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COTTON PRODUCTION IN FAR WEST TEXAS
with emphasis on
IRRIGATION AND FERTILIZATION

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Summary

Eleven separate fertility-irrigation tests with Acala 1517 cotton were conducted on major Trans-Pecos soil types during the 4-year period, 1959-62. The effect of irrigation frequency and soil fertility level on many aspects of cotton production were determined, including yields, skip-row production, earliness, boll weight, seed weight, lint weight, lint percent, fiber quality, water use efficiency and disease incidence. Both irrigation frequency and fertility level had significant effects on many of the above aspects and characteristics.

More frequent summer irrigation (oftener than every 14 days) had highly diverse effects on yields at various locations. This was attributed to soil type and texture, irrigation design, soil physical conditions, depth of rooting, disease incidence or other factors. No general recommendations regarding best irrigation practices appear advisable at this time.

Fertility requirements of Acala 1517 cotton appear to be relatively independent of irrigation frequency except on sandy soils where leaching losses are serious. Maximum yields in all tests were obtained with 120 to 180 pounds of applied nitrogen per acre. Higher rates generally **decreased** yields slightly. Phosphate additions at low to optimum nitrogen rates had little or no effect on yields in most tests.

Skip-row planting on productive soils presents possibilities of greatly increased yields per planted acre in the El Paso Valley.

Crop maturity was greatly delayed by more frequent irrigation on all soil types and at all locations. Heavier nitrogen rates, combined with frequent irrigation, had an additional delaying effect. Nitrogen applications with less frequent irrigation appeared to prolong the fruiting season rather than to cause actual delays in maturity. Less frequent irrigation in late summer greatly speeded maturity in one test, but losses in yield resulted.

More frequent irrigation generally resulted in heavier bolls, heavier seed and slightly more lint per boll, with decreases in lint percent and sometimes fewer bolls per plant. Nitrogen increased boll and seed weights but had little effect on weight of lint per boll. Phosphate with frequent irrigation greatly increased seed weight.

Fiber properties (length, strength, fineness) were only slightly affected directly by irrigation frequency or fertility level, but were adversely affected indirectly by prolonged fruiting and delays in maturity attributable to frequent irrigation and fertilization. Later-maturing bolls were smaller, had lower lint percents and slightly shorter fiber of definitely poorer quality.

Water use efficiency (pounds of lint per inch of applied water) was greatly reduced by more frequent irrigation in all tests at all locations.

Incidence of verticillium wilt was greatly increased by more frequent irrigation plus heavy nitrogen applications on soils of the El Paso Valley.

No immediate need has been found for application of potassium or trace minerals to cotton on any of the soils of the Trans-Pecos area.

ERRATA

B-1001, "Cotton Production in Far West Texas with Emphasis on Irrigation and Fertilization," page 7, left column, second paragraph from the bottom, third sentence.

This sentence should read: "For 2 to 2½-bale yields, no less than 100 pounds and no more than 150 pounds of nitrogen per acre each year is required (<u>none</u> following legumes)," instead of "(<u>more</u> following legumes)."

COTTON PRODUCTION IN FAR WEST TEXAS
with emphasis on
IRRIGATION AND FERTILIZATION

*D. E. Longenecker, E. L. Thaxton, Jr. and P. J. Lyerly**

The Trans-Pecos region is the only area of Texas where cotton is grown under full irrigation. Annual rainfall, ranging from approximately 12 inches in eastern Pecos County to 8 inches in El Paso County, is too slight and uncertain to be of any real value for cotton production. Farmers generally consider the effects of rainfall detrimental rather than beneficial to cotton.

Irrigated agriculture, therefore, is limited to those areas where either surface or ground waters of acceptable quality are available for irrigation. The major area using surface waters is the Rio Grande Valley above and below El Paso, with some irrigation at Presidio. A small acreage of alluvial soils in the Pecos River Valley also is irrigated with river water. Perennial springs at Balmorhea provide water for about 8,000 acres in that area. By far the larger portion of irrigated acreage is by pump irrigation. Of the 15 more or less distinct irrigated areas in the Trans-Pecos, seven are entirely dependent on pump irrigation, while the other eight areas depend on supplemental pumping. Total acreage now or previously in irrigation comprises about half a million acres. The map of the Trans-Pecos land resource area gives the approximate location of the 15 irrigated areas, Figure 1. These areas and the approximate acreage in each, with type of irrigation (surface or pump) and a brief description of soil types are listed in Table 1.

Cotton is by far the chief cash crop grown in far West Texas. Approximately 73 percent of the total irrigated acreage is in cotton. This percentage was considerably larger before cotton acreage restrictions were introduced. Most of the cotton grown is of higher fiber quality—long-staple Acalas and extra long-staple American-Egyptian types. The hot summers, low humidity, low rainfall and bright sunlight provide an almost ideal climate for quality fiber production. Average yields are high and are limited primarily by cool spring and fall temperatures and an average frost-free period of only about 200 days.

Although per-acre yields are high in comparison with other Texas areas, the potentials in cotton production have not even been approached. Average yields now range between 1½ and 2 bales per acre for the Acala types. These cottons, with proper management, are capable of yielding from 2½ to 3 bales per acre. Even higher yields than this are possible with skip-row production. Failure to obtain these potential yields can be attributed to many factors, most of which fall into the classification of farm management. Chief among these are inefficient irrigation practices and improper fertilization.

This publication presents the results of 4 years' field tests with Upland cotton by the Texas Agricultural Experiment Station on major Trans-Pecos soils. The effect of irrigation frequency and fertilization on many aspects of cotton production will be discussed, including yields, earliness, lint percent, boll and fiber characteristics, water-use efficiency and disease incidence.

Design and Location of Field Tests

The 11 tests over the 4-year period, 1959-62, were of the same basic field design. Each test was of randomized block design with six complete replications and 144 total plots, covering approximately 3 acres. Plots were four rows wide and 40 feet long. Yield data and boll

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Contents

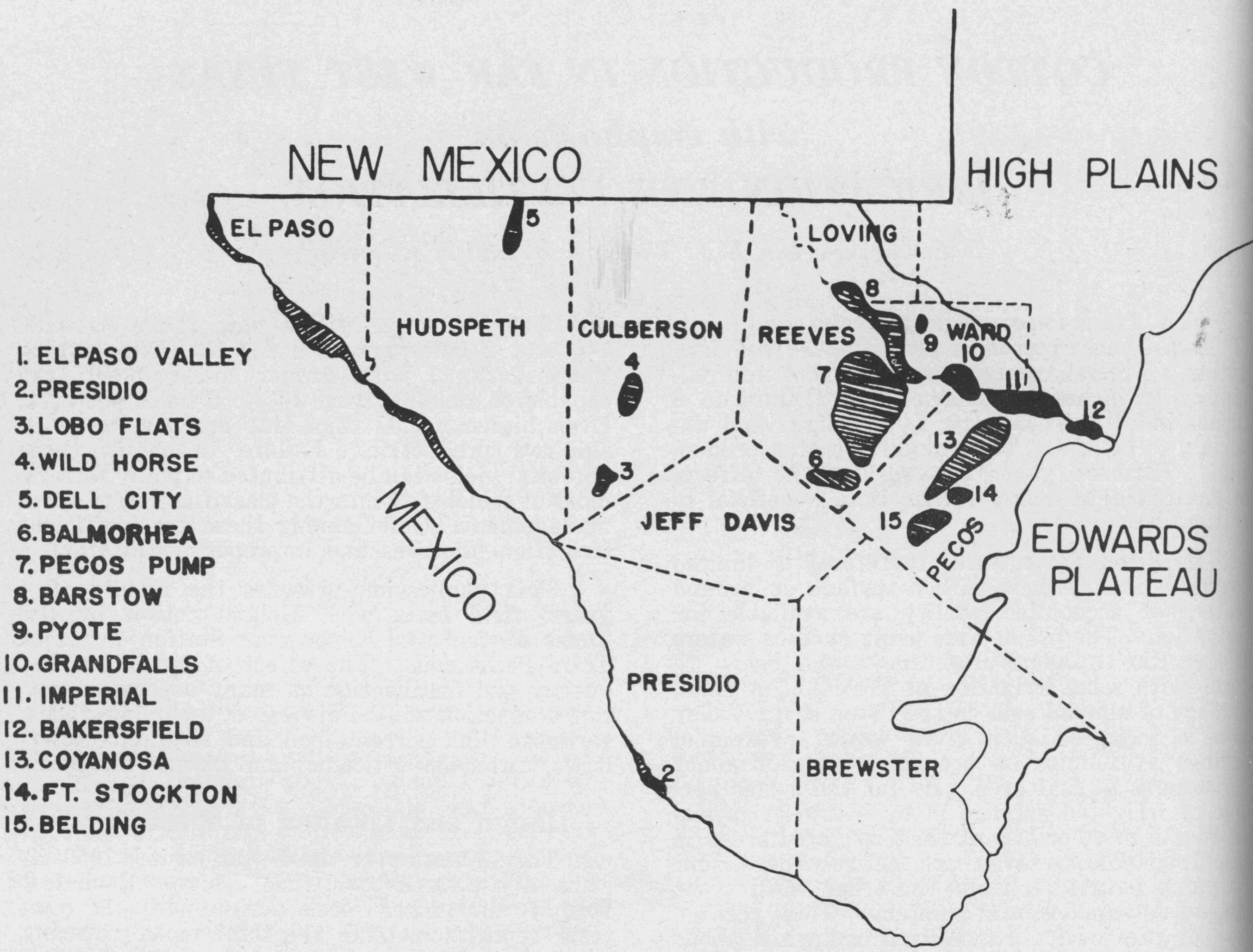

Figure 1. Map of the Trans-Pecos area showing location and approximate extent of irrigated portions.

TABLE 1. IRRIGATED AREAS AND SOILS OF THE TRANS-PECOS LAND RESOURCE AREA WITH RELATED INFORMATION

Area	Approximate irrigated acreage	Pump or surface irrigation	Nature and texture of surface soils
		ALLUVIAL SOILS	
El Paso Valley	90,000	Both	Stratifield alluvial sands, loams and clays
Presidio	6,000	Both	Stratifield alluvial loams and clays
Barstow	40,000	Both	Alluvial loams and clays
Grandfalls	13,000	Both	Alluvial loams and clays
Imperial	15,000	Both	Alluvial loams and clays
Bakersfield	9,000	Both	Alluvial loams and clays
		UPLAND SOILS	
Pecos	160,000	Pump	Silt loams and loams
Coyanosa	80,000	Pump	Loams and clay loams
Belding	18,000	Pump	Loams and clay loams
Fort Stockton	7,000	Both	Loams
Van Horn (Lobo Flats)	10,000	Pump	Clay loams and clays
Van Horn (Wild Horse)	10,000	Pump	Sandy loams and clay loams
Dell City	20,000	Pump	Silt loams
Balmorhea	10,000	Both	Sandy loams and clays
Pyote	4,000	Pump	Sands and loamy sands
Total	492,000		

samples for determination of boll and fiber characteristics were taken only from the center two rows. Each test included 10 fertilizer treatments, (11 in 1962) with six rates of nitrogen and four rates of superphosphate. All of the phosphate and half of the nitrogen (ammonium nitrate) was sidedressed in early June. The other half of the nitrogen was sidedressed in early July.

Each replication was split for two frequencies of water application, designated as summer irrigation frequencies. This method was chosen for several reasons; (1) irrigation practices from area to area varied considerably, (2) most growers were irrigating at definite intervals because it best fitted farm operations and (3) many of the tests were located on lands of cooperating growers, with irrigations performed by the grower. Five of the tests were in the El Paso Valley on alluvial soils, four at Pecos and one each at Fort Stockton and Van Horn on upland soils. All tests except one were harvested by hand three times to obtain earliness data.

Effect of Irrigation and Fertilization on Cotton Yields

Substation 17

Alluvial soils of the Rio Grande Valley are mostly loams or clay loams with a montmorillonite clay fraction. These soils are highly fertile and are generally underlain at various depths by silt or sand which provides good underdrainage. Their major shortcoming is the tendency of the surface soils to deteriorate structurally under continuous row cropping. This causes crusting and clodding and makes tillage operations difficult. When in good physical condition, these soils will produce high yields of most farm crops having reasonable tolerance to salinity. Practically all valley irrigation is level, runs are relatively short, and cotton is planted on beds after pre-irrigation.

Three tests (1959, 1960 and 1961) were conducted at Substation No. 17 near El Paso. Two of the tests (1959 and 1960) were conducted on the same plot of Gila loam soil. The third was on Gila clay loam. Both fields had been deep-plowed to about 30 inches a year or two before the tests were initiated and this is believed to have had a considerable effect upon the results. Summer irrigation frequencies on all tests were every 10 and every 16 days, beginning in early June and ending early in September. Acala 1517C was the cotton variety grown.

In all three tests the effect of differential irrigation and fertilization on yields, boll characteristics and fiber quality was similar. For that reason, the data from these tests have been combined, and average yields for the 3-year period are shown in Figure 3.

Figure 2. Tractor-mounted fertilizer apparatus used to apply various rates of nitrogen and phosphate to experimental test plots.

Yield curves for 10-day and 16-day summer irrigation show that the response of cotton to applied fertilizer was not greatly affected by irrigation frequency. Maximum yields (approximately 2½ bales per acre) with 16-day irrigation were obtained with the 120 N-60 P_2O_5 rate. Highest yields with 10-day irrigation were obtained at the 240-60 rate; however, the 50 pounds of additional seed cotton obtained per acre with 10-day irrigation would not pay the cost of the extra 120 pounds of nitrogen. In these tests, therefore, it would not have been profitable to apply more than 100 to 120 pounds of nitrogen per acre, regardless of irrigation frequency. Greatest response to nitrogen was obtained with the lowest applied rate — 60 pounds of nitrogen per acre. At the 300 pound nitrogen level, yields were somewhat reduced at both irrigation frequencies.

