Brennan	Very low to low	Wide range, very low to high	Medium to high	Low	Very low to low	5 to 25

The soils have developed under a subhumid to semitropical climate and have retained a high base status, being neutral to calcareous on the surface and calcareous in the subsoils. Such conditions of soil formation in the Valley have produced soils of sandy loam to clay texture; moderately low to low in organic matter, low in nitrogen, generally low in phosphorus, but high in potassium and calcium.

Table 1 gives an estimate of the fertility status of the principal soils of the cotton producing areas of the Valley (6). This estimate is

Figure 1. Experimental fertilizer distributor mounted on a tractor.

Figure 2. Deep-Feeder fertilizer distributor mounted on a tractor.

based on soil test information of Valley soils from the Soil Testing Laboratory, Texas A. & M. College System, College Station, Texas.

COTTON FERTILIZER RESEARCH

Methods and Materials

All fertilizer tests reported were conducted in cooperation with cotton growers or grower organizations. Research personnel applied the fertilizer materials, took field notes and recorded and evaluated the data. Planting, cultivation, irrigation, insect control and other management practices were carried out by the grower under field conditions and in accordance with production practices of his general farming operations.

All dry fertilizer materials with conventional placement were applied from a tractor-mounted, multiple-cell, belt-type fertilizer distributor (Figure 1) similar to the one described by Rea and associates (9).

Fertilizers in the subsoil were applied with a Deep-Feeder fertilizer distributor (Figure 2) manufactured by Pittsburg Forgings Company, Caraopolis, Pennsylvania. Liquid fertilizers were applied with a chisel applicator (Figure 3)

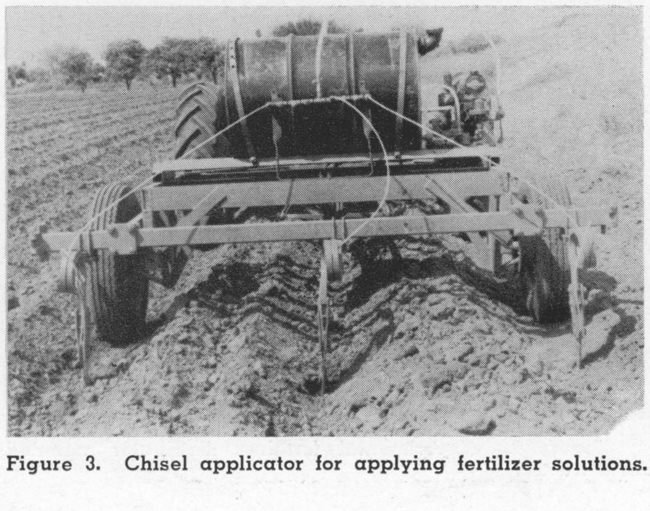

Figure 3. Chisel applicator for applying fertilizer solutions.

equipped with a motor-driven gear pump for metering the fertilizer materials into the soil.

Sixty pounds of the nitrogen and all of the phosphate and potash were applied as a preplanting treatment. The remaining amount of each nitrogen treatment was applied in a single sidedressing treatment at the squaring stage of growth. Preplanting fertilizer was placed 2 to 3 inches below and to the side of the seed zone.

The experimental design in all cases was an ordinary randomized block or a complete factorial randomized block. Plot size consisted of four to eight rows (38 inches wide) 50 feet in length. Four to eight replications were always used. The middle two rows were harvested for yield data.

Results on Irrigated Land

Irrigated cotton fertilizer tests reported here were conducted during 1955-58. All but the 1958 data have been reported (2, 4). A summary of the effect of different kinds and amounts of fertilizers on the average yields of lint cotton is given in Table 2.

Cotton grown under these conditions responded principally to applications of nitrogen with maximum yield increases from the initial 60 pounds. Occasional yield increases were obtained from the use of superphosphate in con-

TABLE 2. EFFECT OF FERTILIZER TREATMENT ON THE AVERAGE YIELD OF DELTAPINE TPSA COTTON GROWN UNDER IRRIGATION

Fertilizer treatment, pounds per acre	Pounds of lint cotton per acre			
	1955	1956[1]	1957	1958
	Willacy fine sandy loam	Willacy fine sandy loam	Harlingen clay	Willacy fine sandy loam
0-0-0	1024	956	910	804
0-60-0	1101			
0-120-0	973	951		840
0-0-60	1099	1002		947
0-60-60	1068			
0-120-60	1057	945		1084
60-0-0	1141	1035	1002	1110
60-60-0	1217		1021	
60-120-0	1149	988	1064	1252
60-0-60	1140	1003		987
60-60-60	1227		1051	
60-120-60	1117	1007	1022	967
120-0-0	1185	1044	1000	1180
120-60-0	1157		1028	
120-120-0	1183	1016	1036	1150
120-0-60	1205	1013		987
120-60-60	1182		1059	
120-120-60	1151	1011	1119	1084
120-120-60-M[2]				1425
180-120-0			1033	
180-120-60			1071	
L.S.D. 0.05	120	65	82	221
0.01	162	87	109	296

[1]In 1956 an additional 60 pounds of potash were sidedressed to all treatments which contained potash, making a total of 120 pounds per acre.

