EVALUATION OF ROW WIDTHS AND NITROGEN FERTILIZATION FOR COTTON PRODUCTION

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CHAPTER I

INTRODUCTION

Nitrogen is the element most commonly deficient for cotton (Gossypium hirsutum) production in the southwestern part of the United States. The amount of available N found in the soil at any one time is usually small, while the quantity withdrawn annually by crops is comparatively large. Deficiencies of N can result in reduced yields. Also an oversupply may result in detrimental effects. Thus a carefully regulated N supply may be of extreme importance in controlling the vegetative and fruiting behavior of the cotton plant. With the interest in fertilizer requirement, the other concomitant problem is narrow row cotton production. During the past few years, cotton planters and harvesters have been developed that are capable of operating effectively over a wide range of row spacings. Herbicides have provided a method of weed control that is not limited to standard row width equipment. These developments have made possible the production of cotton in other than the conventionally spaced 40-inch rows.

Specialists and producers have reasoned that narrow row, high population cotton production holds great potential for reducing production costs. Cotton producers are searching for ways to produce high quality, high yielding cotton by efficient economical means. The proven and potential advantages of narrow row cotton production are creating considerable interest among growers of both dryland and irrigated cotton.

CHAPTER II

LITERATURE REVIEW

All organisms including plants need some form of fixed N to make the proteins for their growth. A few microorganisms and blue-green algae can convert the elemental N of the atmosphere into useable, fixed forms. Certain bacteria (Rhizobium) that grow in nodules on the roots of legumes (beans, peas, alfalfa) synthetize amino acids, using N_2 from the air (29). Lightning bolts also fix N_2 in the form of nitric oxide (NO) which goes through nitrogen dioxide (NO_2) to nitric acid and nitrates (29). N as the innert gas N_2 constitutes 78% of the earth's atmosphere. It is continuously cycled through the environment from the atmosphere to growing plants and back to N. The principal steps are presented in the classical N cycle as shown (Figure 1).

Fixation of N to produce organic N is carried out by specialized bacteria. Ammonia is nitrified or converted to nitrates by two specialized groups of bacteria: nitrosomonas oxidizes ammonia to nitrites and nitrobacter oxidizes nitrites to nitrates (29).

The heavy use of fertilizers, however, raises the question where does the fixed N from fertilizers finally go in the environment? As shown in the N cycle, pathways are provided through the activities of soil bacteria to return fixed N to the atmosphere as N_2. These natural processes are now complicated by the addition of industrially fixed N in the form of ammonia, ammonium nitrate and urea fertilizers.

There are two problems connected with the heavy use of N fertilizers to increase crop yields. Most of the fixed N ends up as nitrites and nitrates in the soil and ground water. Nitrites and nitrates are harmful to animals and humans, particularly children.

The second problem that arises when crop yields are increased by heavy N fertilization results from more rapid removal of other essential elements from the soil by the increased yield (29). These elements and others must sooner or later be replaced in the soil if agricultural crops are to grow properly under heavy fertilization.

Nitrogen Movement in the Soil

Fertilizer applied as nitrates moves freely in the soil. This causes a tremendous problem for crops with shallow root systems. Leaching of nitrates constitutes one of the main channels of outgo of N from soils. The movement of the nitrates is closely related to the movement of the soil water. The amount of N lost through leaching will depend on a large number of variables. Among the more important of these variables are:

1. Form and amount of soluble and unadsorbed N present or added,
2. Amount and time of rainfall,
3. Infiltration and percolation rates which are markedly affected by soil composition, texture, structure, depth of profile and surface treatments,
4. Water-holding capacity of the soil and its moisture content throughout the profile at the time a rain occurs,
5. Presence or absence of a crop and its growth characteristics,

6. Rate of removal of the N by the crop, and
7. Extent to which there is an upward movement of N in the soil during periods of drought (3).

One of the more important developments is the emphasis that has been put on precipitation evapotranspiration data (3). If during a period of a few days evapotranspiration exceeds precipitation, obviously there can be no leaching if soil moisture was not above field capacity initially. When precipitation exceeds evapotranspiration leaching can occur after the soil has reached field capacity. Such studies show that there is little liklihood of loss of nitrates from regions where the annual rainfull is low, unless the soil is very sandy or the rainfall is unusually heavy during short periods. In the winter, in northern countries, where snow cover may be important, much movement of water through the soil profile may be expected unless the soil is frozen. This emphasizes how essential it is to avoid the accumulation of nitrates in soil during the late summer and fall months except, of course, where rainfall is so low that leaching is not of common occurrance.

The downward movement of water, other than that in capillary pores of the soil, is rather rapid through the macropore system of medium textured soils. The larger the volume of this system, the more readily the water will move. The presence of a crop, however, tends to reduce this movement because of evapotranspiration. The crop, therefore, greatly minimizes leaching losses of N both directly by assimilation, and indirectly by reducing the amount of leachate. The pattern of downward movement of nitrate of soil of different textures and structures differs markedly. Allison (2) states that there is little difference in the amount of rain required to remove nitrate from surface layers of light or heavy soils, but heavy and continuous rain is required to remove nitrate completely from either type of soil.

Nitrogen is the element most commonly deficient for efficient cotton production in the southwestern part of the United States. The amount of available N found in the soil at any one time is usually small, while the quantity withdrawn annually by crops is comparatively large. Deficiencies of N can result in reduced yields. Also, an oversupply may result in detrimental effects. Thus, a carefully regulated N supply may be of extreme importance in controlling the vegetative and fruiting behavior of the cotton plant.

The main function of N, as reported by Crowther (12) is to initiate meristematic activity. The total growth of the cotton plant depends primarily on the rate of the development of leaf surfaces and the efficiency of leaves produced. Eaton and Rigler (13) found that an increase in nitrate supply to cotton resulted in increased vegetative growth and number of bolls set. Hamilton *et al*. (17) reported increased stem and branch length, increased cross sectional area of stem and increased plant weight with N application. Cotton plants at different stages of development show striking differences in chemical composition. Abbott *et al*. (1) found the highest N percentage in both leaf blades and stalks of cotton at 60 days growth, regardless of level of fertilizer application. Beyond this period there was a step-wise decrease in N percentage.

Wadley (34) reported that while most N fractions of cotton were influenced very little by N supply, the concentration of nitrate was affected.

Work by Joham (22) indicated that petioles from the main stem at the third and fourth nodes from the apex are the most suitable plant part for tissue testing. MacKenzie et al. (23) also reported that the nitrate-N content of the petiole from the most recently matured leaf was related to rate of N applied and to total yield.