The effect of superphosphate on yields can be observed at the 60 and 300 pound rates of nitrogen. At the 60-pound nitrogen level, the addition of 60 pounds of P_2O_5 per acre was of doubtful value. Yields were increased slightly with 16-day irrigation but were decreased with 10-day irrigation. At the 300-pound nitrogen

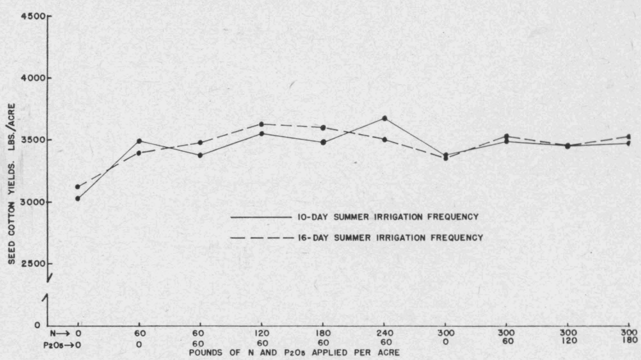

Figure 3. Three-year average yields of 1517C seed cotton as affected by irrigation frequency and soil fertility level at Substation 17 (1959-61).

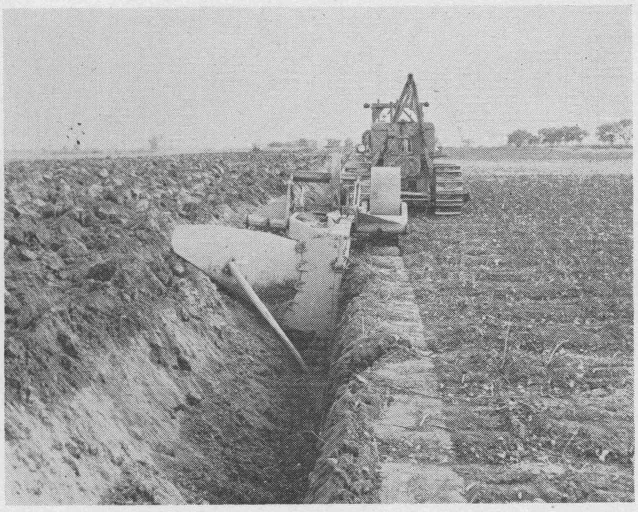

Figure 4. Deep-plowing operation on alluvial soils in the El Paso Valley.

level the effect of phosphate was more apparent. Yields were rather sharply reduced by lack of applied phosphate at both irrigation frequencies at this high nitrogen level. This probably reflects an unbalanced nitrogen-phosphate condition which was corrected by 60 pounds of P_2O_5 per acre. Results of these and previous tests at this location indicate that this phosphate effect was caused more by very high nitrogen than by low phosphate, and is not likely to be significant at recommended 100 to 120-pound rates of nitrogen. Soil tests have shown sufficient available phosphate for normal cotton growth on all but very sandy El Paso Valley soils.

Failure of the cotton to show a yield response to more frequent (10-day) irrigation on these soils indicates that sufficient water for crop needs was supplied with the 16-day frequency. With 16-day irrigation, cotton grew shoulder-high and showed no signs of suffering for water at any time during the three seasons. Stalks were taller and more rank with 10-day irrigation but produced no more bolls per plant. Fruiting was delayed and verticillium wilt infection was more severe; both of these factors will be discussed later.

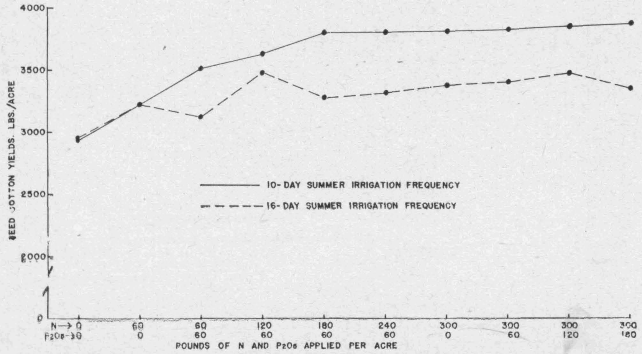

Figure 5. Two-year average yields of 1517C seed cotton as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

In these tests, the cotton was planted on double-row (cantaloupe) beds in late April. Seedlings emerged quickly, seedling disease damage was negligible, and the cotton grew off rapidly. It is believed that the previous deep-plowing permitted development of extensive root systems which were able to obtain moisture from considerable soil depths. Ten-day irrigation at this location resulted in three unnecessary summer irrigations and needless application of about 12 inches of water, which contributed appreciably to production costs.

Fabens

In both 1959 and 1961, identical field tests were conducted on the Buckland farm near Fabens, 15 miles east of the previously described tests on similar alluvial loam (1959) and clay loam (1961) soils. Climatic conditions were alike at the two locations. Irrigation design and irrigation frequency were also similar, with level 600 to 800-foot runs and summer irrigation frequencies of 10 and 16 days. The only apparent difference was in the physical condition of the soil. The fields at Fabens had never been deep-plowed and were in generally poorer structural condition than those at Substation 17. The cotton, also, was planted about two weeks earlier at Fabens in colder soils. Young plants suffered severely from seedling disease and although final stands were good, almost all roots had been damaged to some extent.

Figure 5 gives the 2-year average seed cotton yields for the Fabens tests. Both tests gave similar response to irrigation frequency, but they differed greatly from those at Substation 17. In both tests, more frequent irrigation resulted in significant increases in yields, averaging almost 300 pounds of seed cotton per acre. Overall yields were somewhat lower at Fabens than at Substation 17.

It appears that the response to additional water at Fabens can be attributed primarily to poorer soil physical conditions and perhaps seedling disease damage. Although no actual measurements of root systems were made, observations showed that roots at Fabens were not nearly so deep or extensive as at Substation 17. Most of the roots were in the top 2 feet of soil. Shallow-rooted crops generally respond to more frequent irrigation because (1) the root systems, being less extensive, have less soil volume from which to extract water, and (2) surface soils dry out more rapidly because of evaporation. Conversely, shallow-rooted cotton is more susceptible to flooding damage and "wet feet." The marked response of cotton to deep plowing, often noted on alluvial soils, is apparently associated with deeper root systems and better water penetration, although actual data is mainly lacking.

The effect of fertilizers on yields at Fabens showed some similarity to Substation 17. With 10-day irrigation, the 180 N-60 P_2O_5 rate was most profitable. Higher nitrogen rates had little additional effect on yields. The 16-day frequency apparently did not supply enough water for most efficient use of fertilizer. Maximum yields with this irrigation schedule were obtained at the 120 N-60 P_2O_5 level. Higher nitrogen rates acted to decrease yields somewhat.

At the 60-pound nitrogen level, the effect of superphosphate was the reverse of that at Substation 17. Yields were increased with 10-day irrigation and decreased with 16-day irrigation. There is no logical explanation for this as yet. At the 300-pound nitrogen level, superphosphate additions had no appreciable effect on yields at either irrigation frequency.

Summarizing the results of these and other tests in the El Paso Valley, it appears difficult to make general recommendations as to best irrigation frequency for cotton. Crops on similar-appearing soils may show marked differences in response to water even during the same year. Soil physical condition, depth of rooting and date of planting all may affect yields, even though weather conditions and insect control are good. It can be concluded, however, that where soil physical conditions are conducive to deep rooting, and other factors are not limiting growth, good cotton yields can be produced with only four to five summer irrigations — much less than is generally applied.

Factors often contributing to higher yields on these soils are maintenance of deeper furrows all season for more adequate and uniform irrigation, and later planting (late April) to avoid seedling disease damage in cold soils. Most growers are unaware that seedling disease can destroy taproots and cause cotton to be relatively shallow rooted without any visible evidence or appreciable loss of stands. A deep-plowing operation usually will benefit yields on most medium and fine-textured valley soils by breaking up impervious layers and by turning under structurally deteriorated surface soils. Subsoiling also helps.

When alfalfa or other legumes are grown occasionally and phosphate applied to the legumes, no additional phosphate should be needed by cotton at the present time. With continuous cotton, a moderate phosphate application (50-60 pounds of P_2O_5 per acre) every 5 to 6 years may be desirable to avoid possible unbalanced nitrogen-phosphate conditions. For 2 to 2½-bale yields, no less than 100 pounds and no more than 150 pounds of nitrogen per acre each year is required (more following legumes). This nitrogen should preferably be sidedressed in late May or early June. Sandy soils may require split applications to avoid excessive leaching losses.

Pecos

The largest body of upland soils under irrigation in the Trans-Pecos area is the Reeves-Reagan series[1], composed of grey to brown, highly calcareous loams and silty clay loams, underlain by soft gypsiferous caliche deposits at depths of 2 to 4 feet. However, these soils in the Pecos area contain a high percentage (60 to 65 percent) of silt and tend to disperse easily when wet forming hard thick crusts and clods.

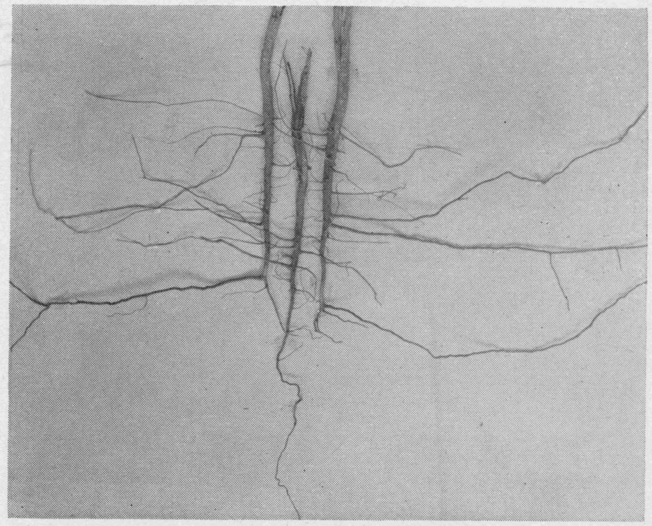

Figure 6. Typical cotton roots from Fabens test showing shallowness of rooting and absence of taproots. Greatly restricted taproot (center plant) penetrated crack through compacted soil.

The Pecos area is entirely pump irrigated. Saline ground waters average about 2,700 ppm total salt. Cotton yields have generally been good in spite of this because soils are permeable and salts are easily removed by leaching. Cotton is usually lister-planted and worked onto beds as the season progresses. Surface irrigation is either sloping or level, with generally longer runs than in the El Paso Valley. Much of the Pecos pump area has been developed from virgin soils during the past 20 years. Because waters were saline and soils were permeable, many farmers have developed the practice of frequent irrigation combined with heavy nitrogen applications in cotton production.

Four consecutive years of cotton tests (1959-62) were conducted on these soils at Substation 9, Soils and Crops Unit, Pecos, Texas. Field design

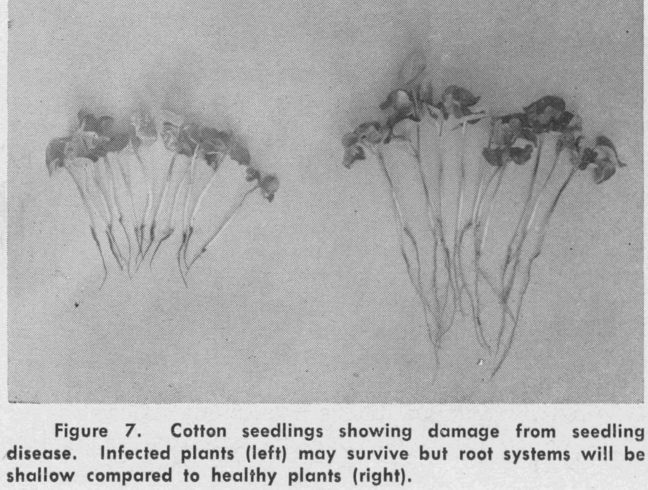

Figure 7. Cotton seedlings showing damage from seedling disease. Infected plants (left) may survive but root systems will be shallow compared to healthy plants (right).

[1]Tentatively re-named "Hoban."

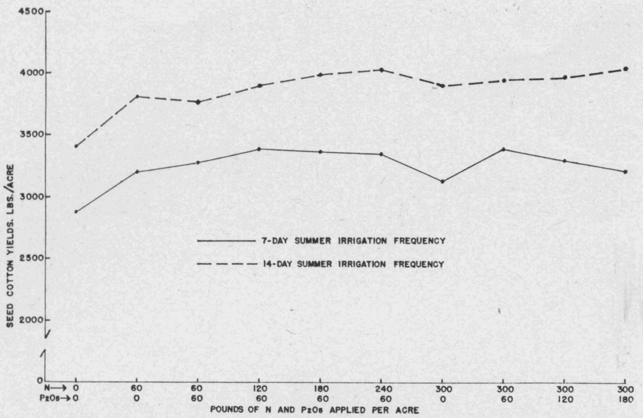

Figure 8. Three-year average yields of 1517C seed cotton as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-61).

was identical to El Paso Valley tests. The first 3 years (1959-61) tests were established on level land with short (400-foot) runs. The 1962 test was on sloping land (0.4 percent slope) with 800-foot runs. Results for the first 3-year period are given in Figure 8. Summer irrigation frequencies were every 7 and every 14 days in all Pecos tests.

Figure 8 clearly shows that cotton yields were greatly reduced by frequent (7-day) irrigation on level runs. These yield reductions occurred at all fertility levels and were without question caused primarily by adverse soil physical conditions resulting from frequent irrigation. With 7-day irrigation the soils stayed wet rather than moist. Cotton grew shoulder to head high, had a definitely lighter green leaf color, and a generally less thrifty appearance. Cotton getting 14-day irrigation was chest high, had a better leaf color and was more bushy and healthy looking. More crusting and clodding occured with 14-day irrigation because soils dried out more between irrigations. Because of the formation of large cracks, soil aeration was much better, however, and this factor appears largely responsible for the significant differences in growth and yields.

There seems to be no doubt that the combination of level soils and frequent irrigation had strong adverse effects on many aspects of cotton growth and physiology. Data on boll characteristics, to be presented later, bear out these conclusions.

The response to nitrogen applications was significant with both irrigation frequencies, but was greater with 14-day irrigation. Maximum yields with 2-week irrigation were obtained at the 240 N-60 P_2O_5 level, an increase of 620 pounds per acre over the no-fertilizer plots. With weekly irrigation, maximum yields were reached at the 120 N-60 P_2O_5 level, a total increase of 500 pounds per acre. Apparently the cotton was able to utilize applied fertilizer more efficiently with less frequent irrigation. There was no significant yield response to phosphate except a reduction at the 300 N-O P_2O_5 level with both irrigation frequencies, indicating an unbalanced N-P_2O_5 condition. The net result of too frequent irrigation on level runs was an average loss of over 600 pounds of seed cotton per acre in addition to the cost of applying 6 extra summer irrigations, a combined loss of approximately 100 dollars per acre.