[2]M refers to 75 pounds of Es-Min-El per acre applied with preplanting application.

junction with nitrogen, but such increases were inconsistent and of little significance. Potash alone or in combination with other fertilizer materials did not result in significant yield increases.

The addition of 75 pounds per acre of Es-Min-El (a mixture of minor elements) in 1958 in conjunction with other fertilizer materials (N, P and K) caused a significant increase in yield over all other treatments. This test was conducted on an area which had been leveled 18 months previously. A considerable amount of top soil had been removed from the test area during the leveling operation, which was partly responsible for the response to minor elements. More extensive work on corn in the same area had shown the yield response from minor elements to be primarily from the addition of zinc.

Fertilizer treatment did not significantly affect staple length or lint percentage in any of the tests.

Results on Non-irrigated Land

Several attempts have been made in recent years to determine the response to fertilizers of cotton grown under dryland conditions. Almost as many times these tests have had to be abandoned for one reason or another. Poor stands from limited moisture or destruction of stands from wind and sand have contributed to the difficulty of obtaining such information. The data presented in Table 3 were obtained from a dryland test conducted east of Raymondville in 1958 on a Willacy loam soil.

No real or significant response was obtained from fertilizers nor any difference in the response to dry or liquid fertilizers.

Moisture conditions were extremely favorable through most of the growing season which apparently accounted for the unusually high yields for this non-irrigated area. Late winter rains provided a good reserve supply of soil moisture and timely rains furnished ample moisture throughout most of the growing season.

Results of Subsoil Fertilization

The possibility of combining subsoiling and deep fertilization to enhance root extension for more efficient utilization of subsoil moisture has been the object of considerable research (8, 10) in recent years. An experiment was initiated in 1955 at the Valley Experiment Station on Hidalgo loam soil to determine whether subsoiling in conjunction with different depths of fertilization might result in the growth of a deeper root system and thereby increase the yield of cotton. This experiment was carried on for 3 consecutive years in the same area. The first 2 years' results have been reported (3). Annual treatments included in the test are indicated in Table 4.

Table 5 indicates that deep fertilization did not increase yields significantly over the regular or conventional method of fertilization, nor was

TABLE 3. EFFECT OF FERTILIZER TREATMENT ON THE AVERAGE YIELD OF DELTAPINE FOX COTTON GROWN UNDER DRYLAND CONDITIONS, 1958

Fertilizer treatment	Pounds of lint per acre	Fertilizer treatment	Pounds of lint per acre
0-0-0	1194	30-60-0	1047
0-30-0	1090	60-0-0 "L"	1110
0-0-30	1110	60-0-0	1169
0-30-30	1045	60-30-0	1159
30-0-0	976	60-60-0 "L"	1283
30-0-0 "L"[1]	1040	60-60-0	1149
30-30-0 "L"	1055	60-60-30	1120
30-30-0	1035	60-60-30 M	1278
30-30-30	1243	Es-Min-El[2]	1139
30-30-30-M[3]	1189	90-60-30	1060
L.S.D.	N.S.		N.S.

[1]"L" indicates fertilizer treatment was from fertilizer solutions.
[2]75 pounds per acre.
[3]75 pounds of Es-Min-El per acre.

lint percentage or boll size affected appreciably. In 1958, however, non-subsoiled plots with deep fertilization produced more pounds of cotton per acre-inch of water than did non-subsoiled plots with conventional fertilization. Yields were increased significantly during 1957-58 by subsoiling.

Root distribution measurements of plants grown under the different treatments were made in 1956 by a method described by Bloodworth *et al.* (1) in which a Kelley core-sampling machine was used, Table 6. Root samples were not taken in 1957-58. A large percentage of the roots was in the top foot of soil for all treatments. The overall distribution of roots below 12 inches was better where both subsoiling and deep fertilization were practiced.