Fruiting Characteristics

Although vegetative characteristics are of interest and may in some cases be related to lint yield, factors that determine lint yield directly are plant density, the number of flowers per plant, boll retention, boll size and lint percentage.

Evidence is presented to show the validity of soil and petiole analyses as diagnostic tools in planning N fertilizer programs. The level of nitrate-N in leaf petioles was found to be a good indicator of the N nutrition of the cotton plant. The N needs of cotton can be determined throughout the growing season by utilizing soil and petiole analyses. The amount of available N found in Oklahoma soils varies from amounts insignificant for optimum early growth of the cotton plant to quantities more than adequate for growth throughout the season.

The 1938 Yearbook of Agriculture (33) in dealing with the relationships of soils and plants, suggests that it is highly desirable to know, not only the total or potential supply of a particular element present in the soil, but also the part of the total which is capable of serving the immediate and progressive needs of growing plants. Both inorganic and organic forms of N are found in ionic forms in soils and are readily absorbed and utilized by plants.

Plant analyses have been used as a means of assessing the nutritional status of plants. When utilizing plant analyses, one must consider the part of the plant to be sampled. MacCollam (24) indicated that since the leaves are the organs of active assimilation, their composition must be the best basis for estimating the nutritional process. However, Ulrich (32) considers conducting tissue to be the best index of response to nutrient application because it is likely to reflect closely the current nutrient absorption.

The work of several investigators indicated that petioles of the most recent fully grown leaves gave the best indication of the N status of the cotton plant.

Batra (6) reported that the time of day the petioles were sampled or the soil moisture conditions at the time of sampling had little effect on the nitrate concentration found in the tissue.

Various criteria of vegetative growth have been used for cotton such as: main stem and branch length, number of branches, cross sectional area of stem, and plant weight. Hamilton et al. (17) found that additions of N to a deficient soil increased the length of main stem plus branches, the cross sectional area of stems and plants weight. The number of branches was not affected. Plant spacing did, however, influence the number of branches.

Recent work in Arizona and New Mexico (10) shows that N applied to N deficient soil increased plant height, primarily by internode elongation. In these studies the number of nodes and vegetative branches also was increased by N application.

Early work by Crowther (12) indicated the dependence of meristematic activity on N supply resulting in a marked effect on node numbers. Plant size as indicated by one or more of these criteria is determined by the N supply during the early stages of growth.

Experimental data shows that adding N to N deficient soils increases both the total number of flowers and bolls, Hamilton et al. (17).

A shortage of N causes a reduction in the rate of flowering and in the duration of most intense flowering. Likewise, a N shortage during early growth reduces plant size and the number of possible flowering sites.

The amount of soil and applied N available to the plant is reflected by the level of nitrate-N in the plant tissue. It has been found, Joham (22), that the plant tissue which best reflected this relationship was the main stem petiole near the apex of the plant. The level of nitrate-N in the tissue is also influenced by the level of other soil nutrients. Thus, a high nitrate level in the plant tissue might be due to P deficiency.

The "critical concentration" of nitrate-N was found to be 0.03% NO_3-N by fresh weight at the 13 week growth stage.

MacKenzie and his co-workers (23) found that nitrate-N content of petioles was highest at the early stages of growth and levels up to 18,000 ppm NO_3 were found, but during the latter part of the growing season, the level declined to between 1000 and 2000 ppm nitrate-nitrogen. The level was more related to the amount supplied to the plant than the variety or soil moisture. Baker (5) also found the level of nitrate-N in the petioles to be highest at the mid-square state of growth and was affected by rates and times of N application. Grimes et al. (16) also reported that nitrate-N concentration from the most recently matured leaves were influenced by N fertilization levels, time of sampling in the season, and water management. Plant populations did not alter the nitrate-N levels of petioles.

Yield

It appears that the yield response due to N application varies depending on the site, previous cropping history, soil N status and rate of application. Thus, Baker (5) obtained significant increases in yield only at one location in one trial out of four trials over two years. Murray et al. (26) also have obtained some yield response to N fertilization.

After more than thirty years work in the Sudan (Africa), Jackson and Burhan (20) found that the response to N application differed widely according to the rotation, being greatest in the poorer rotations such as cotton following cotton. The response when cotton was grown after sorghum was also small.

In areas where pests are a problem, very high N rates have been known to cause excessive vegetative growth and complicated pest control. With regard to the pest problem, Burhan (11) recently confirmed previous reports that there was a significant N response by spraying interaction. He obtained only 24% increase in yields when fertilizer N was applied to unsprayed cotton whereas, 63% yield increase was recorded when fertilized cotton was sprayed. The excessive vegetative growth in question has been known to delay maturity or cause a larger proportion of the crop to be formed late in season. This resulted in low yields, especially, in areas where early frost occurred.

There appears to be agreement that N applied at planting or early in the season is most effective in increasing yield. Baker (5), found application prior to the eighth leaf stage to be more beneficial than later dressings. But in areas with longer seasons such as southwestern and far west United States, and with good pest control measures, later N application could lead to new growth and boll production, and therefore, increased yield.

In Australia, Evenson (14) found that attempts to increase yield by applying extra N extended the growing period into onset of unfavorable weather associated with the end of a season and, thus, adversely affected quality.

Fiber Quality

Length, strength and fineness are the fiber properties most commonly reported. The influence that fertilizer N has on fiber characteristics has not been given detailed attention and the existing results are inconsistent.

A review report by Tucker and Tucker (31) observed that the overall effect of N appears to be an increase in total yield brought about by prolonging the fruiting period. The increases in yield were, therefore, usually in the form of late harvest.

Nelson (27) reported that N and K application increased lint length from N application. But Tucker and Tucker stated that fiber length has been shown to increase from applied N where N shortage occurred.

Grimes *et al*. (16) observed that increments of N improved fiber length slightly only when water was severely limiting, has no effect when water supply was adequate, and decreased fiber length when water additions were excessive.

But the preponderance of evidence indicates that N has little effect on fiber length and strength. With regard to fiber fineness a review by Tucker and Tucker (31) indicated that N supply has not been observed to cause variation in fiber fineness of practical importance. Results of this work of Grimes et al. (16) and Murray et al. (26) also support this assertion.

Cotton Spacing

Cotton spacing studies have been conducted in the United States for more than 80 years. Brown reported on tests conducted throughout the cotton belt between 1886 and 1919 (9).