In 1962 the test was conducted on 0.4 percent slope in an adjoining field. One other difference was the inclusion of a 180 N-O P_2O_5 fertilizer treatment to better evaluate the effect of superphosphate. Results are shown in figure 9, and are quite different from those of the previous 3 years. In this test, highest average yields were obtained with 7-day irrigation. These differences were apparent at 9 of the 11 fertility treatments and were statistically significant at the 5 percent level.

With 0.4 percent slope, very little crusting or clodding occurred. Water was confined to the bottoms of the furrows, and beds were wetted by lateral capillary movement, commonly called "subbing." With this management system the soil was irrigated without appreciable flooding, soils were kept moist without crusting or clodding, cultivation was easier and the beds remained loose and friable. Cotton grew taller and somewhat more dense with 7-day irrigation but there were no visible effects of over-irrigation such as occurred on level soils. It can be concluded from these tests that any irrigation system which brings about the adverse effects of flooding, crusting, clodding or waterlogging of these soils will contribute to lower yields and other growth effects.

It appears that sloping irrigation should be most suitable in this area provided that adequate and fairly uniform water penetration can be obtained without excessive tail water losses. Provisions for return flow may have to be incorporated into the systems. Most desirable irrigation frequency and degree of slope have not yet been determined. Work at the Trans-Pecos substation is in progress to determine this.

Response to nitrogen on sloping runs was good with both irrigation frequencies, with highest yield increases obtained under 14-day irrigation. Maximum yields occurred with 180

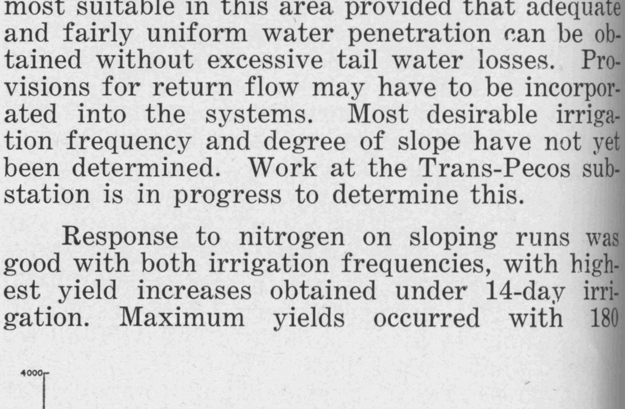

Figure 9. Average yields of 1517D seed cotton as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

pounds of nitrogen per acre regardless of irrigation frequency. Higher nitrogen rates resulted in significant yield reductions with 14-day irrigation and may indicate that the crop did not receive sufficient water for maximum response to fertilizer. The only apparent effect of superphosphate on yields was the previously noted yield reduction with 14-day irrigation at the 300 N-0 P_2O_5 level. This did not occur with 7-day irrigation, for reasons not clear at the present time.

These tests indicate that nitrogen rates for Acala 1517 in this area should never exceed 180 pounds of nitrogen per acre. The good permeability characteristics of these soils, while excellent for salinity control, undoubtedly are conducive to high nitrogen leaching losses. For this reason NH_3 or ammonium-type forms should be more desirable owing to their greater resistance to leaching. Split nitrogen applications would also appear to be advisable. There does not seem to be any immediate need of yearly phosphate applications for cotton. Phosphate recommendations as made for the El Paso Valley would probably be applicable here also.

Fort Stockton

Only one test was conducted in the Fort Stockton area, and this was on the Chandler Farms at Belding in 1960. Although fertilizer or water recommendations for the area cannot be made on the results of one test, the findings are informative for other reasons.

In this test, 10-day summer irrigation was carried out on all plots from early June until mid-July. At this time half of the plots continued with the same schedule while the other half was cut back to irrigation every 20 days. Last irrigation for all plots was on Sept. 13th. The purpose of this irrigation arrangement was to determine the effect of reductions in late summer irrigation frequency on yields, earliness, boll characteristics and fiber quality.

The soil in the test area was a dark brown, deep, well-aggregated loam, classified as Reeves loam deep phase, but differing greatly from the soils at Pecos. It was representative of a large body of soils in the Belding-Coyanosa area which rank among the most productive soils in the entire Trans-Pecos region. The test was on level land; 1517C cotton was planted on single-row beds in late April. From emergence to maturity, cotton in all plots was strong and vigorous, undoubtedly the finest-looking crop of the entire test series. Yield data are reported in Figure 10.

These results clearly show that drastic cutbacks in late summer irrigation frequency can have a serious effect on yields in this area. Elimination of three late summer irrigations reduced final seed cotton yields an average of 350 pounds per acre, a highly significant reduction.

As will be shown from earliness, boll characteristic and fiber quality data, these yield re-

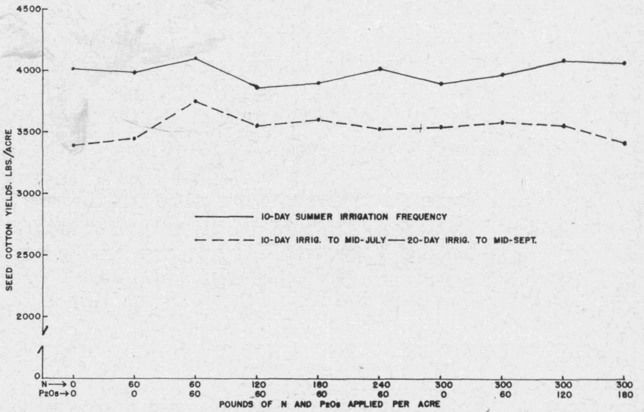

Figure 10. Average yields of 1517C seed cotton as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

ductions apparently were the only adverse effect attributable to less water in late summer. All other aspects were favorable. Yields with 20-day late summer irrigation still averaged 2½ bales per acre. Less favorable late-season weather in 1960 probably would have lessened the difference between irrigation frequencies. This aspect is discussed more fully under "earliness."

This was the only one of 11 tests in which nitrogen applications gave no significant yield increases. Cotton growth, yields and soil-test information all indicated that available soil nitrogen was adequate for crop needs without further additions. Cotton was shoulder to head high in all plots with a deep green leaf color. Corn had been grown the previous season.

There is some indication that additional phosphate was used to good advantage by the crop, particularly at the 60-pound nitrogen level. At this nitrogen rate, 60 pounds of P_2O_5 per acre gave significant yield increases with both irrigation regimes. These increases were not evident at the 120 and 180-pound nitrogen levels, however. Further tests on these soils would be necessary before specific recommendations could be made.

Van Horn

The final test to be reported was established in the Wild Horse section of Van Horn on the Chandler Farms in 1962. This test was on uniformly deep Reeves sandy loam of only moderate fertility. Acala 1517D cotton was planted April 27 on single-row beds. The field had an approximately 0.1 percent slope with 800-foot runs. Summer irrigation intervals were every 12 and every 18 days, to conform with the grower's schedule. The 18-day plots got five summer irrigations; the 12-day plots received eight. Stands were good, the cotton grew off rapidly, and weather conditions all season were favorable. Yield data are given in Figure 11.

This test emphasizes a situation that differed appreciably from any of those previously described. Soil physical conditions here appar-

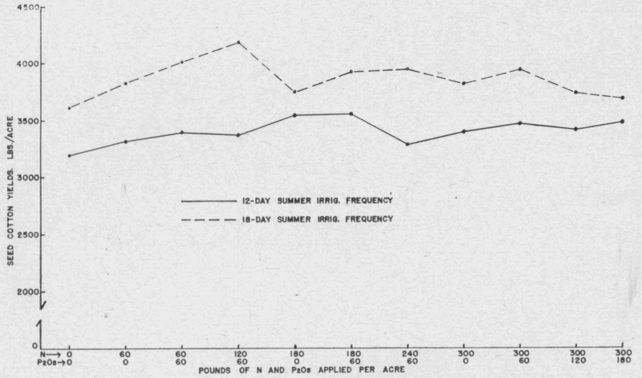

Figure 11. Average yields of 1517D seed cotton as affected by irrigation frequency and soil fertility level at Van Horn (0.1 percent slope, 1962).

ently were not a limiting factor. The soil was friable, infiltration rates were very good, and the cotton in all plots was vigorous and deep rooted. Even though three fewer irrigations were used, the 18-day irrigation schedule produced significantly higher yields. With the 18-day frequency, plants were about shoulder high, compared with above-head height in the 12-day plots. However, the large stalks of the 12-day plots did not set a heavy boll load and maturity was definitely delayed. Reductions in yield occurred at all fertility levels, and fertility differences appear to be partly responsible for differences in yield.

Judging from the almost 3-bale yields on the 18-day plots, soil moisture did not appear to be a limiting factor in this test. The 12-day schedule supplied excess water which caused rank vegetative growth and apparently leached away nitrogen, which prevented the setting of a heavier boll load. Light also was probably a factor reducing boll set in this tall cotton. The conclusions concerning nitrogen were based on several facts: (1) Yield reductions on the 12-day plots were greatest near the head ditch where infiltration was greatest, and (2) at least 5 or 6 inches of water were applied per irrigation to these permeable soils. Also, considerably greater response to nitrogen was evident with less frequent irrigation. On these permeable soils, too frequent or too heavy irrigation can add to production costs and also may reduce yields by leaching away applied nitrogen.

Highest yields, 3 bales per acre, were obtained with 18-day irrigation at the 120 N-60 P_2O_5 level, proof that heavy nitrogen applications are not necessary for good yields, even on permeable soils. Phosphate significantly increased yields at the 60 and 180-pound nitrogen levels with 18-day irrigation but not with more frequent irrigation. This emphasizes the often complex interrelationships among water, nitrogen and phosphate in irrigated cotton production. More tests in this area will be necessary before definite irrigation or fertilizer recommendations can be made.

It may be concluded from results of these tests that it would be exceedingly difficult to recommend specific summer irrigation frequencies for best cotton production, even within any particular area. Many factors operate which influence to some extent the effect of irrigation frequency on yields in any given year. Most of them have been discussed to some extent. These include soil texture, irrigation system design, soil structure, date of planting, depth of rooting and climatic variability, as well as others. For these reasons, it appears inevitable that the determination of best irrigation frequency on any particular farm, with any particular set of management practices, must rest with the grower himself. No farmer can afford **not** to be doing some experimenting on his own. A change in slope, in length of run, in cotton variety, in type of bed, even in depth of furrow, may alter the response of cotton to water.

Skip-row Yields

It has been known for many years that outside cotton rows often produce higher yields than solid-planted rows. The explanation appears to result partially from the effect of extra light, but is undoubtedly caused partly by less root competition for water and fertilizer on outside rows. Whatever the cause, the effect has been recognized in irrigated cotton areas, and much cotton from the Mississippi Delta to California has been grown in skip-row fashion. This involves leaving one or more unplanted rows at regular intervals throughout the cotton field.

Recent (1962) easing of USDA regulations on skip-row planting now makes it possible for as little as one unplanted row in a regular skip pattern to be deducted from alloted acreage and presents the possibility of greatly increased yields per planted acre. The question involved is whether or not the increased yields from outside rows is great enough to offset the extra costs of preparing and maintaining skip areas. Many growers have been disappointed with skip-row methods. Others continue to plant all or part

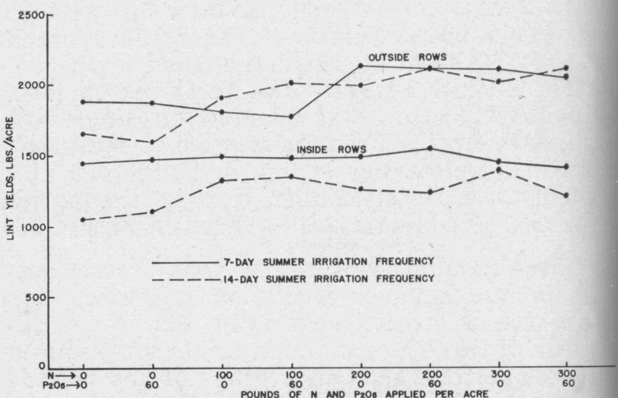

Figure 12. Comparative lint yields from inside and outside rows of 1517C cotton as affected by irrigation frequency and soil fertility level at Substation 17 (1958).

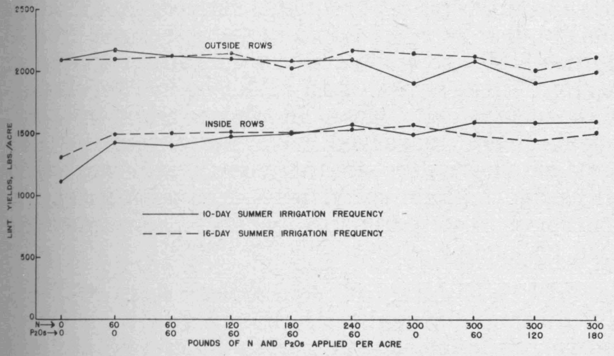

Figure 13. Comparative lint yields from inside and outside rows of 1517C cotton as affected by irrigation frequency and soil fertility level at Substation 17 (1961).

of their allotments in this manner. The problem is not only one of management but involves other factors as well.

During the past 5 years, three evaluations of skip-row plantings were made in the El Paso Valley. All three gave essentially similar results, and only two will be reported here. In 1958 a combination fertility-irrigation test with 1517C cotton on alluvial clay loam at Substation 17 was planted so that one outside row of each plot bordered an adjacent 2-row skip area. These outside rows were harvested separately, and Figure 12 compares the yields of lint with inside (or solid-planted) rows. Summer irrigation frequencies were every 7 and every 14 days. In 1961 the fertility-irrigation test at Substation 17, previously reported, was designed so that one outside row of each plot bordered an adjacent four-row skip area. Lint yields from outside and inside rows are reported in Figure 13. In both tests the skip areas were maintained in weed-free borders by occasional disking and rebordering to obtain best control of irrigation water.

In each of these tests, outside rows yielded an average of almost 600 pounds more lint per planted acre than inside rows, calculating all rows in the field as border rows. In other words, a system of plant two, skip two or plant two, skip four would have yielded well over a bale more cotton per planted acre. These increases would have been obtained even though average solid-planted yields in both fields were well above 2 bales per acre. In both tests the cotton was tall and vigorous, and boll set on outside rows was great enough to cause the plants to bend over into the skip areas in late summer. This occurred because most lateral branching and boll set on these rows was on the skip side, a strong indication that light plays an important role in skip-row production.