The cotton was irrigated three times in 1956. Plants were never allowed to become stressed for moisture. The 1957 test was irrigated one time in July only after plants were stressed severely for moisture. The cotton received one irrigation in 1958 on June 2 just before the plants were

TABLE 4. SUMMARY OF ANNUAL SUBSOILING AND FERTILIZER PLACEMENT TREATMENTS

Treatment	Description
A[1]	Subsoiled to 18 inches and conventional method of fertilizer application with 60 pounds of N per acre applied as sidedressing at squaring.
B	Non-subsoiled and conventional method of fertilizer application. Sidedressed as in A.
C	Subsoiled and deep placement of fertilizer at 6 to 18 inches deep. Sidedressed as in A.
D	Non-subsoiled with deep placement as in C. Sidedressed as in A.

[1]In 1956, conventional method of fertilizer application refers to 60 pounds of N and 60 pounds of P_2O_5 placed in the soil approximately 3 inches below the seed zone before planting. The P_2O_5 was increased to 120 pounds in 1957-58.

TABLE 5. EFFECT OF SUBSOILING AND FERTILIZER PLACEMENT ON THE YIELD, QUALITY AND WATER UTILIZATION OF DELTAPINE TPSA COTTON ON A HIDALGO LOAM SOIL

Treatment	Average pounds of lint cotton per acre			Pounds of lint cotton per acre-inch of water[1]			Lint turnout, percent			Bolls per pound		
	1956	1957	1958	1956	1957	1958	1956	1957	1958	1956	1957	1958
A	1156	689	1053	60.8	27.9	62.9	36.2	34.8	36.6	73	79	72
B	1094	570	912	57.5	31.3	54.5	36.8	35.5	36.5	76	88	73
C	1187	609	1012	62.4	33.8	60.4	36.3	34.9	36.6	74	79	73
D	1087	538	972	57.2	29.6	58.0	36.6	33.6	36.9	74	85	71
L.S.D. .05	N.S.	103	90									

[1]Based on rainfall and irrigation water:
1956—rainfall 4.21" + 14.8" irrigation water = 19.01"
1957—rainfall 12.07" + 6.13" irrigation water = 18.20"
1958—rainfall 7.39" + 9.36" irrigation water = 16.75"

beginning to suffer from moisture shortages. Deep fertilization under these conditions did not significantly increase yields, although soil moisture samples taken in the soil profile did indicate more moisture removal from lower depths when deep fertilization was practiced.

DISCUSSION AND RECOMMENDATIONS

Irrigated Cotton

Cotton fertilizer tests conducted for 4 years indicate that irrigated cotton in the Lower Rio Grande Valley responds principally to applications of nitrogen fertilizer. The initial 60 pounds generally accounts for most of the increase in production. Under most conditions, 60 to 120 pounds of nitrogen per acre per cotton crop should provide sufficient nitrogen to produce maximum yields. These results may vary somewhat with previous cropping history and land use practices.

Annual applications of phosphate failed to give significant increases in the yield of cotton. While annual cool-season crops respond frequently to phosphate applications, it seems that the decomposition of crop residues and the subsequent mineralization of organic phosphorus in most cases provides sufficient phosphorus for the cotton crop. Forty to 60 pounds of phosphoric acid (P_2O_5) per acre should be applied every 2 to 3 years somewhere in the rotation of crops for maintenance of the phosphorus level in the soil. This maintenance application may be applied to the legume if one is included in the cropping system.

TABLE 6. TOTAL WEIGHT AND DISTRIBUTION OF COTTON ROOTS AS INFLUENCED BY SUBSOILING AND DEEP FERTILIZATION, 1956

Depth, inches	Percentage of total weight by treatment			
	A	B	C	D
0-6	5.26	33.33	27.01	6.71
6-12	82.41	46.75	51.00	70.78
12-18	4.04	4.11	3.84	6.02
18-24	3.32	5.40	5.02	5.95
24-36	3.47	6.88	9.83	8.40
36-48	1.25	2.79	2.67	3.00
48-60	.24	.71	1.13	.10
60-72	.06	.03	.49	.04
Total weight, gm.	4.5	5.3	5.9	5.4

Valley soils generally test very high in potash, and fertilizer tests show that the yield of irrigated cotton is not increased by potash applications.

The response of irrigated cotton in the Lower Rio Grande Valley to minor element applications has not been investigated fully; however, the 1958 tests indicate that, under certain conditions, the application of minor elements may be necessary for optimum yields.