Results of spacing experiments conducted at several locations in Alabama from 1924 to 1935 were reported in 1937 (25).

These early tests were evaluated mainly from the standpoint of yield. Generally speaking, these tests showed that plant spacing in the drill rows could vary considerably without materially affecting yield, provided the plants were uniformly distributed.

Accelerated interest in mechanization and chemical weed control following World War II resulted in new interest in plant spacing experiments. In addition to the effect of spacing on yield, these tests were deemed necessary to establish stand limits for planting to a stand to determine the effect on mechanical harvesting. Most of the tests were conducted on the traditional 36 to 40 inch row spacing.

A three year (1952-1954) spacing test at the Delta Station in Mississippi compared plant populations ranging from 27,000 to 85,000 plants per acre (9). Plant population ranging from 27,000 to 54,000 plants per acre resulted in no differences in yield or machine picking efficiency.

Plant populations of 69,000 or more per acre decreased yield and picking efficiency in dry years. Spacing caused no difference in seed cotton moisture or foreign matter, or in lint moisture, foreign matter, grade and staple of machine picked cotton.

Comprehensive spacing tests were conducted during a six year period (1952-1957) in Oklahoma on stripper harvested cotton. The plant populations used in these tests varied from year to year and ranged from a low of about 4,000 to a high of about 130,000 plants per acre. Twenty-eight attributes were measured although some measurements were not taken each year. Where there were several years' data and trends were consistent, with the following conclusions being made. Those attributes that increased in value as plant population increased were:

1. pre-harvest loss
2. height of the low boll
3. small leaf trash
4. gin turnout

Those attributes measured that consistently decreased in value as plant population increased were:

1. weight of the bolls
2. root depth
3. plant height
4. plant width
5. height of the high boll
6. sticks in the harvested cotton
7. total machine loss
8. staple length

Other attributes measured that showed definite but less consistent trends were evaluated. Those that tended to increase as population increased were:

1. percent emergence
2. motes in the harvested cotton
3. large leaf in the harvested cotton
4. total trash in the harvested cotton
5. cotton-per-bur ratio in pre-harvested loss and
6. dollars returned per 2,400 pounds of material ginned.

Those attributes that tended to decrease in value as plant population increased were:

1. net yield
2. total yield
3. machine loss on the ground.

Plant population studies were made in California in 1949 and 1950 to determine the effect of the number of plants per acre as obtained by different thinning methods on yield, lint quality and adaptability to mechanical harvesting (10). Plant populations ranged from 10,000 to 78,400 plants per acre. With hand thinning, there was practically no difference in yield when the population was 19,000 or more plants per acre. But yield decreased when plant populations were 15,000 or less.

With drilling to a stand, the yield was not affected when the plant population was 28,000 or more plants per acre but decreased when the population was 23,000 or less.

The effect of plant population on picking efficiency showed some trend toward higher picking efficiencies with the larger populations, however, the results were so inconsistent and the differences so slight that no definite conclusions could be drawn. The effect of plant population on trash content did not follow a definite pattern, but the greatest population resulted in the highest trash content.

Row Spacings Effect

Cotton is planted in rows for numerous reasons. One of the primary reasons is that this system of planting permits the use of soil tillage implements to control weeds and grasses. Since cotton is planted on raised seedbeds in some areas in the cotton belt, an area is required between the rows of cotton to obtain the soil to build the ridges. If cotton is planted in furrows, space must be allowed between the furrows for the displaced soil. The higher the beds or deeper the furrows, the greater the distance required between the centers of the rows of cotton. The space between the rows of cotton is also used to convey irrigation water and provide traffic lanes for tractors, sprayers and harvesters.

The distance between the rows has gradually decreased over the years as cotton production has shifted from animal power to mechanical power. The distance between the centers of the rows has been standardized at 38 to 40 inches (96-101 cm), primarily for simplification of manufacture and assembly of machines.

Improved cultural practices including increased use of fertilizers, irrigation and herbicides has resulted in renewed interest in several areas on the effect of row spacing on cotton production. Farmers and researchers have experimented with row spacing varying from six inch (15.0 cm) to various forms of skip-row planting in effort to reduce costs and increase returns from each planted acre.

Skip-row planting normally employs the standard 40 inch rows. However, cotton is planted in only a selected number of rows between skips of unplanted rows. This system of planting is based upon the premise that outside rows of cotton planted adjacent to unplanted areas produce higher yields than single rows within a field in which every row is planted. The most common system is to plant four rows and skip four, since it utilizes conventional four row equipment more efficiently.

There are several other systems in which planted and unplanted rows may be arranged to take advantage of the outside row effect upon yield.

The increase in yields resulting from the various system of skip-row planting varies considerably with areas, climatic conditions, and cultural practices. For example, in experiments conducted with the "four-in and four-out" system of skip-row planting at the Delta Experiment Station in Mississippi, increases in yields ranged from 24 to 73% over solid planted cotton (9). The variation in yields was attributed to climatic conditions which varied from year to year. The highest gains were obtained during low rainfall periods. Similar results have been reported in other cotton producing areas.

A study was initiated in 1954 on the Texas High Plains on narrow cotton production. Row spacing of 20, 21, and 24 inches (50, 53, 61 cm) and two rows, 14 inches (34 cm) apart on conventional 40 inch beds (101 cm) were included in the study. Experimental data over a four year period on irrigated cotton showed increases in yields ranging from 6 to 25% for close-row spacing over the conventional 40 inch rows. Another important factor gained with close-row spacing and high population was earlier fruiting. The high rates of fruit production were made possible by the exceptionally large number of fruiting positions present early in the fruiting season.

Weed control and harvesting have been problems in this method of cotton production. New and more effective herbicides have minimized the weed control problems. Mechanical harvester prototypes have been designed and built by agricultural engineers in research for harvesting, narrow-row and broadcasted cotton.

The effect of row spacings upon yields of cotton have also been investigated in the high rainfall areas of Arkansas and Texas.

The cotton in both areas was grown without supplemental irrigation. Under natural rainfall conditions in 1964, the yields of broadcast cotton were significantly lower than cotton growing in 40 inch rows in Texas. Yields in 1965 were approximately the same for cotton growing both systems of production.

Fiber Characteristics

Much of the evidence in the literature indicates that the cotton fiber properties commonly measured are not influenced by plant population. Cotton cultivars are able to maintain most of their inherent fiber properties even when produced with high plant populations. Thus, fiber strength, length and lint percentages were not affected by population as reported by Hawkins and Peacock (18). Travernetti (30) also observed that fiber length and strength were not influenced by plant population. Several physical properties of cotton fibers are directly dependent upon soil moisture conditions.