Nitrogen increased outside row yields in 1958 but had little effect in 1961 on soil that had recently been deep-plowed. In the 1961 test, outside rows on the no-fertilizer plots yielded an average of over 4 bales per planted acre. This indicates the tremendous yield potential of these finer textured alluvial soils when conditions are right for maximum production.

Researchers in Arizona have calculated that the first ¼ bale increase in skip-row planting is absorbed by increased production costs. In these tests, then, assuming a plant-two system, profits would have been increased by ¾ bale per planted acre.

Tall, healthy, deep-rooted cotton is essential for good success with skip-row planting. The heavy boll loads required on outside rows demand that the plants be large and vigorous enough to set and carry this load. For this reason, best success with skip-row cotton is obtained on soils of high production potential. These tests show that high yields can be obtained without special irrigation or fertilizer treatment on

Figure 14. Skip-row planted cotton in the El Paso Valley. On productive soils, this practice can greatly increase yields per planted acre without additional fertilizer or water.

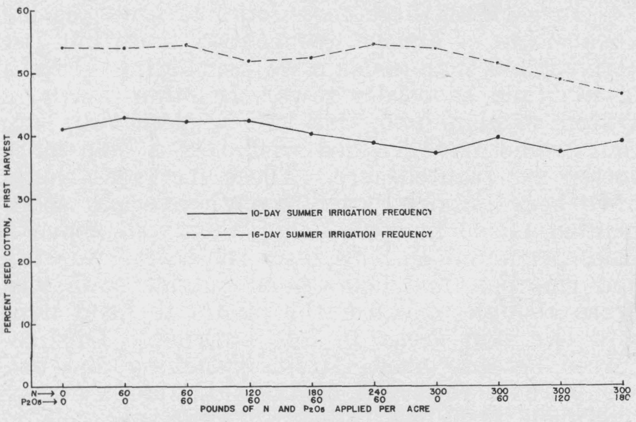

Figure 15. Three-year average percent of 1517C seed cotton harvested at first picking as affected by irrigation frequency and soil fertility level at Substation 17 (1959-61).

productive soils. Skip-row planting, under good management, presents opportunities for greatly increased yields and profits in southwest irrigated areas. It also permits easier access to the cotton for insect control and defoliation spray programs with ground rigs.

Effect of Irrigation and Fertilization on Water Use Efficiency

The term "water use efficiency" has been widely used in irrigated crop production to describe the efficiency of irrigation with respect to crop yields. In hay and forage production it has been defined as "the pounds of dry matter produced per inch of water applied." In cotton production, it has come to mean the pounds of lint produced per inch of water applied. It is particularly important in comparing different cotton types or varieties but has significance in all irrigated areas from the standpoints of water conservation and production costs. The term includes rainfall also, but for all practical purposes, rainfall in this area can be disregarded.

Actual measurements of applied water were not made in these tests, but reasonable approximations will serve for purposes of this discussion. In all tests, "water use efficiency" was much lower with more frequent irrigation. Pounds of lint per inch of applied water ranged from a high of 40 at Substation 17 in 1961 with 16-day irrigation to a low of 15 at Pecos in 1961 with 7-day irrigation. Even in those tests in which yields were increased with more frequent irrigation, the water use efficiency still was significantly higher with less frequent irrigation. Nitrogen, by increasing yields, improved water use efficiency.

With limits, of course, greater efficiency is always obtained with less water in irrigated cotton production, even with indeterminate type Acala cottons. No information is currently available in this area as to how little water is actually needed to produce a profitable cotton crop. One bale of 1517D per acre was produced at the Pecos Station in 1962 with only one summer irrigation. Further investigations are needed along this line.

Effect of Irrigation and Fertilization on Earliness

Cotton growers are well aware that early-harvested fiber usually returns the highest prices because of better grades and generally higher fiber quality. This is especially true in the Trans-Pecos area with its limited growing season, where high quality cottons of indeterminate fruiting habits are grown almost exclusively.

For this reason the effect of irrigation and fertilization on earliness is of considerable importance. In these tests, earliness was determined by the percentage of the total yield at first harvest. Generally three pickings were made, beginning when 20 to 40 percent of the bolls were open. Figures 15-19 give the percentages of seed cotton at first harvest for the tests at Substation 17, Fabens, Pecos and Fort Stockton, respectively. These data were not obtained at Van Horn because of a shortage of hand labor for harvesting.

These results are conclusive evidence that more frequent irrigation has a definite delaying effect on crop maturity. In all 10 tests, extra summer irrigations delayed maturity by significant amounts regardless of soil fertility level.

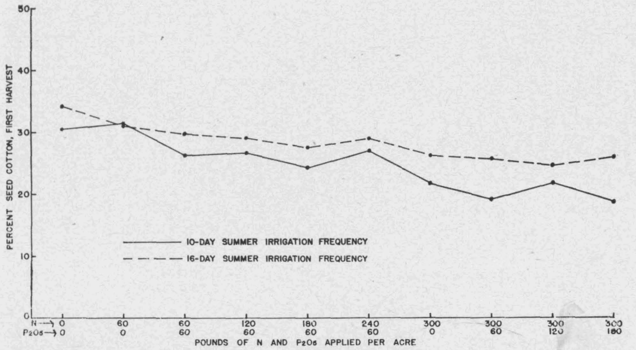

Figure 16. Two-year average percent of 1517C seed cotton harvested at first picking as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

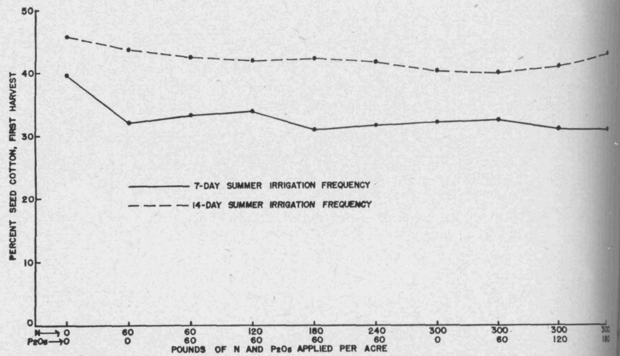

Figure 17. Three-year average percent of 1517C seed cotton harvested at first picking as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

The percentages at first harvest were lower as well as the actual amounts harvested. This effect was particularly noticeable in the 3-year average data at Substation 17 where yields were not increased by extra water and at Pecos (Figure 17) where extra water greatly decreased yields. Even at Fabens and Fort Stockton, where more frequent irrigation increased yields significantly, the percentages at first harvest were lower.

It can be concluded from these data that less frequent summer irrigation would definitely hasten maturity in this area. The Fort Stockton test (Figure 19) strongly indicates that late-summer irrigation frequency holds the key to earliness in the Acala varieties. In this test, omission of three late summer irrigations reduced yields significantly, but final yields still were 2½ bales per acre. With 20-day late-summer irrigation, harvest was completed by November 10. With continued 10-day irrigation, final harvest was completed in early December. With adverse late fall weather (early freeze) many of these bolls would have failed to open. However, these yield reductions show that some caution should be exercised in reducing late-summer irrigation frequency. These data are not sufficient to make specific recommendations. It appears that on most medium to fine-textured soils some reductions in late-summer irrigation frequency are possible without appreciable losses in yield. In areas with early first frost date (Van Horn and Dell City), the benefits of earlier maturity would more than offset slight yield reductions.

The data show that nitrogen applications generally had a slight additional delaying effect on maturity when expressed as percentage of total yield. However, there were no significant differences in **amounts** harvested at first picking (data not shown). The overall effect of nitrogen appears to be an increase in total yield brought about by prolonging of the fruiting period. Increases in yield due to nitrogen are therefore usually in the form of heavier late harvests, which can not be called a delay in maturity. This is borne out by data from no-nitrogen plots in which first harvest yields were good but late harvest yields were very light. Acute lack of nitrogen tends to make Acala cottons more determinate in their fruiting habits by reducing late-summer top growth and consequently reducing the late-boll load.

The only apparent effect of superphosphate on earliness was at Pecos in 1962, where phosphate at high nitrogen levels appeared to induce heavier yields at first harvest. There is **no evidence** in any of these tests that earliness can be improved by phosphate at recommended nitrogen rates.

Effect of Irrigation and Fertilization on Boll Characteristics

Little information is available concerning the effect of fertilizers and water on cotton boll characteristics under southwest irrigated conditions. This information should be of considerable importance not only in basic cotton research but also in the practical aspects of scientific cotton production. Boll characteristics of any particular cotton variety are largely hereditary in nature and subject only to relatively minor variations in response to environmental changes. For that reason, these variations, when they occur, are sometimes indicative of serious physiological disturbances. In addition, changes in boll characteristics can have an appreciable effect on lint yields per acre and are therefore of direct interest to the cotton grower.

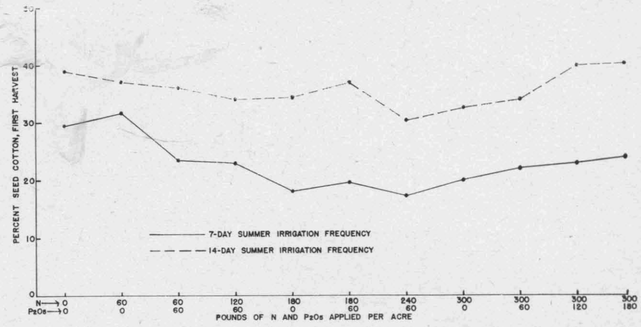

Figure 18. Average percent of 1517D seed cotton harvested at first picking as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

The four boll characteristics to be discussed here are (1) seed cotton weights per boll, (2) lint weights per boll, (3) seed weights per boll and (4) lint percent. Lint percent is closely related to but not synonymous with "gin turnout," which is always somewhat lower because of the removal of burs, trash, etc. in the ginning operation. Lint percent of 1517C cotton can vary anywhere from 39 to 33 percent as a result of changes in environmental conditions. Assuming 2-bale cotton yields, a variation of only 3 percent could mean a difference of 30 pounds of lint or about 10 dollars per acre. Lint percent or "gin turnout" depends on the relative

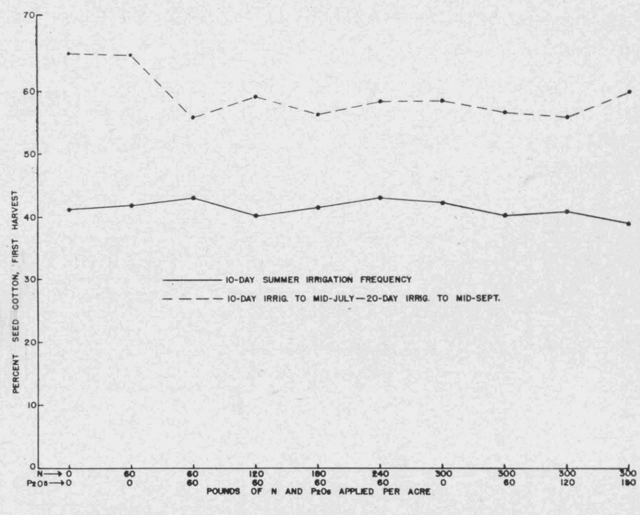

Figure 19. Average percent of 1517C seed cotton harvested at first picking as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

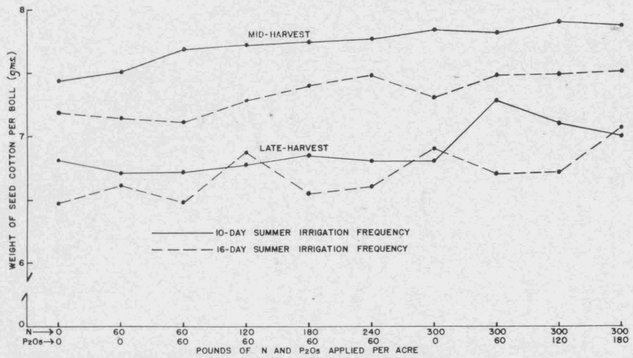

Figure 20. Three-year average weights of 1517C seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-61).

weights of lint and seed per boll. For that reason, the effect of fertilizers and water on lint and seed weights is important. Lint yields per acre also are affected by boll size and the number of bolls per plant. A variation in lint percent could be partly or entirely offset by changes in boll weight or number of bolls per plant; the opposite also could be true. A lower lint percent together with smaller bolls or fewer bolls per plant could mean a considerable loss in pounds of lint per acre.

In all field tests, 20-boll samples were carefully selected from each fertilizer and irrigation treatment — 10 bolls from each of two replications. These were taken at two different dates corresponding to mid-harvest and late harvest periods. The samples were ginned and evaluated for boll and fiber properties at the fiber laboratory at Substation 17.

No actual data were taken on stand counts or number of bolls per plant. Planting rates and row spacings varied slightly from location to location. For that reason, evaluations of boll characteristics will be made at each individual location. Comparisons between locations would not be entirely justified.

Substation 17

Figures 20-23 show the effects of irrigation frequency and fertility level on boll weight, lint weight, seed weight and lint percent, respectively, at Substation 17. All data are 3-year averages.

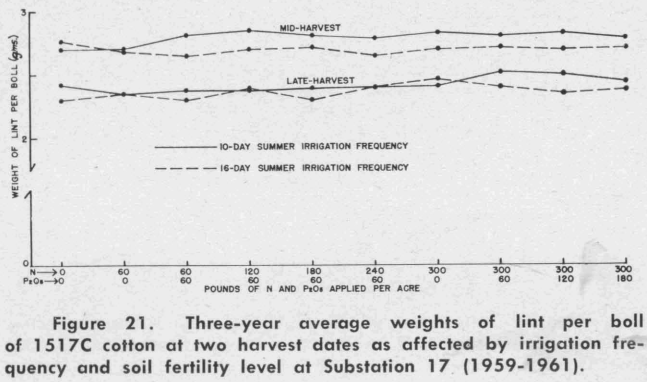

Figure 21. Three-year average weights of lint per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

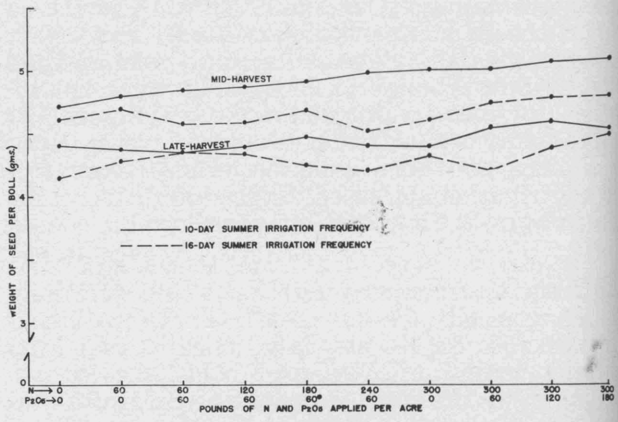

Figure 22. Three-year average weights of seed per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

Boll weights (Figure 20) are by nature subject to considerable variation. Different bolls on the same plant, maturing at the same time, may differ considerably in seed cotton weight. This is caused only partly by location of the boll on the plant. Minor variations in boll weight curves should therefore be disregarded, and only the more obvious conclusions should be drawn.