If cotton is grown on land recently leveled where considerable top soil has been removed, an application of minor elements may be profitable. At other times under highly alkaline conditions certain minor elements may be tied up in unavailable forms. This occurred in several fertilizer tests in 1958, with an apparent tie up of zinc with soil and fertilizer phosphate. Under the conditions, acute zinc deficiencies occurred or yield increases were obtained from the addition of zinc with other fertilizers.

Soils vary widely within the Lower Rio Grande Valley. Soil samples should be taken from each field with any major differences in soil type, cropping history and land use. With this information, soil scientists, agronomists and other agricultural workers can make more specific recommendations as to the best fertilizer program to follow for a specified system of farming.

Non-irrigated Cotton

Table 3 did not indicate any significant increase in the yield of cotton from fertilizer applications. Limited data, perhaps, do not warrant specific conclusions at this time; however, dryland fertilizer tests with grain sorghum in 1956 (5) likewise revealed no response from fertilization.

In any non-irrigated area, favorable response of crops to fertilization depends on soil moisture conditions. Dryland soils of the Lower Rio Grande Valley are relatively young as far as cropping history is concerned. Limited soil moisture supplies apparently have afforded some protection from exploitation of the inherent fertility in such areas. In many cases, fertility reserves are adequate for maximum production under existing soil moisture conditions. In other instances, where soil moisture is adequate, fertilizer applications may be profitable. When soil moisture is adequate, applications of nitrogen may be profitable. Generally, 20 to 30 pounds of nitrogen per acre per application will be sufficient. If moisture conditions continue to be favorable, further light applications may be beneficial. Even with soil test information and crop and land use history, the grower should be guided by soil moisture conditions in determining the amount of fertilizers to apply.

Subsoil Fertilization

Subsoil fertilization alone under irrigated conditions has not resulted in consistent yield increases, although somewhat more efficient utilization of subsoil moisture occurred as a result of the practice. Such practice is most likely to be valuable under conditions of limited moisture. When top soil moisture is adequate, sufficient nutrients for good growth usually will be obtained from shallow depths. Subsoil fertilization may be valuable under non-irrigated conditions of the area. It is under such conditions that the practice has proved most profitable in other areas.

FERTILIZER APPLICATION PRACTICES

Maximum benefit from the application of fertilizers to cotton is possible only when good, sound methods of fertilizer application are practiced. Some of the recommendations of the National Joint Committee on Fertilizer Application (7) concerning methods of applying fertilizer to cotton follow.

Solid and Non-pressure Liquids

Fertilizer usually should be applied in bands to the side and below the seed at planting time. If equipment is not available for simultaneous planting and fertilization, preplant fertilizers may be banded in the bed before planting. Planting should not be done directly over the fertilizer band since such practice may inhibit germination or cause injury to small seedlings. Banding of fertilizer materials approximately 3 inches to the side of the seed and 2 to 3 inches below the seed level is considered good placement.

Broadcast applications of dry fertilizer, or full coverage injection of solutions or fertilizers applied in irrigation water usually are less effective than banded or sidedressed fertilizer.

Sidedressed fertilizer should be applied far enough to the side of the row to prevent serious mechanical injury to the roots. Distance away from the plant will be governed by the stage of growth.

Split applications of nitrogen often are desirable where leaching may be a problem, with part applied before planting and the remainder applied in one or more sidedressed treatments early in the season.

Soluble fertilizer material may be applied in irrigation water when it is impractical to apply it by other methods. Fertilizers applied in water usually are only partially as effective to the immediate crop as materials applied by direct soil application. Certain conditions, however, warrant the application of fertilizer materials in irrigation water.

Pressure Liquids

Experience has shown that it may be hazardous to plant cotton directly over recent applications of anhydrous ammonia injected 6 to 8 inches deep. The opening made by the injector blade should be covered properly and sealed to prevent upward movement of free ammonia. Applications which allow diffusion of ammonia into the seed row or root zone of seedling plants may be injurious. Danger of injury may increase in dry soils where high rates of ammonia are used. Damage of this nature can be avoided best by applying the ammonia 6 to 8 inches to the side and below the level of the seed.

Aqua and anhydrous ammonia behave similarly when applied to the soil; therefore, similar equipment and methods may be used in their application.

Sidedressed applications of ammonia materials should be applied 6 to 8 inches deep and 6 to 10 inches to the side of the cotton plants, depending on the extent of the root system.

When cotton is sidedressed, escaping ammonia may burn the leaves of plants. This damage usually is outgrown in a short time, but the escaped ammonia is lost.

As with other fertilizer materials, anhydrous and aqua ammonia applied in irrigation water are only partially as effective as when applied directly into the soil.

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