CHAPTER III

MATERIALS AND METHODS

This study included two field experiments. Field sites were chosen on the basis of soil types as well as past cropping story. In general the soils used were loamy and had received heavy application of a commercial N fertilizer in recent years.

Location of Field Sites

Two field sites were used for testing purposes. The first chosen was located near Colony and was irrigated. The second was selected near Arapaho and was dryland. Both sites were located in the west-central part of the state. Before applying the N treatments, a sufficient amount of soil was collected to perform the following soil tests: nitrate N, available P, exchangeable K, Ca, and Mg.

The soils had previously been mapped by the Soil Conservation Service and they are being classified as: Port loam at Arapaho and Cobb fine sandy loam at Colony.

The port series are deep loamy soils. The surface layer is reddish brown or dark brown, calcareous loam or clay loam of granular structure. This layer is about 10 inches thick and easy to moderately difficult to till. The subsoil contains more clay and is more compact in the lower part than in the upper. The upper part is red to dark red clay loam or silty clay loam of moderate, medium, granular structure. The lower part is red, calcareous light clay loam of weak, fine granular structure. The Port series is a member of the fine silty mixed thermic udic Paleustolls. Port soils are naturally well drained. Internal drainage is medium, and permeability is moderately slow. The ability of these soils to absorb and retain soil moisture is moderate.

The Cobb series is a member of fine, loamy, mixed thermic family of Haplustalfs. These soils have a reddish brown fine sandy loam, A horizon, and a reddish brown sandy clay loam and a Bt horizon that is weakly cemented sandstone at a depth of 30 inches.

Experimental Treatments

Experiment I (Row Width)

To determine the effect of narrow row cotton production on yields, plant growth and fiber characteristics under dryland and irrigated conditions.

Four row widths were used: 20, 40, 61 and 101 cm (8, 16, 20 and 40 inches).

Ten inch rows were also included in the irrigated tests. The standard 40 inch row (101 cm) was used as a check in both tests. Fiber samples were taken and analyzed. Information of the following fiber properties were obtained: fiber length, percent uniformity and fineness. Prior to harvesting time in the second week of December, after vegetative growth had completely ceased, the heights of ten consecutive plants in the middle of the plots were taken. The total number of bolls that had reached maturity were also counted. Thus, all immature bolls or those that were partially open, but badly damaged by insects or by weather were counted and discarded as bad bolls. Visual observations among treatments on relative periods of plant maturity and boll openings were made.

Observations on pest and insect damage showed that there was no need for spraying the plots during the growing season.

The plots were harvested on December 14, 1974. The harvesting of the plots was done by hand. The snapped cotton bolls were weighted together with the burr. Weighed samples of ten mature bolls were deburred, weighed, delinted and reweighed to obtain seed cotton and lint yields. From these, the yields for various treatments were calculated.

Measurements on fiber characteristics were made on the lint from the ten bolls from each plot. The data taken on the fiber were: fiber fineness from micronaire values, strength measured with the stelometer and measurement on fiber length such as 2.5 percent span length and uniformity index were made on a digital fibergraph.

Experiment II

Five N levels: 0, 40, 120 and 160 lbs/A were applied. No K nor P were applied because soil tests showed K and P to be more than sufficient. Test results showed 71 lbs/A P and 950 lbs/A K at Howard's farm and 138 lbs/A P and 310 lbs/A K at Bond's farm. Soil and plant samples were taken at a month interval to determine the N movement in the soil and the Nitrate-N level in the petioles. Soil samples were taken at all plots at Bond's farm as well as Howard's. The samples were taken at the following depths:

0 to 6 inches

6 to 12 inches

12 to 24 inches

24 to 36 inches

After collection, the samples were brought to the Oklahoma State University Water and Soil Testing Laboratory where they were dried and analysed.

Petioles of the most recent mature leaf were sampled at the squaring, flowering and bolling stages. Plants in the middle of the plots were sampled. These were dried in the oven at $80^{o}C$ for 24 hours and ground in a Wiley Mill to pass through a 40-mesh sieve. A weight of 0.2 gm was placed into a flask containing 50 ml of 0.1 N $CUSO_4$ solution and heated in a steam bath for ten minutes to extract the nitrates. After this, 0.1 gm $Ca(OH_2)$ and 0.2 gm $MgCO_3$ were added and flasks shaken for five minutes to decolorize the solution and floculate the organic matter. The flask contents were then filtered and the filtrate was analyzed for nitrate-N contents using the Brucine method of Jenkins et al. (21) and that of De Martini as modified by Finger (15).

In this study of nitrogen movement in the soil, soil samples were taken before the fertilizer was applied at Bond's and Howard's farms. Then soil samples were taken again one month after the nitrogen fertilizer was applied to investigate the downward movement of nitrate. The soil samples were taken at these depths:

0 to 6 inches

6 to 12 inches

12 to 24 inches

24 to 36 inches

A third sampling was done five months after the nitrogen fertilizer was applied. The results of the study are shown in Tables XIV, XV, XVI, XVII, SVIII and XIX. Just before fertilizing Bond's site, the soil samples taken from the farm showed this nitrogen level (Table XV):

0 to 6 inches	less than	10 lbs/A
6 to 12 inches	-----	18 lbs/A
12 to 24 inches	-----	15 lbs/A
24 to 36 inches	-----	11 lbs/A

One month after the field was fertilized the results of soil test were showing high levels of N at the surface and five months later the nitrogen has moved to lower depths (Tables XVII, XIX).

CHAPTER IV

RESULTS AND DISCUSSION

Experiment I (Row Widths)

Boll Yield

As spacing increased, the number of good bolls increased significantly (Table I). It is interesting to point out that there were positive significant correlations between the number of good bolls and lint and seed cotton yields. However, no such relationship existed between total bolls and yields. The number of total bolls per plant was significantly affected by plant spacing. There was a highly significant increase in the number of bolls as row spacing was increased from 20 to 101 cm (Table I).

Lint Yield

Two out of the three narrow row spacings out yielded the 101 cm (40") check rows in the dryland test (Table III). The highest yield was with 61 cm (24") row width, followed by 41 cm (16") row width.

In the irrigated test only the 41 cm (16") row width out yielded the conventional 101 cm (40") row width (Table IV).

Lint Percent

Lint percent of the dryland test was highest in 61 cm rows (24"), followed by the 41 cm rows (16") (Table V). In the irrigated test only 41 cm rows (16") out yielded the conventional 101 cm rows (40") (Table VI).