Greatest differences in boll weights were due to irrigation frequency. At mid-harvest, seed cotton weights were significantly heavier with more frequent (10-day) summer irrigation. These differences averaged 0.4 gram per boll. A similar but less noticeable effect was evident at late harvest. Differences in boll weight at this date averaged 0.18 gram in favor of more frequent irrigation.

Figures 21-22 show that these same differences occurred in weights of both lint and seed per boll, with the greatest effect being on seed weights. As will be seen later, this same effect was true to some extent in all tests where cotton was deep-rooted and healthy, and was particularly noticeable at Fort Stockton where late-season soil moisture was very low in some plots. It can be concluded with reasonable certainty that one

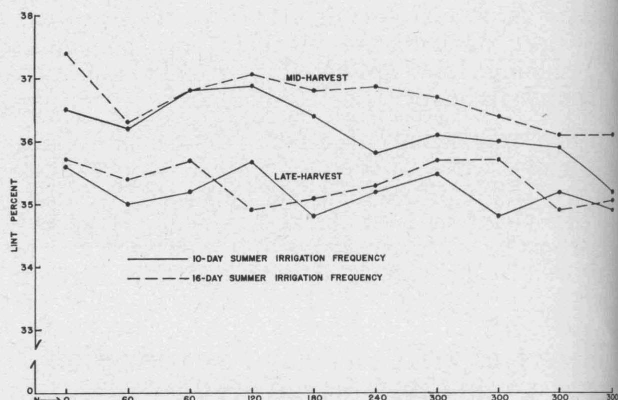

Figure 23. Three-year average lint percents of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

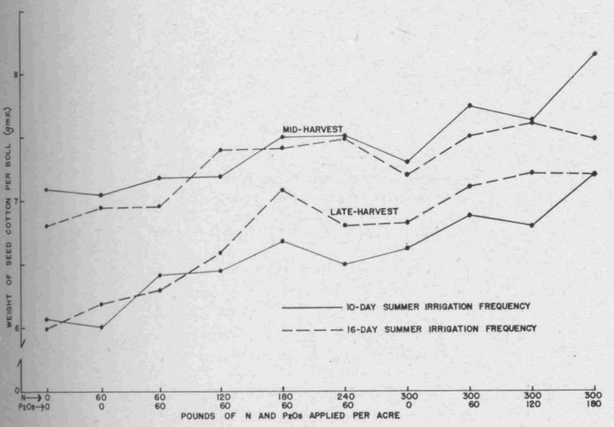

Figure 24. Two-year average weights of 1517C seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

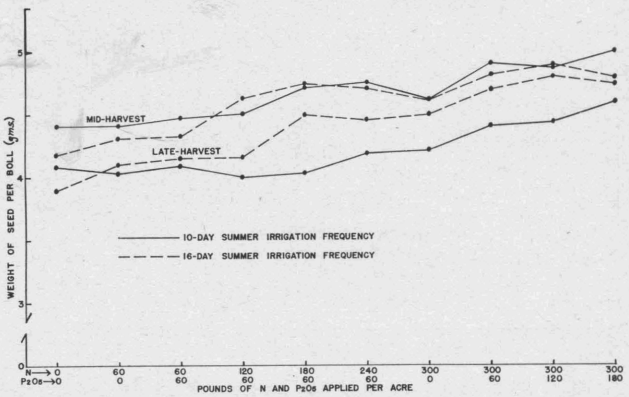

Figure 26. Two-year average weights of seed per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

result of more frequent irrigation during the fruiting season is to increase boll weight, with greater effect on seed than on lint. Seed weight increases at Substation 17 averaged 0.27 grams per boll at mid-harvest and 0.12 grams at late harvest. Corresponding lint weight increases were 0.10 and 0.05 grams.

The effect of more frequent irrigation in increased seed weights is reflected in the lint percent data (Figure 23). Mid-harvest lint percents averaged 36.7 for 16-day irrigation as compared to 36.2 for 10-day irrigation. These differences were small but significant. Late harvest differences were much less (0.2 percent).

The effect of maturity date on all boll characteristics should be noted. Late-harvested bolls were much lighter in weight at both irrigation frequencies. Both seed and lint weights were lower. Lint percent was also appreciably lower. These effects were strongly evident in all tests at all locations and are partly associated with lower temperatures during late-season boll development. For this reason alone, growers should strive to alter management practices so as to obtain earlier maturity.

Nitrogen increased both boll weights and seed weights appreciably at mid-harvest, with greatest increases occurring at the highest nitrogen levels. This response to nitrogen was evident in all tests at all locations, as will be observed later. In contrast, lint weights per boll were relatively unaffected by nitrogen. This too was essentially true in all tests. Lint weight appears to be the most stable of all boll characteristics measured in these tests at any given harvest date. It is affected only slightly by irrigation frequency and scarcely at all by fertilizers. It is concluded that the principal effect of nitrogen on boll weight can be attributed to its action in increasing the weight of seed.

The effect of phosphate on boll characteristics at Substation 17 was variable and difficult to evaluate. Some slight increases in seed weight at high nitrogen levels may have been due to phosphate applications. There was no consistent effect of phosphate on either lint weight or lint percent.

Fabens

Figures 24-27 show the 2-year average boll characteristic data for the Fabens tests. Some distinct differences were evident between these results and those at Substation 17 for reasons not entirely clear at this time.

More frequent summer irrigation increased boll weight slightly at mid-harvest but not at late harvest. Additional water also did not increase

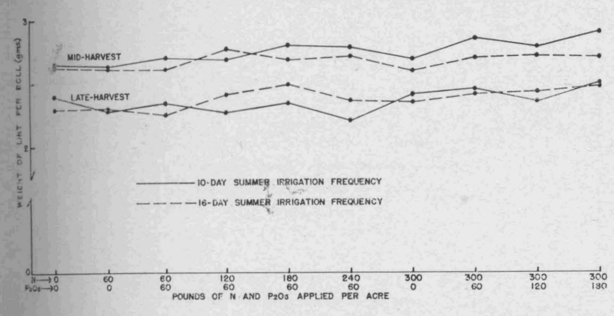

Figure 25. Two-year average weights of lint per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

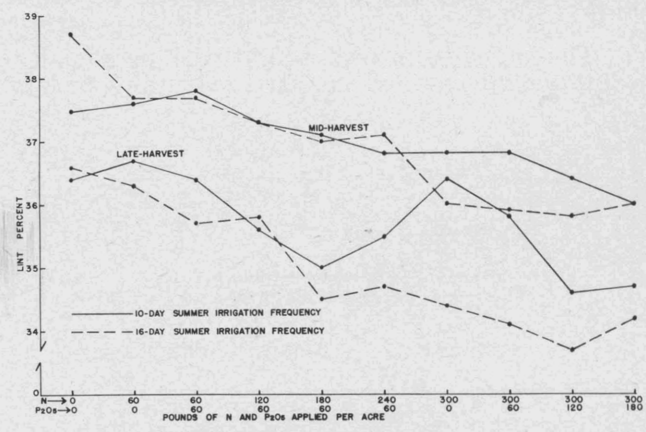

Figure 27. Two-year average lint percents of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

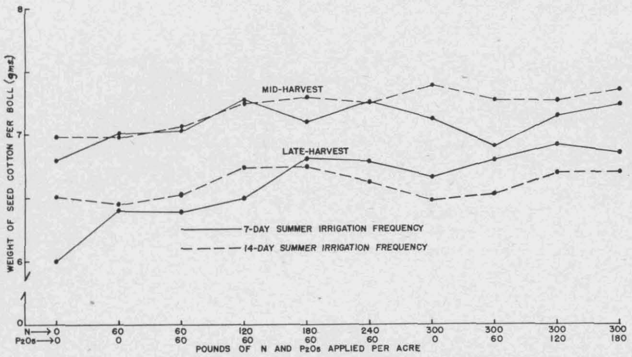

Figure 28. Three-year average weights of 1517C seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

seed weights at mid-harvest, and late harvest seed were definitely lighter with 10-day irrigation. As will be seen from the tests at Pecos, Fort Stockton and Van Horn, the Fabens results were exceptional and indicate that some factor was disturbing normal plant functions to some extent. This could have been caused by excessive soil moisture or "wet feet" effects at intervals during the fruiting period.

Other effects were more or less similar to those at Substation 17. Later maturing bolls showed definite reductions in boll weight, lint weight, seed weight and lint percent. These reductions occurred at all fertility levels and at both irrigation frequencies.

The effect of nitrogen and phosphate on boll and seed weights was more apparent here than at Substation 17. Boll weights were increased approximately 10 percent by the highest fertilizer rates at both irrigation frequencies. Both nitrogen and phosphate were effective in this respect. Seed weights were increased in similar manner. One effect of more shallow rooting appears to be a greater response to applied fertilizer on these alluvial soils. The almost complete lack of response to fertilizer by outside skip rows at Substation 17 in 1961 adds weight to this conclusion. As at Substation 17, lint weights per boll were relatively unaffected by either nitrogen or phosphate.

The increases in seed weight with no changes in lint weight resulted in sharp reductions in lint

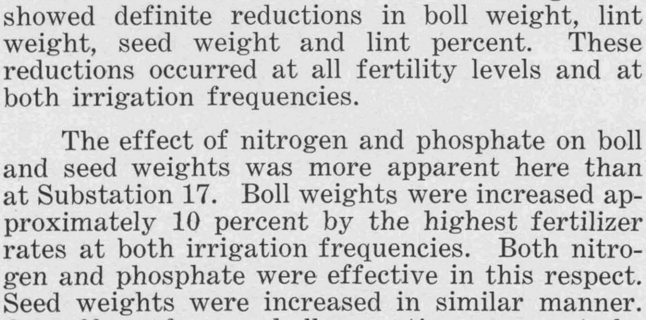

Figure 29. Three-year average weights of lint per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

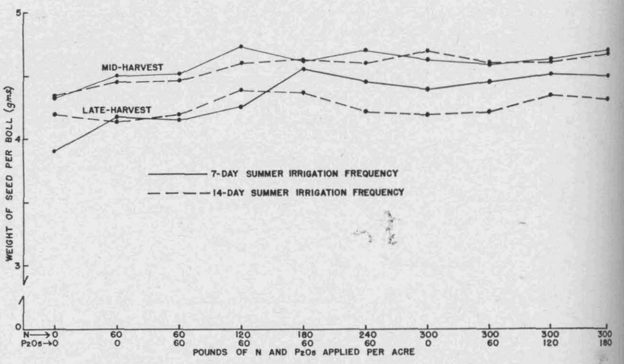

Figure 30. Three-year average weights of seed per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

percent as fertility rates increased. Lint percents were reduced 1½ to 2½ percent by heavy fertilization, regardless of irrigation frequency. This effect was observed at Substation 17 but was much more apparent here.

Pecos

The considerable effect that different soil conditions can have on boll properties is clearly evident in the four tests at Pecos. As previously described, the tests from 1959 to 1961 were conducted on level runs with disastrous effects on yields from excessive soil moisture and adverse soil physical conditions. The 1962 test on 0.4 percent slope gave greatly different yield results because neither high soil moisture nor poor soil physical conditions were limiting growth.

Figures 28-31 give the 3-year average boll characteristics data for the tests on level runs. Figures 32-35 give similar data for the 1962 test on 0.4 percent slope. Acala 1517D, grown in the 1962 test, has similar boll properties to 1517C, and comparisons between the tests are justified.

The effect of soil conditions on boll weight (Figures 28 and 32) was obvious. In the level run tests there were no significant differences in boll weights due to irrigation frequency. How-

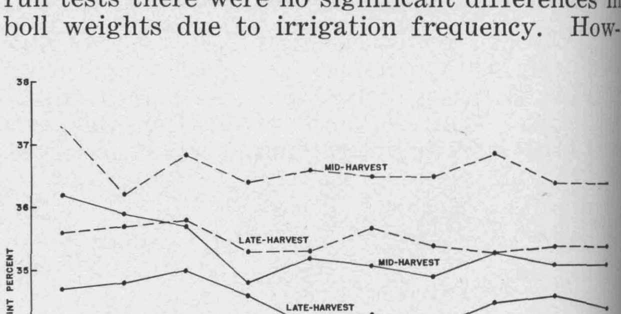

Figure 31. Three-year average lint percents of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

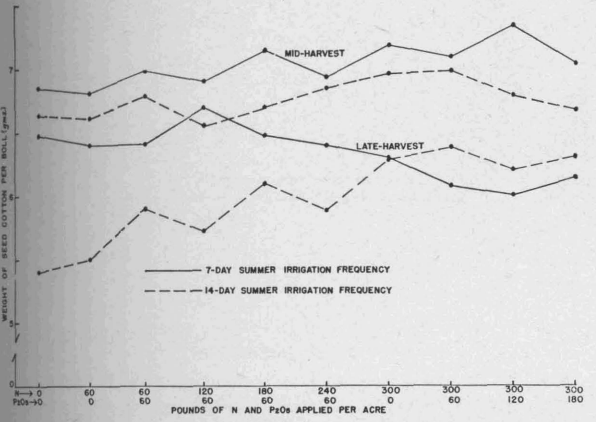

Figure 32. Average weights of 1517D seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

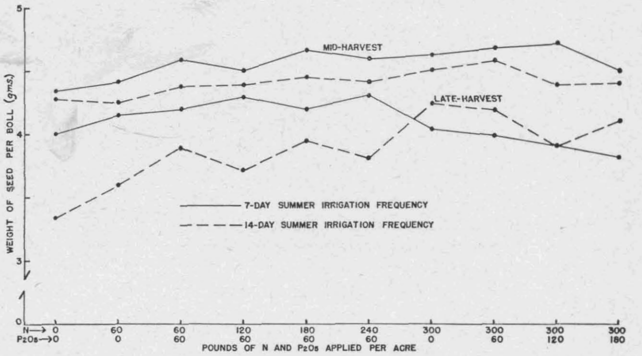

Figure 34. Average weights of seed per boll of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

ever, on 0.4 percent slope, frequent (7-day) irrigation produced definitely heavier bolls at both mid-harvest and late harvest, and these differences were evident at all fertility levels except high nitrogen at late harvest. There seems little doubt that more normal growth processes were represented on the sloping runs. On level runs, these normal physiological processes were disturbed, particularly with frequent irrigation.