Fiber Properties

In the dryland test, narrow row spacings did not improve lint grade over the 101 cm row (40") (Table V). Row width had no effect on fiber length and uniformity. An average of 90 psi in fiber strength was obtained in the narrow row spacing as compared to the 101 cm (40") row. In the irrigated test (Table VI) lint grade, fiber uniformity and fiber strength were not affected by row width. Fiber length was slightly reduced by reducing row width. Row spacing affected the fiber fineness. The average micronaire values in both the dryland and irrigated narrow row spacing increased compared to the conventional (40") rows. The increase in fiber coarseness was advantageous, as it places the lint close to, or in, the premium micronaire range.

Experiment II (Nitrogen Rates)

Plant Height

Nitrogen application affected plant height very significantly. Increasing N application significantly increased plant heights as illustrated (Table IX, Figure 7). There was a significant difference between the check and 160 lbs/A. No difference at all was found between the check and 40 lbs/A. There was significant difference too, between

120 lbs/A and 160 lbs/A levels.

Other visible effects on nitrogen application was a production of luxuriant and prolonged vegetative growth coupled with a somewhat prostrated and delayed fruiting time span. At the time of harvesting, plants in the plots with high N rates (120 and 160 lbs/A) were still bearing numerous immature bolls. In a longer, warmer season it is possible that these bolls could have matured and contributed to yields.

Generally, the shortest plants were noted in the treatments that received no or low N applications.

Nitrate-Nitrogen Content of Petioles

The differences in the NO_3-N content of petioles at squaring, flowering and bolling stages of plant growth were highly significant (Figure 2). Generally there was the highest level at squaring stage and this declined sharply as plants advanced to the bolling stage.

Nitrate-N Movement in the Soil Profile.

Evidence was found in this study that nitrate-N moved freely in the soil profile (during the five month study period) from the upper or surface layers (Figures XVI, XVII) to the lower or deeper layers (Figures XVII, XIX). The check at 0 to 6 inch layer showed a level of 40 pounds/acre (Figure XVI). One month after the field was fertilized, the 0 to 6 inch layer in the 120 pounds/acre treatment showed a level of 250 pounds/acre, an indication that the nitrate-N was still at the surface. Five months later, when the same treatment was sampled and analyzed it showed only a level of 48 pounds/acre, indicating that the nitrate-N had moved down the profile.

In this study no response to N fertilizer was obtained because of the adequate N status in the soil due to residual nitrogen from previous heavy N fertilizations.

TABLE I

AVERAGE PLANT POPULATION AND PLANT CHARACTERISTICS OF FOUR ROW WIDTHS FOR THE DRYLAND TEST

Row Width (cm)	Number Plants/Acre (thousand)	Number Bolls/Plant	Plant Height (cm)	Height of First Fruiting Branch (cm)
20 cm rows (8")	141.1	2.1	37.59	19.81
41 cm rows (16")	79.1	3.2	34.00	17.57
61 cm rows (24")	61.1	4.8	44.19	18.54
101 cm rows (40")	68.8	4.7	55.11	19.55

TABLE II

AVERAGE PLANT POPULATIONS AND PLANT CHARACTERISTICS OF FIVE ROW WIDTHS FOR THE IRRIGATED TEST

Row Width (cm)	Number Plants/Acre (thousand)	Number Bolls/Plant	Plant Height (cm)	Height of First Fruiting Branch (cm)
20 cm rows (8")	143.7	2.2	44.90	15.74
25 cm rows (10")	112.2	2.4	45.72	12.70
41 cm rows (16")	95.8	2.6	41.40	15.24
61 cm rows (24")	72.6	3.7	45.40	15.49
101 cm rows (40")	78.4	3.9	64.50	24.13

TABLE III

AVERAGE LINT YIELD OF FOUR ROW WIDTHS
FOR THE DRYLAND TEST

Row Width	Lint Yield lbs/Acre
20 cm rows (8")	483
41 cm rows (16")	494
61 cm rows (24")	501
101 cm rows (40")	492

TABLE IV

AVERAGE LINT YIELD OF FIVE ROW WIDTHS
FOR THE IRRIGATED TEST

Row Width	Lint Yield, lbs/Acre
20 cm rows (8")	389
25 cm rows (10")	477
41 cm rows (16")	500
61 cm rows (24")	468
101 cm rows (40")	480

TABLE V

AVERAGE LINT PERCENT AND FIBER PROPERTIES OF FOUR ROW WIDTHS FOR THE DRYLAND TEST

Row Width	Lint Percent	Grade	Length 2.5% Span	Length % Unif.	Strength PSI	Fineness
20 cm rows (8")	35.8	41	1.11	44	84.7	3.0
41 cm rows (16")	37.7	41	1.06	43	86.0	3.5
61 cm rows (24")	38.0	41	1.06	44	88.0	3.3
101 cm rows (40")	34.6	42	1.08	44	83.7	2.6

TABLE VI

AVERAGE LINT PERCENT AND FIBER PROPERTIES OF FIVE ROW WIDTHS FOR THE IRRIGATED TEST

Row Widths	Lint Percent	Grade	Length 2.5% Span	Length % Unif.	Strength PSI	Fineness
20 cm rows (8")	35.9	41	1.00	43	86.3	3.2
24 cm rows (10")	35.9	41	1.03	42	88.4	3.1
41 cm rows (16")	36.6	41	1.02	45	92.8	3.5
61 cm rows (24")	37.3	41	1.03	44	89.7	3.3
101 cm rows (40")	35.3	41	1.06	42	89.4	3.0

TABLE VII

DESIRABLE LEVELS OF NITRATE-NITROGEN IN COTTON PETIOLES AT VARIOUS STAGES OF PLANT DEVELOPMENT

Stage of Growth	Desirable Levels of NO_3-N in ppm[1/]
First Squares	15,000 to 18,000
First Flowers	12,000 to 14,000
First Bolls	6,000 to 10,000
First Open Bolls	4,000

[1/] Gardner and Tucker, 1967.

TABLE VIII

RELATION OF INITIAL SOIL NITRATE LEVEL TO EARLY SEASON NITROGEN NEEDS OF COTTON

Soil Nitrate ppm No_3-N	Stage of Growth at Which N Fertilizer May be Needed[1/]
0 - 10	at planting or as soon after as practical
10 - 20	by six leaf to square stage
20 - 30	by time of first flower
30 plus	use petiole test to determine if needed

[1/]Gardner and Tucker, 1967.