Lint weights per boll also showed considerable differences between the level and sloping tests. On level runs (Figure 29) 7-day irrigation resulted in significantly **smaller** weights of lint per boll at both mid-harvest and late harvest. The reverse was true on sloping runs. As indicated at Substation 17, more frequent irrigation normally contributes to slightly heavier lint weights per boll.

Seed weights per boll likewise were affected by the differences in irrigation design. On level runs (Figure 30) there were no significant differences between seed weights with 7 and 14-day irrigation at mid-harvest. On sloping runs (Figure 34) mid-harvest seed were definitely heavier with 7-day irrigation. Clear-cut differences between these tests were also present in late-harvest seed weight data.

These striking differences in boll characteristics were strongly reflected in lint percents (Figures 31 and 35). Although higher lint percents occurred with less frequent (14-day) irrigation on both level and sloping runs, the differences due to irrigation frequency were much greater with level irrigation. These averaged 1.3 and 1.0 percent for mid-harvest and late harvest, respectively, on level runs as compared with 0.5 percent and no difference on sloping runs. This further indicates the definitely adverse effects of frequent irrigation on level fields on this soil type.

The effect of maturity date on boll characteristics again was apparent in the Pecos tests. Later maturing bolls showed significant reductions in boll weight, lint weight, seed weight and lint percent regardless of irrigation design or irrigation frequency.

As in the Substation 17 and Fabens tests, nitrogen applications resulted in generally larger boll weights and seed weights per boll. Lint weights per boll again were little affected by nitrogen . Consequently, lint percents were accordingly lowered by higher rates of nitrogen. Reductions in lint percent due to nitrogen were greatest on sloping runs.

There was little evidence that phosphate had any effect on boll characteristics at the 60-pound nitrogen levels. However, additions of phosphate at the highest nitrogen rates showed some tendency to increase both boll and seed weights on the level border tests (Figures 28 and 30).

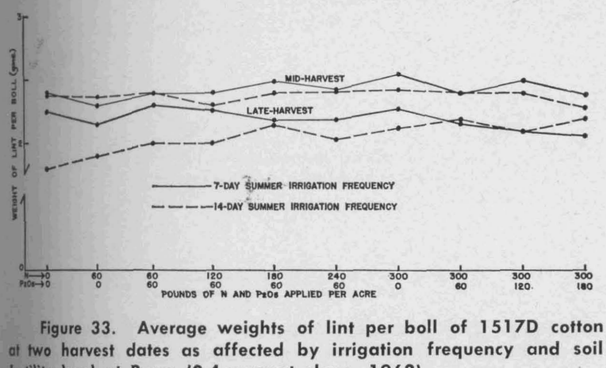

Figure 33. Average weights of lint per boll of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

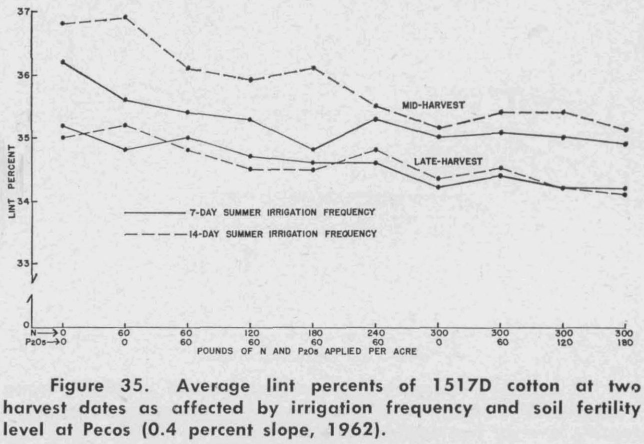

Figure 35. Average lint percents of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (0.4 percent slope, 1962).

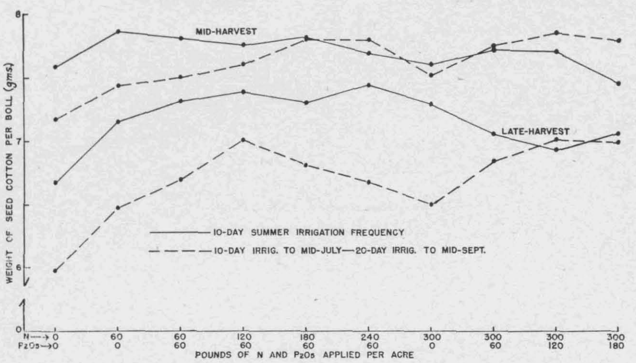

Figure 36. Average weights of 1517C seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

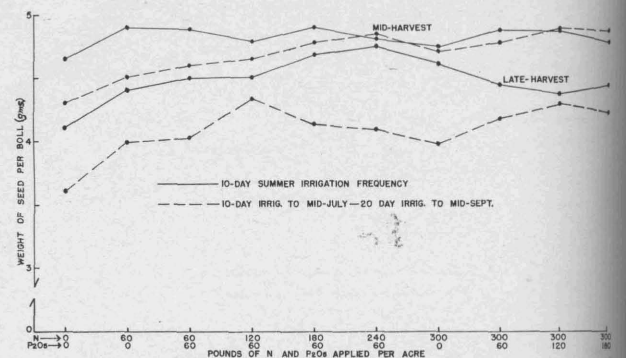

Figure 38. Average weights of seed per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

Fort Stockton

The tests at Fort Stockton on deep, fertile Reeves loam in 1960 was primarily concerned with the effects of differential late-summer irrigation frequency on cotton growth and yields. However, boll characteristics as well as yields and earliness were affected by the elimination of three late-summer irrigations. Figures 36-39 show the results of this test on boll weight, lint weight, seed weight and lint percent, respectively.

Lengthening the interval between irrigations to 20 days in late summer did not greatly affect boll weights or seed weights at mid-harvest. Late-harvest boll and seed weights, however, were greatly reduced in weight. Lint weights were not greatly affected, therefore most of the loss in boll weight can be attributed to lighter seed. Apparently, depletion of soil moisture in the 20-day plots in September and October was great enough to reduce strongly the moisture content of late harvest seed. Some leaf wilting was apparent on these plots before defoliation in early October. No wilting occurred on 10-day irrigated plots.

The lower late-harvest seed weights on the 20-day plots had a significant effect on lint percent (Figure 39). Cotton on these plots showed exceptionally high lint percents both at mid-harvest and late-harvest. These averaged 38.3 and 38.9 percent, respectively, compared with 37.3 and 36.9 percent for 10-day irrigated cotton, an overall increase of 1½ percent. Calculations indicate that about 10 percent of the seed cotton yield reduction from less water (Figure 10) was therefore due to loss of moisture from the seed and not an actual lint loss.

Although specific recommendations cannot be made without further studies, there is a possibility that many Trans-Pecos cotton growers could profit from some moderate reductions in irrigation frequency during August and September. This would particularly apply to tall, rank cotton on finer textured soils. Benefits to be expected would be earlier harvest, higher grades and higher gin turnout. Caution should be exercised to avoid drastic water reductions with consequent yield losses as occurred in this test.

Although nitrogen had no effect on yields in this test, it did increase seed weights (Figure 38) and late-harvest lint weights (Figure 37). The effect of phosphate on yields, previously noted, can be seen in increased boll weights and seed weights, particularly at the highest nitrogen levels.

Van Horn

Results of the last test, on deep sandy loam soil at Van Horn in 1962, substantiate previous conclusions in many respects. Data are given

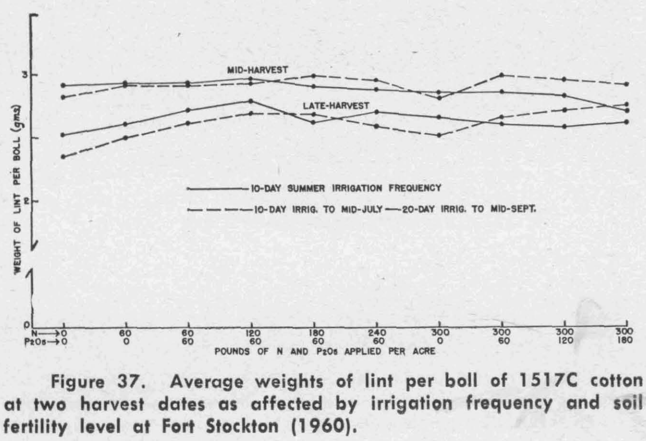

Figure 37. Average weights of lint per boll of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

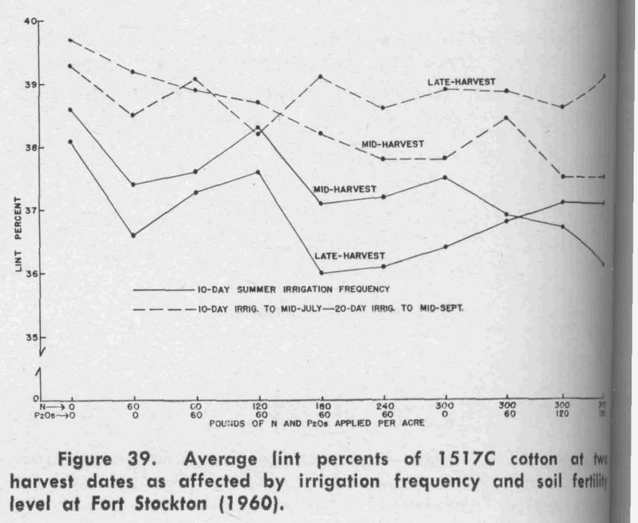

Figure 39. Average lint percents of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

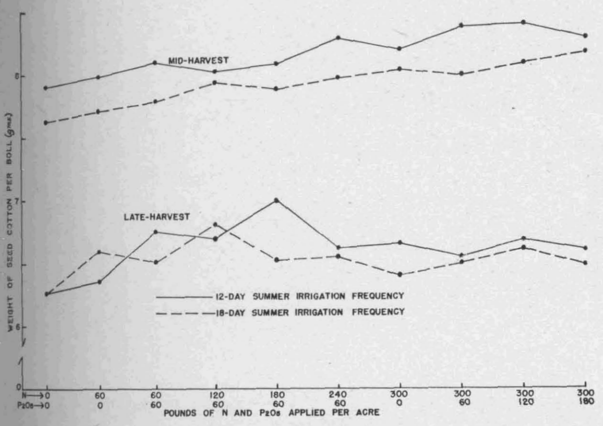

Figure 40. Average weights of 1517D seed cotton per boll at two harvest dates as affected by irrigation frequency and soil fertility level at Van Horn (0.1 percent slope, 1962).

in Figures 40-43. In this test, irrigation frequencies from mid-June to early September were every 12 and 18 days.

As in other tests, more frequent summer irrigation resulted in definitely heavier boll weights at mid-harvest, with the effect still noticeable at late-harvest. It also increased lint weights and seed weights appreciably at mid-harvest. Lint percents were considerably lowered at all fertility levels at late harvest but only at high nitrogen levels at mid-harvest.

This test shows that more frequent irrigation may result in heavier boll, lint and seed weights, yet yields of seed cotton may actually be **decreased.** Extra water contributed to heavier bolls but fewer bolls per plant, even though the plants were larger. This condition probably exists in many fields where shading in tall rank cotton often results either in excessive shedding of flowers and small bolls or in a tendency to remain vegetative, with less total flower and boll production. At present, lack of sufficient light appears to be the primary cause of lower yields in tall dense cotton. Answers to the problem may be (1) less frequent irrigation, (2) skip-row planting, (3) wider row spacings or (4) fewer plants per foot of row, any or all of which might be effective.

Once again, nitrogen increased both boll and seed weights at mid-harvest, while again having little effect on lint weights per boll. At late harvest, however, boll weights and seed weights dropped significantly at fertilizer rates above the 180 N-60 P_2O_5 level. No logical explanation is immediately available. It may have been due to production of more bolls per plant at high nitrogen levels on this sandy soil.

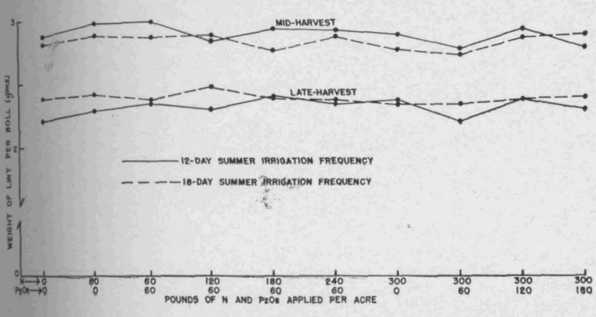

Figure 41. Average weights of lint per boll of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Van Horn (0.1 percent slope, 1962).

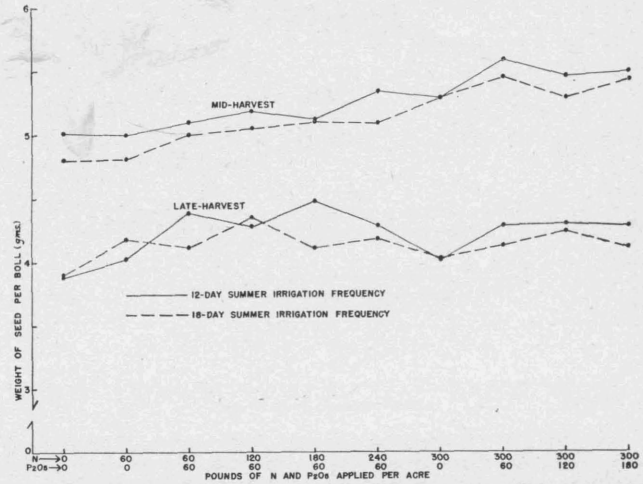

Figure 42. Average weights of seed per boll of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Van Horn (0.1 percent slope, 1962).

Phosphate had no effect on lint weights but showed a tendency to increase boll and seed weights slightly, particularly at high nitrogen levels. The effects of maturity date on boll characteristics again were evident.

Effect of Irrigation and Fertilization on Fiber Properties

The quality of cotton fiber is currently based on measurements of the three characteristics, length, strength and fineness, each of which is highly genetic in nature. In most presently grown varieties, these fiber characteristics are the result of many years of breeding research and are not subject to appreciable variation caused by environmental conditions. Within any particular variety these three characteristics vary within narrow limits, and for this reason, variety name

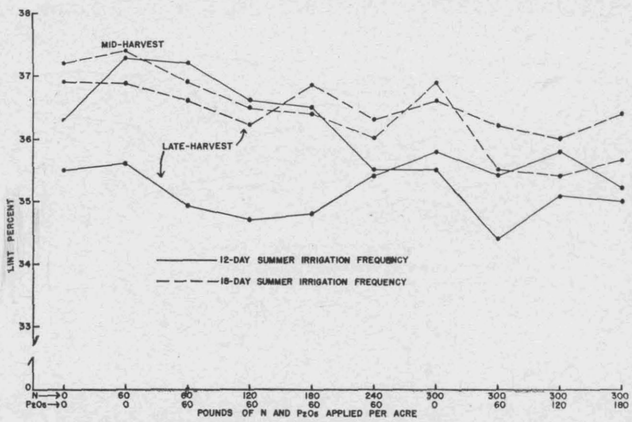

Figure 43. Average lint percents of 1517D cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Van Horn (0.1 percent slope, 1962).

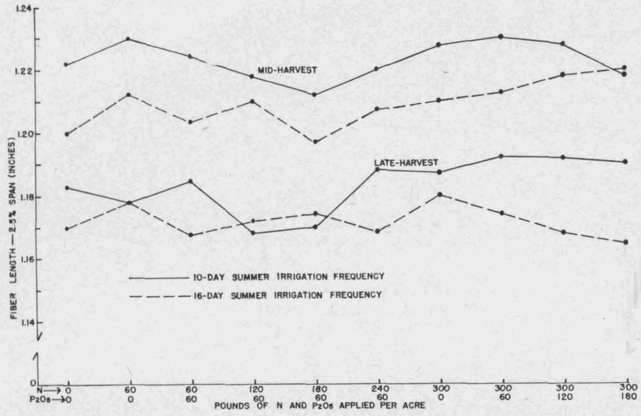

Figure 44. Three-year average fiber length (2½ percent span) of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

has come to be almost synonymous with a specific quality of fiber.

In order to determine how much, if any, variation in fiber properties could occur because of irrigation and fertility differences, fiber samples from all 1959-61 tests were analyzed in the fiber laboratory at Substation 17. Analysis of 1962 samples had not been completed, so these results could not be reported.

Fiber Length

Fiber length measurements are complicated by the fact that any ginned lint sample contains strands varying greatly in length. The most significant measurement of fiber length, or staple, has for many years been the "upper half mean," a measure of the average length of the longest half of the fibers in a given sample. In recent years a new digital fibrograph has come into use which measures a similar value called the "2½ percent span length." For all essential purposes, "upper half mean" and "2½ span length" are equivalent and comparable. Figures 44-46 give the 2 or 3 year average 2½ percent span length data for the Substation 17, Fabens and Pecos tests, respectively. Figure 47 gives the 1-year data from the Fort Stockton test.

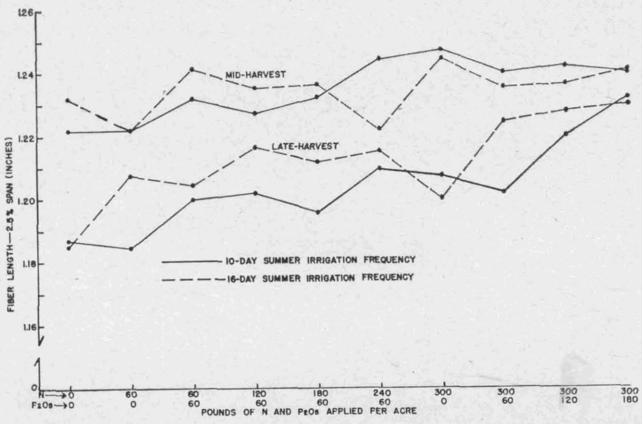

Figure 45. Two-year average fiber length (2½ percent span) of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

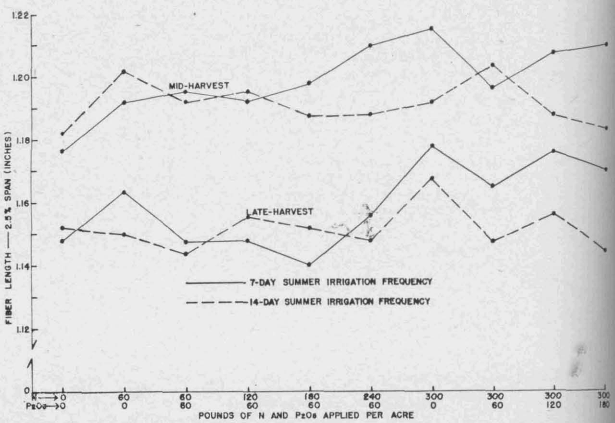

Figure 46. Three-year average fiber length (2½ percent span) of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

In all tests, one fact becomes immediately apparent. Late-harvested fiber was somewhat shorter than mid-harvested fiber, regardless of irrigation frequency or fertility level. This effect of maturity date on fiber length was significant in all tests, differences averaging between 0.03 and 0.04 inches in each. However, these reductions in length with later maturity were small and might escape detection by cotton classers.

It is important to recognize that maturity date does have an effect on fiber length in this area. Most late-harvested bolls are set, and their fiber length determined, in late August and early September. The generally cooler temperatures and less intense sunlight at this time of year may be responsible for the shorter fiber. Whatever the cause, this again emphasizes the importance of striving for early maturity.

The effect of irrigation frequency on fiber length was not the same in all tests. The Fabens and Pecos tests showed no significant differences at either maturity date. Those at Substation 17 showed a slight but definite length increase from 10-day irrigation at mid-harvest but not at late

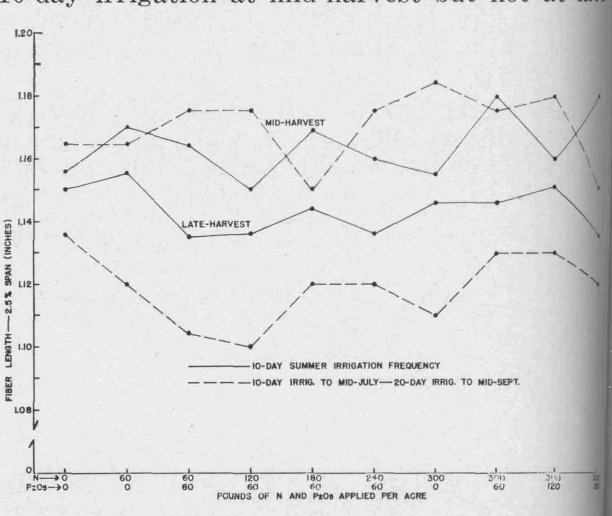

Figure 47. Average fiber length (2½ percent span) of 1517C cotton at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

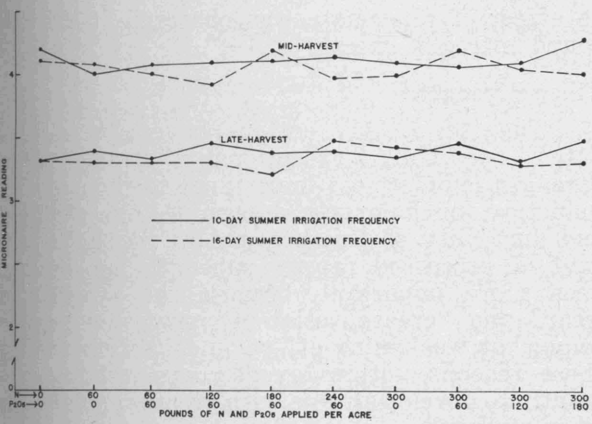

Figure 48. Three-year average micronaire (fineness) of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

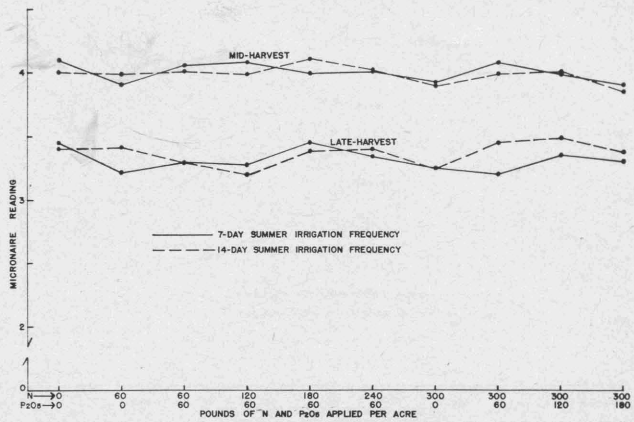

Figure 50. Three-year average micronaire (fineness) of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

harvest. Results at Fort Stockton, where late-harvest soil moisture was very low in certain plots showed a significant difference (favoring 10-day irrigation) at late harvest but not at mid-harvest. It appears that the effect of irrigation frequency on fiber length may be toward slightly longer fiber with more frequent irrigation but these differences, when they occur, are small and probably not of any practical importance.

Fiber length also appeared to be relatively unaffected by soil fertility level. A tendency at Fabens toward increases in length at higher fertility levels was small and not apparent in the other tests.

Fiber Fineness

Fineness of 1517C fiber, as measured by the micronaire, ranges from a high of about 4.2 at mid-harvest to a low of about 3.0 at late harvest. The micronaire measurement is performed primarily to determine fiber maturity. For the spinning of high quality yarn, mills prefer that this cotton have a micronaire value of 3.5 or above. Values lower than this usually indicate some degree of immaturity, with consequently poorer spinning qualities. Strength of individual fibers is also closely related to fineness.

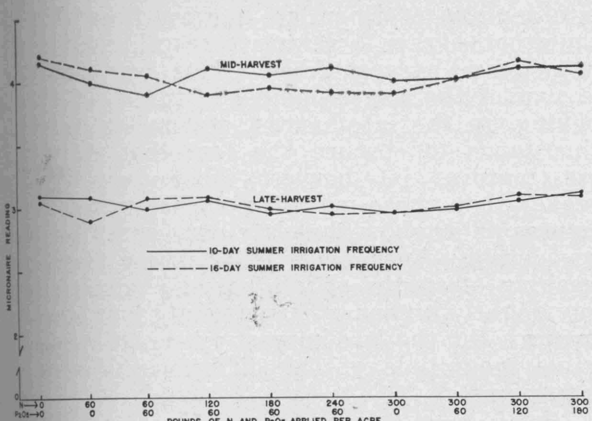

Figure 49. Two-year average micronaire (fineness) of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

Figures 48-50 show the 2 and 3 year average micronaire measurements of fiber samples from the Substation 17, Fabens and Pecos tests, respectively. Figure 51 gives 1-year data for the Fort Stockton test. All values reported are averages of four separate measurements.

It can readily be seen that irrigation frequency had little or no **direct** effect on fiber fineness in any of these tests. This was true of both mid-harvest and late-harvested cotton. Minor fluctuations in the curves must be attributed partly to variation inherent in the micronaire procedure and in boll sampling. However, insofar as its effect on maturity is concerned, irrigation frequency had a significant effect upon fiber fineness. Tests at all four locations showed definitely lower micronaire readings (finer fiber) at late harvest than at mid-harvest. The effect of more frequent irrigation on delay of maturity (previously discussed) would therefore also contribute to fiber immaturity. This fact is of considerable importance where high quality cottons such as 1517C are grown in areas with limited growing season, such as the Trans-Pecos region. It appears that bolls set progressively later than September 1 in this area will produce fiber that tends to be more and more immature, regardless of water and fertilizer management. The factors responsible are probably both climatic and physiological.

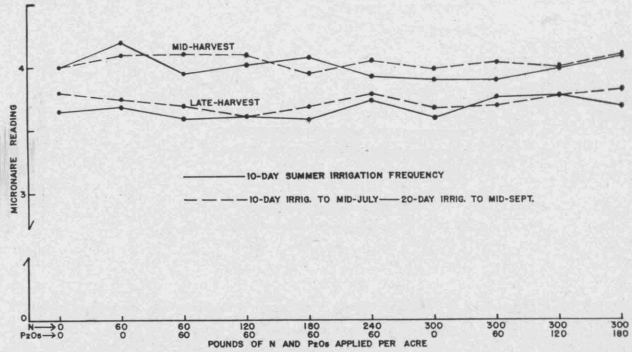

Figure 51. Average micronaire (fineness) of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

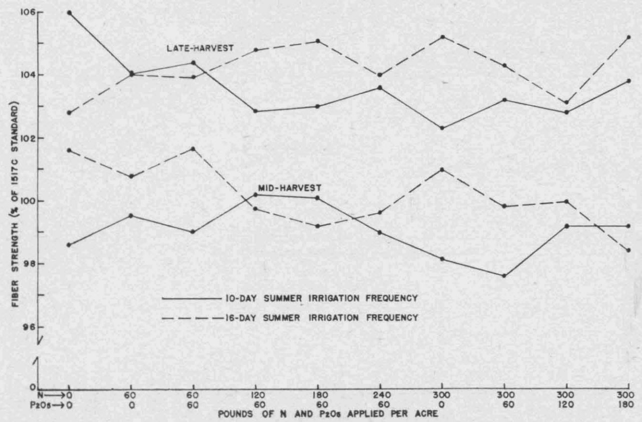

Figure 52. Three-year average strength of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1961).

The effect of nitrogen on fiber fineness is also related to boll maturity date. Both mid-harvest and late-harvest data at all locations show that nitrogen additions did not directly affect micronaire readings at either irrigation frequency. Nitrogen did, however, increase yields significantly in all but the Fort Stockton test, and these yield increases from the higher nitrogen plots were largely in the form of heavier late-season pickings. In this respect, then, nitrogen also could be said to contribute to fiber immaturity.