TABLE IX

NITROGEN TREATMENT EFFECT
ON PLANT HEIGHT

Nitrogen Levels Pounds/Acre N	Plant Height in cm
0	74
40	74
80	78
120	85
160	95

TABLE X

ANALYSIS OF COTTON SAMPLES FOR TOTAL NITROGEN SAMPLES TAKEN WHEN THE COTTON WAS ONE MONTH OLD, HOWARD'S PLOTS

Treatments Pounds/Acre N	% N
0	2.4
40	2.2
80	2.4
120	2.3
160	1.8

TABLE XI

ANALYSIS OF COTTON SAMPLES FOR TOTAL NITROGEN SAMPLES TAKEN WHEN THE COTTON WAS TWO MONTHS OLD, HOWARD'S PLOTS

Treatments Pounds/Acre N	% N
0	1.8
40	2.4
80	2.1
120	2.5
160	2.4

TABLE XII

ANALYSIS OF COTTON SAMPLES FOR TOTAL NITROGEN SAMPLES TAKEN WHEN THE COTTON WAS ONE MONTH OLD, BOND'S PLOTS

Treatments Pounds/Acre N	% N
0	2.4
40	2.1
80	2.2
120	2.3
160	2.2

TABLE XIII

ANALYSIS OF COTTON SAMPLES FOR TOTAL NITROGEN SAMPLES TAKEN WHEN THE COTTON WAS TWO MONTHS OLD, BOND'S PLOTS

Treatments Pounds/Acre N	% N
0	1.7
40	1.9
80	1.8
160	2.1

TABLE XIV

ANALYSES OF SOIL SAMPLES TAKEN BEFORE THE FIELD WAS FERTILIZED, HOWARD'S PLOTS

Soil Depth "inches"	pH	NO_3-N Pounds/Acre	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 - 6	7.8	30	71	950
6 - 12	7.8	25	53	800
12 - 24	7.9	17	23	450
24 - 36	8.0	16	23	350

TABLE XV

ANALYSES OF SOIL SAMPLES TAKEN BEFORE THE FIELD WAS FERTILIZED, BOND'S PLOTS

Soil Depth "inches"	pH	NO_3-N Pounds/Acre	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 - 6	6.7	<10	138	310
6 - 12	6.8	18	143	320
12 - 24	6.9	15	41	280
24 - 36	6.7	11	14	250

TABLE XVI

ANALYSES OF SOIL SAMPLES TAKEN ONE MONTH AFTER THE FIELD WAS FERTILIZED, HOWARD'S PLOTS

N Levels Pounds/Acre N	Soil Depths in inches	NO_3-N Pounds/Acre	pH	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 (check)	0 - 6	40	7.8	69	1010
	6 - 12	25	7.8	36	700
	12 - 24	28	7.9	28	380
	24 - 36	32	7.4	23	310
40	0 - 6	120	7.8	67	810
	6 - 12	12	8.0	31	480
	12 - 24	11	7.8	28	360
	24 - 36	29	8.0	23	330
80	0 - 6	50	7.9	72	970
	6 - 12	15	7.8	31	680
	12 - 24	14	7.8	28	480
	24 - 36	11	7.8	21	390
120	0 - 6	250	7.5	138	1160
	6 - 12	29	7.8	61	940
	12 - 24	18	7.7	28	610
	24 - 36	14	7.7	20	430
160	0 - 6	58	7.8	105	930
	6 - 12	21	7.7	41	770
	12 - 24	11	7.8	23	470
	24 - 36	<10	8.0	23	400

TABLE XVII

ANALYSES OF SOIL SAMPLES TAKEN FIVE MONTHS AFTER THE FIELD WAS FERTILIZED, HOWARD'S PLOTS

N Levels Pounds/Acre	Soil Depths in inches	NO_3-N Pounds/Acre	pH	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 (check)	0 - 6	11	8.1	84	930
	6 - 12	10	8.0	56	920
	12 - 24	26	7.5	31	590
	24 - 36	11	8.1	31	390
40	0 - 6	22	7.9	72	990
	6 - 12	84	7.9	33	710
	12 - 24	34	7.8	33	450
	24 - 36	17	8.1	33	380
80	0 - 6	17	7.9	110	1090
	6 - 12	55	7.8	51	880
	12 - 24	56	7.3	31	600
	24 - 36	42	7.9	23	440
120	0 - 6	48	7.7	115	1030
	6 - 12	68	7.7	115	1030
	12 - 24	52	7.6	33	690
	24 - 36	46	7.7	23	430
160	0 - 6	<10	7.8	128	980
	6 - 12	13	7.9	59	850
	12 - 24	13	8.1	26	490
	24 - 36	26	7.9	23	310

TABLE XVIII

ANALYSES OF SOIL SAMPLES TAKEN ONE MONTH AFTER THE FIELD WAS FERTILIZED, BOND'S PLOTS

N Levels Pounds/Acre	Soil Depths in inches	NO_3-N Pounds/Acre	pH	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 (check)	0 - 6	<10	6.6	164	330
	6 - 12	<10	7.0	120	340
	12 - 24	13	6.8	20	230
	24 - 36	10	7.2	15	220
40	0 - 6	66	5.8	174	360
	6 - 12	30	6.7	133	370
	12 - 24	22	6.8	36	300
	24 - 36	14	6.9	13	280
80	0 - 6	190	5.7	192	440
	6 - 12	60	6.5	195	430
	12 - 24	16	6.6	59	300
	24 - 36	10	6.9	18	290
120	0 - 6	120	5.6	187	360
	6 - 12	64	6.0	187	320
	12 - 24	21	6.7	33	300
	24 - 36	12	6.7	18	240
160	0 - 6	84	5.1	195	320
	6 - 12	160	6.0	189	350
	12 - 24	17	6.8	31	360
	24 - 36	10	6.7	15	280

TABLE XIX

ANALYSES OF SOIL SAMPLES TAKEN FIVE MONTHS AFTER THE FIELD WAS FERTILIZED, BOND'S PLOTS

N Levels Pounds/Acre	Soil Depths in Inches	NO_3-N Pounds/Acre	pH	Phosphorus Pounds/Acre	Potassium Pounds/Acre
0 (check)	0 - 6	<10	7.1	184	380
	6 - 12	<10	6.6	159	360
	12 - 24	<10	6.6	38	270
	24 - 36	<10	6.4	13	260
40	0 - 6	<10	6.7	189	370
	6 - 12	<10	6.9	172	460
	12 - 24	<10	6.8	82	370
	24 - 36	19	6.7	38	---
80	0 - 6	<10	6.7	174	340
	6 - 12	31	6.1	179	400
	12 - 24	110	6.5	82	390
	24 - 36	11	6.9	20	400
120	0 - 6	<10	6.1	460	320
	6 - 12	85	5.6	310	320
	12 - 24	130	6.4	133	310
	24 - 36	50	6.4	59	310
160	0 - 6	15	6.1	200	320
	6 - 12	130	5.3	200	330
	12 - 24	220	6.1	133	370
	24 - 36	86	6.6	33	320