These data again emphasize the importance of proper nitrogen fertilization. Without question, cotton requires some nitrogen for most profitable production. Yet nitrogen in amounts above that required for good yields **seldom** results in higher yields, **always** adds to production costs and **may** contribute to fiber immaturity, invariably found in late-maturing bolls.

There was some indication (Figures 49-51) that phosphate additions at the 300-pound nitrogen levels had a slight tendency to improve micronaire readings. This was probably because of greatly unbalanced fertility conditions, since

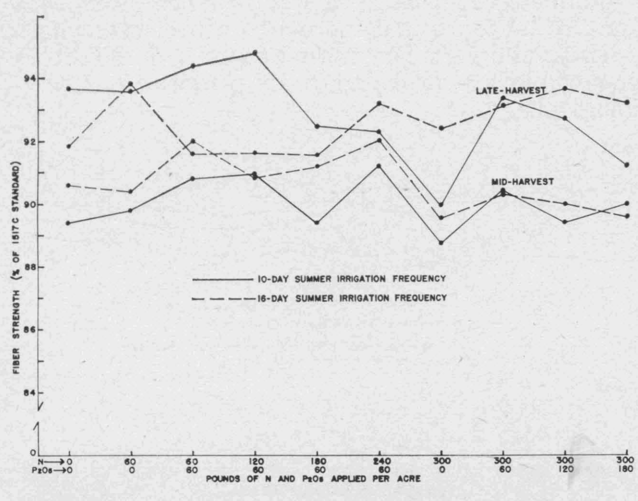

Figure 53. Two-year average strength of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Fabens (1959, 1961).

no effect of phosphate was observed at the 60-pound nitrogen rates.

Fiber Strength

The Acala 1517 cottons have always been noted for their exceptionally strong fiber. Strength is of utmost importance to the spinning industry, for it largely determines the strength and durability of finished goods. With the advent of processed fabrics, strength has become even more important, because the "wash and wear" and "crease resistant" processes have a somewhat weakening effect on cotton fiber. For these reasons, cotton breeders are striving constantly to develop strains with greater and greater fiber strength.

Within any particular cotton variety, strength of individual fibers is an indicator of fiber maturity. Fully mature fibers invariably are stronger than less mature fibers whose cell walls have not been fully developed. Strength and fineness are therefore closely related.

The situation is complicated by the fact that the current stelometer method of measuring fiber strength actually measures the breaking point of a given **weight** of parallel fibers, rather than the strength of individual fibers. Thus, the stelometer values may be misleading. The situation may be explained as follows: A heavy-gage wire may be much stronger than a fine-gage wire, yet if enough fine-gage wire is combined to form an aggregate as thick as the heavier wire, the strength of the combined fine wires may be greater. This, as will be seen, can be true of cotton fiber.

Figures 52-55 show that the stelometer strength values for the samples from the tests at four locations. These values are reported here as percentages of the breaking strength of standard 1517C samples, which were run concurrently. As in the micronaire procedure, some variability was inherent in the stelometer measurements, which largely accounts for the zigzag nature of the curves.

Figures 52-54 show the effect of fiber fineness on stelometer-breaking strength. Aggregate samples of finer late-harvest fiber showed somewhat higher breaking strength than more mature mid-harvest fiber. This was probably because of the larger number of individual fibers making up the late-harvest stelometer samples. This tends to obscure the fact that individual less mature, late-harvest fibers are usually weaker than those maturing earlier in this area. Figures 48-50 show that late-harvested fiber was considerably finer than mid-harvest fiber, yet breaking strengths of late-harvest samples were only slightly higher. This strongly indicates less strength for the late-harvest fiber, although the actual magnitude of the differences cannot be determined.

Neither irrigation frequency nor soil fertility level had much direct effect on fiber strength. Overall values showed no significant differences for the tests at Substation 17 and Fabens, although there was a tendency for more frequent irrigation to produce slightly weaker fiber. At Pecos, where soil physical conditions on level runs were adversely affected by frequent irrigation, there was a definite weakening effect on mid-harvest fiber, although actual percentage differences were not great. Only at Fort Stockton, under widely different late summer irrigation, were appreciable differences in strength noted. Here drastic reductions in late-season irrigation resulted in significantly stronger mid-harvest fiber at all fertility levels. These differences largely disappeared at late harvest.

Effect of Irrigation and Fertilization on Incidence of Verticillium Wilt

There is considerable research evidence to show that both irrigation frequency and nitrogen applications have a significant effect on the incidence of verticillium wilt, caused by the soil-borne fungus *V. albo-atrum*. This pathogen attacks a wide range of cultivated crops and is particularly damaging to irrigated cotton on the finer textured soils of the Southwest. This fungus can exist in cultivated soils for many years, but it multiplies rapidly in the presence of a susceptible crop like cotton. It enters the plant through the roots and gradually spreads throughout the plant. It apparently damages the plant chiefly by plugging the sap-conducting tissues with some metabolic product. This shows as brownish discolorations when infected stems are cut. Although the plants seldom are killed, the disease causes leaf wilting and leaf necrosis, with subsequent shedding of all leaves and petioles in severe cases. This usually occurs in late summer during the boll-maturation period. Leaf shedding causes virtual cessation of normal plant functions. The two most damaging effects are failure of fiber to mature in bolls already set and reductions in yields caused by the absence of normal late-season boll set. Fiber from verticillium-infected plants is always of inferior quality. At present, there is no satisfactory control of this disease.

The effect of irrigation frequency and soil fertility level on severity of verticillium wilt was studied in the tests at Substation 17 during 1959-60. The test area was moderately infected with wilt before 1959, but the disease became more severe on certain plots as a result of irrigation and fertilization during the test period. To study this, counts of visibly wilt-infected plants were made on all plots in September 1959. The plots were then replanted in the identical locations in 1960 to study the cumulative effects of two years of similar management. Figure 56 shows the average number of infected plants per plot for each treatment in each of the two years, expressed as percentages of the total plant population.

Several conclusions can be drawn from these results. It is apparent that adverse effects

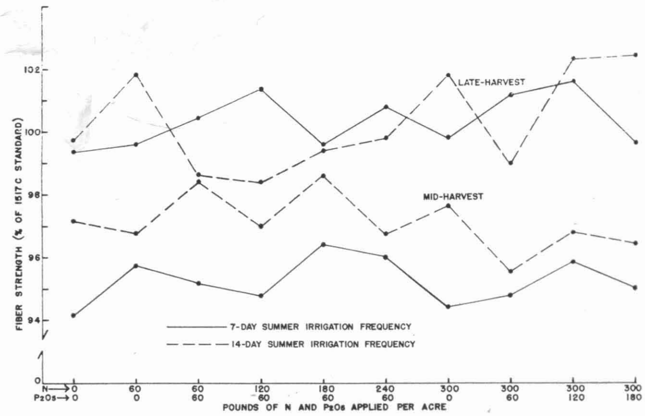

Figure 54. Three-year average strength of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Pecos (level irrigation, 1959-1961).

caused by high soil moisture were major factors affecting the increased severity of the disease. In both 1959 and 1960, plots getting more frequent irrigation showed the highest percentage of infection. Frequent irrigation accounted for an average disease increase of 37 percent in 1959 and 58 percent by the fall of 1960. This cumulative effect indicates that continued frequent irrigation can cause rapid buildup of verticillium within only a few years' time.

The data also show that applications of nitrogen may be instrumental in increasing the incidence of the disease. Although not so evident in 1959, the effects of nitrogen became more apparent in 1960 with more frequent irrigation. The combination of high soil moisture and high nitrogen brought about a rapid increase in the percentage of infected plants, either by a buildup of the organism in the soil or by making the plants more susceptible to infection, or both.

Under certain conditions, the application of phosphate also tended to increase wilt incidence. This was evident in 1960 with frequent irrigation at high nitrogen levels. The effect of phosphate was variable, however, and not so consistent as that due to nitrogen. These re-

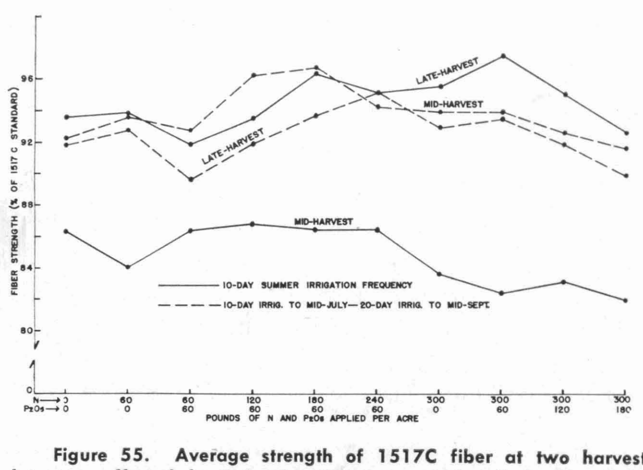

Figure 55. Average strength of 1517C fiber at two harvest dates as affected by irrigation frequency and soil fertility level at Fort Stockton (1960).

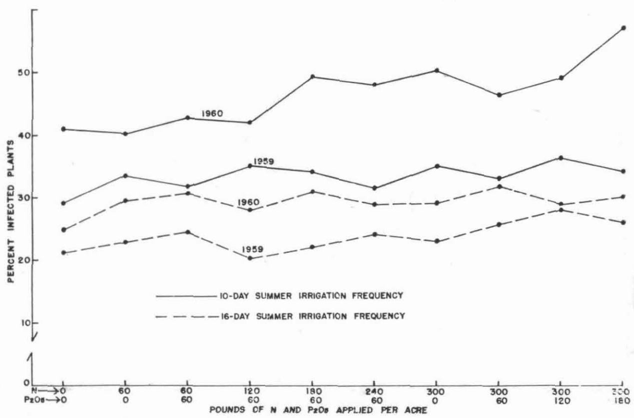

Figure 56. Severity of verticillium wilt (percent of infected plants) as affected by irrigation frequency and soil fertility level at Substation 17 (1959-1960).

sults and those of other research workers present strong evidence for conservation of both water and fertilizer on wilt-infected soils. Once soils are severly infected it becomes almost impossible to grow cotton profitably, and the disease persists as long as susceptible crops are grown.

Need for Other Nutritional Elements

Soils of semi-arid desert regions such as Far West Texas are formed primarily through the physical processes of rock weathering and contain large amounts of primary minerals. These minerals decompose slowly under irrigated cropping and supply the crops with small but ample quantities of various minerals required only in trace amounts for normal plant growth namely, iron, manganese, zinc, copper, boron and molybdenum. Potassium, calcium and magnesium, required in relatively large quantities, are also derived from these primary minerals in amounts more than sufficient for normal growth. In addition, all waters used for irrigation contain appreciable amounts of soluble salts which supply

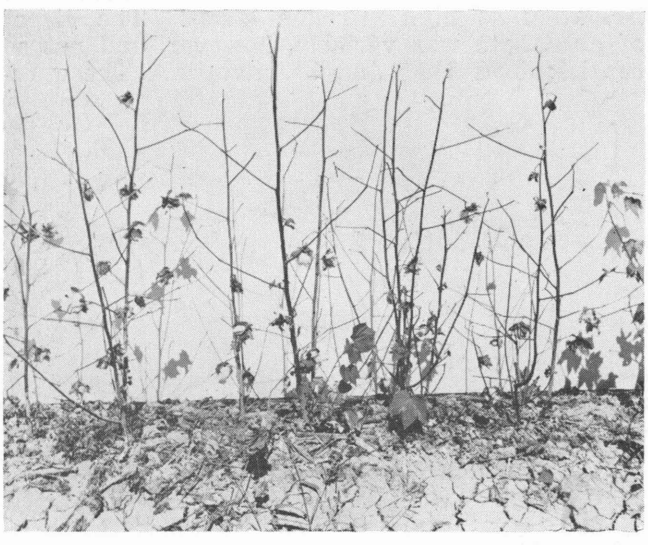

Figure 57. Upland cotton severely infected with verticillium wilt in the El Paso Valley. Both yields and fiber quality are adversely affected.

large additional quantities of potassium, sodium, calcium, magnesium and sulfate, as well as trace amounts of boron and other elements. Irrigation waters alone can add from 300 to 600 pounds each of soluble sodium, calcium, magnesium and sulfate, as well as 100 to 150 pounds of potassium per acre per year to cultivated soils.

There is virtually no possibility that any of the so-called secondary elements (calcium, magnesium, sulfate) could become deficient in Trans-Pecos irrigated soils. Numerous field tests in this area and in New Mexico and Arizona also have failed to show any response of cotton to additions of potassium. Likewise, many soil tests have shown more than ample quantities of soluble potassium to be present in these soils, regardless of soil texture. It is highly unlikely that any except possibly very sandy soils would require additions of potassium for normal cotton growth. More potassium is added in the water each year than is removed in the cottonseed. The lint is virtually pure cellulose, and contains no fertlizer, secondary or trace minerals.

To be certain that cotton did not require additions of any of the trace minerals (iron, manganese, zinc, copper, boron, molybdenum) for normal growth and fruiting, each of the 1959 and 1960 tests discussed here contained 24 plots in which these six elements were added in addition to nitrogen and phosphate. In 12 plots, a FERRO Corp., material FN-501, containing all six elements was sidedressed with the fertilizer at the 180 N-60 P_2O_5 level. In 12 other plots, a soluble spray material MULTI-TRACIN[1], also containing all six elements, was applied as a foliage spray three times during the season at the same fertility level. None of the plots receiving trace elements in any of the tests showed any visibe response. Also, there was no response in yields to any of these treatments which could be attributed to the trace elements.

To determine if any response could be obtained from trace element applications on very coarse-textured soils, a 7 x 7 Latin square field test was conducted on the D. H. Brewster farm at Van Horn in 1958. This test, on deep Reeves loamy sand, included five formulations of trace minerals, four applied to the soil and one as foliar spray, each with and without nitrogen and phosphate. Here again, no response in cotton growth or yields was observed from any of the applied materials. It must be concluded from these tests that no benefit would be obtained from applications of any trace elements to cotton on any Trans-Pecos soils at this time.

Acknowledgments

The authors wish to acknowledge the excellent assistance of Fred Buckland, D. H. Brewster and Chandler Farms, Inc., for their fine cooperation in the establishment and carrying out of co-operative field tests which provided much of the information contained in this bulletin.

[1]Distributed by Dril-Kem, Inc.