TABLE XX

COTTON RESPONSE TO N, BOND'S PLOTS

Treatment	Pounds/Foot Rep I	Pounds/Foot Rep II	Average	Lint + Seed Rep I	Lint + Seed Rep II	Average
0	12.2	11.6	11.9	2657	2592	2624
40	12.1	10.2	11.15	2635	2222	2428
80	12.4	8.5	10.45	2701	1851	2276
120	11.4	12.6	12.00	2483	2744	2613
160	10.2	9.9	11.05	2270	2156	2213

TABLE XXI

COTTON RESPONSE TO N, HOWARD'S PLOTS

Treatments	Pounds/Foot Rep I	Pounds/Foot Rep II	Average	Lint + Seed Rep I	Lint + Seed Rep II	Average
0	8.50	11.25	9.87	1850	2450	2150
40	9.00	11.00	10.00	1960	2396	2178
80	8.25	9.75	9.00	1797	2124	1960
120	10.00	9.00	9.50	2178	1960	2069
160	12.00	9.50	10.75	2614	2069	2341

CHAPTER V

SUMMARY AND CONCLUSIONS

Under the conditions of the experiment at Colony and Arapaho, no cotton response to nitrogen fertilization was recorded. Nitrogen application even reduced lint and seed cotton. High nitrogen treatments produced the lowest yields compared to treatments receiving moderate amounts of nitrogen (80 pounds/acre) and no nitrogen at all. Plant heights were significantly increased by increasing levels of nitrogen treatments. The nitrate-nitrogen levels in the petioles increased significantly with increasing nitrogen rates. The NO_3-N levels were considerably higher at the squaring stage of plant growth, but decreased sharply at the flowering - bolling stages. Attempts to correlate NO_3-N levels of petioles with yields were fruitless. In conclusion, nitrogen application did not increase yield.

The narrow row culture offers many possibilities for improving management efficiencies and reducing production costs. Fewer trips over the field are needed for land preparation and cultivation. If production costs and gross return are considered, the increase in net return per acre is more for narrow rows than for standard 101 cm rows.

One of the main advantages in the narrow row culture is the ability to shorten the production period of the cotton plant. These results have shown that with a higher plant population achieved by decreasing row width, fewer bolls are needed per plant to produce a given yield, with a more uniform maturity and improved lint quality. This is of special value to any area that needs a shorter production period.

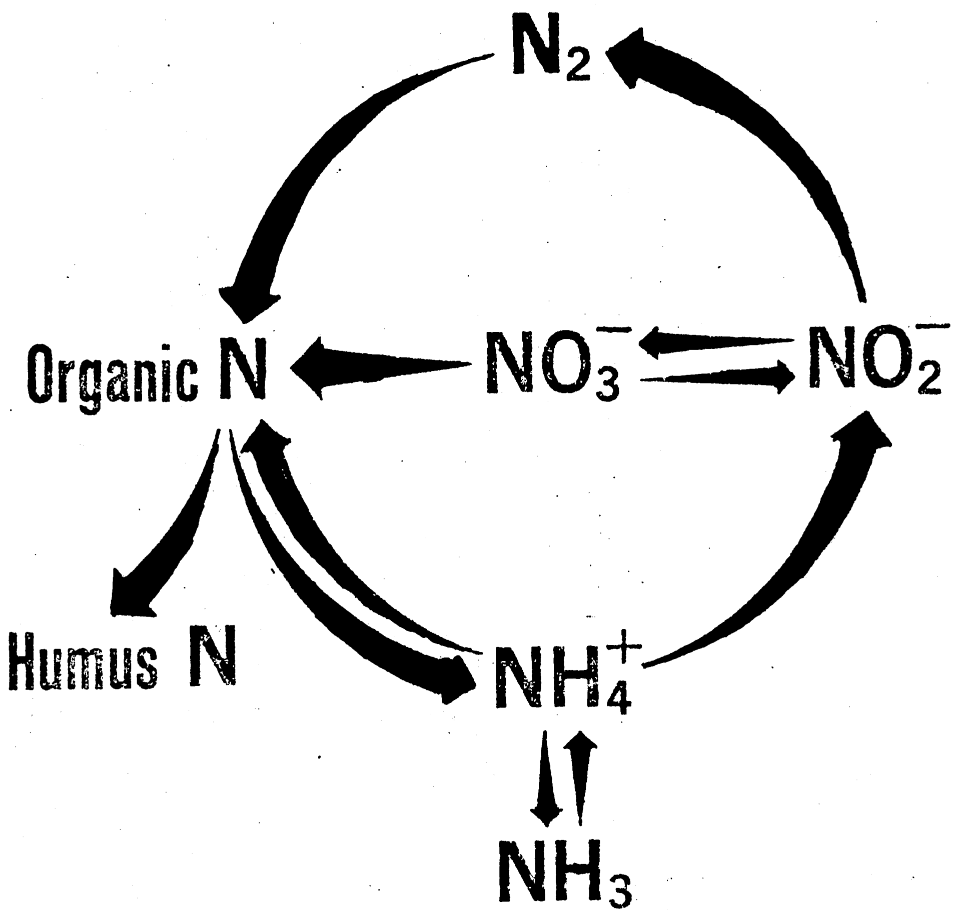

Figure 1. Classical Nitrogen Cycle.

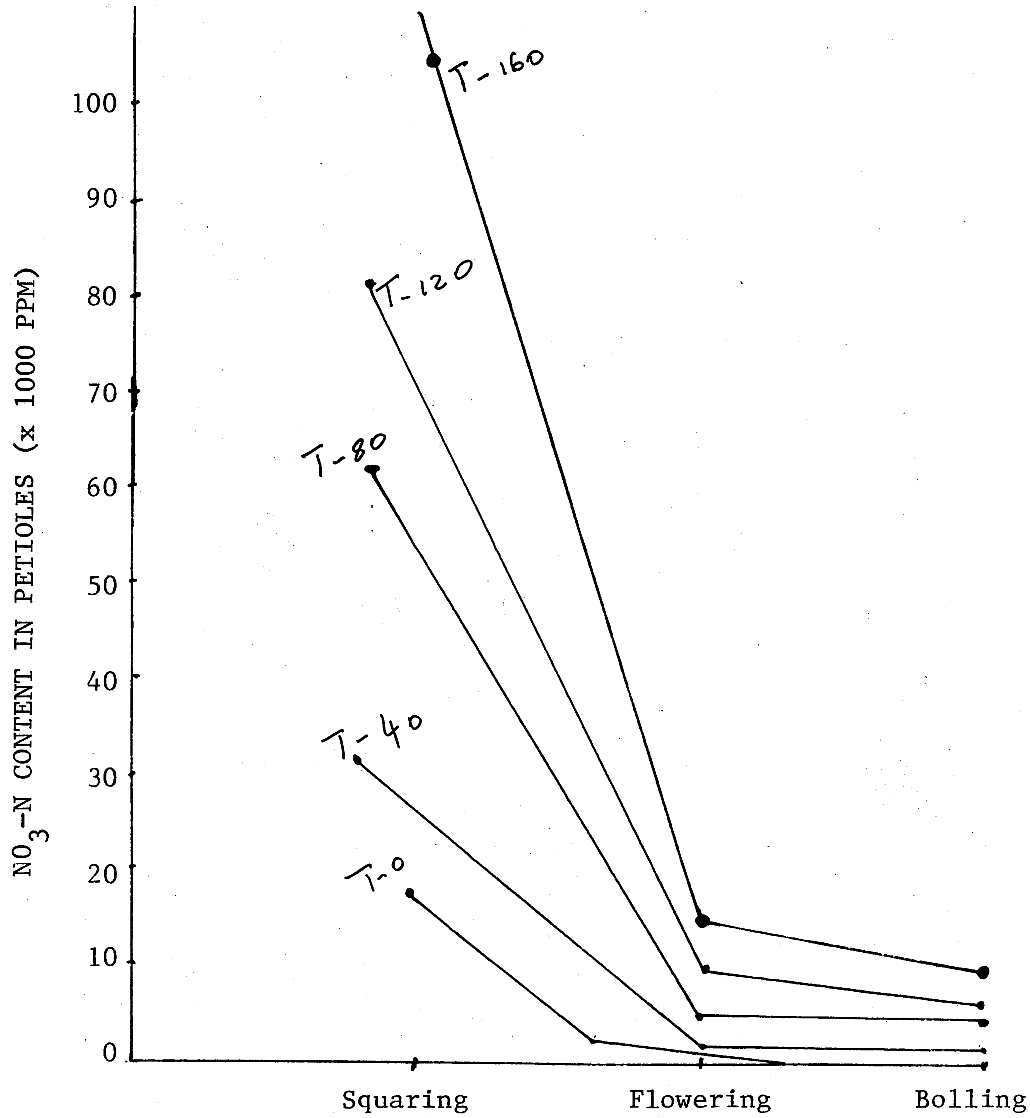

Figure 2. Level of NO_3-N in Cotton Petioles at Three Growth Stages (Howard's Plots).
T = Treatment Levels

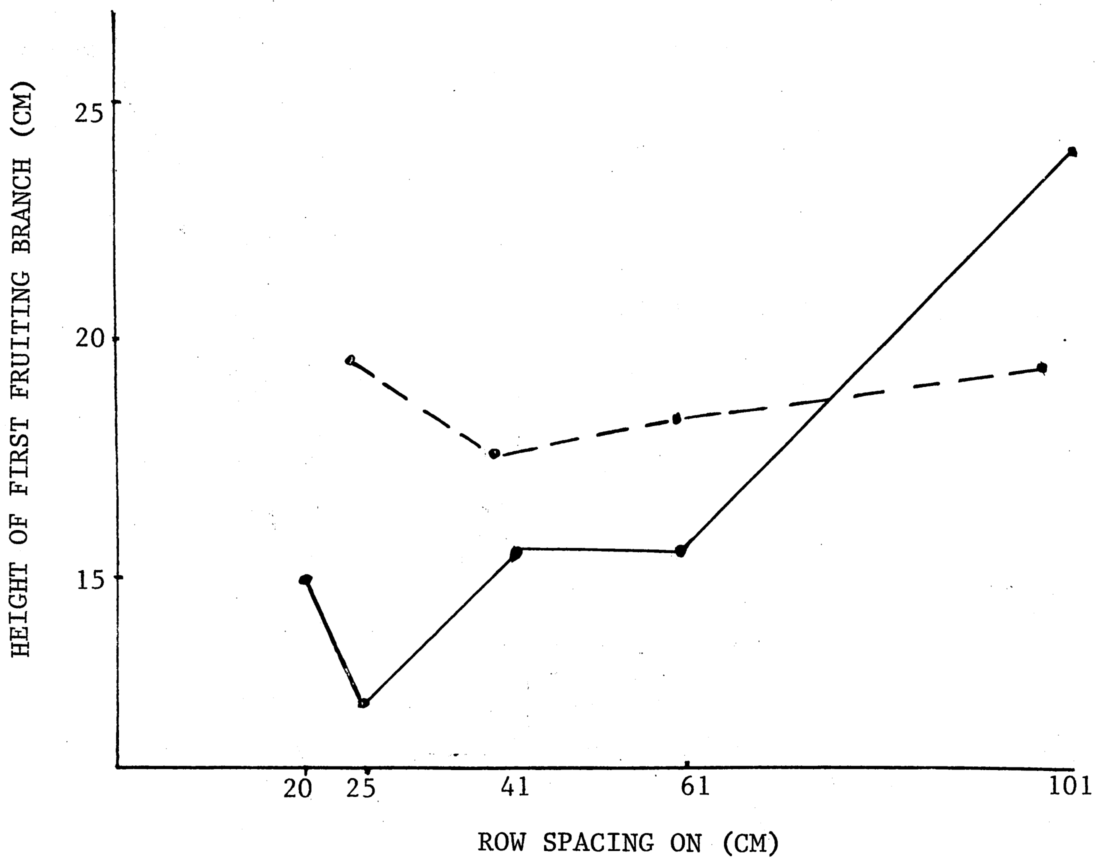

Figure 3. Effects of Row Spacing on Height of First Fruiting Branch.

------Dryland Test (Howard's Plots)

______Irrigated Test (Bond's Plots)

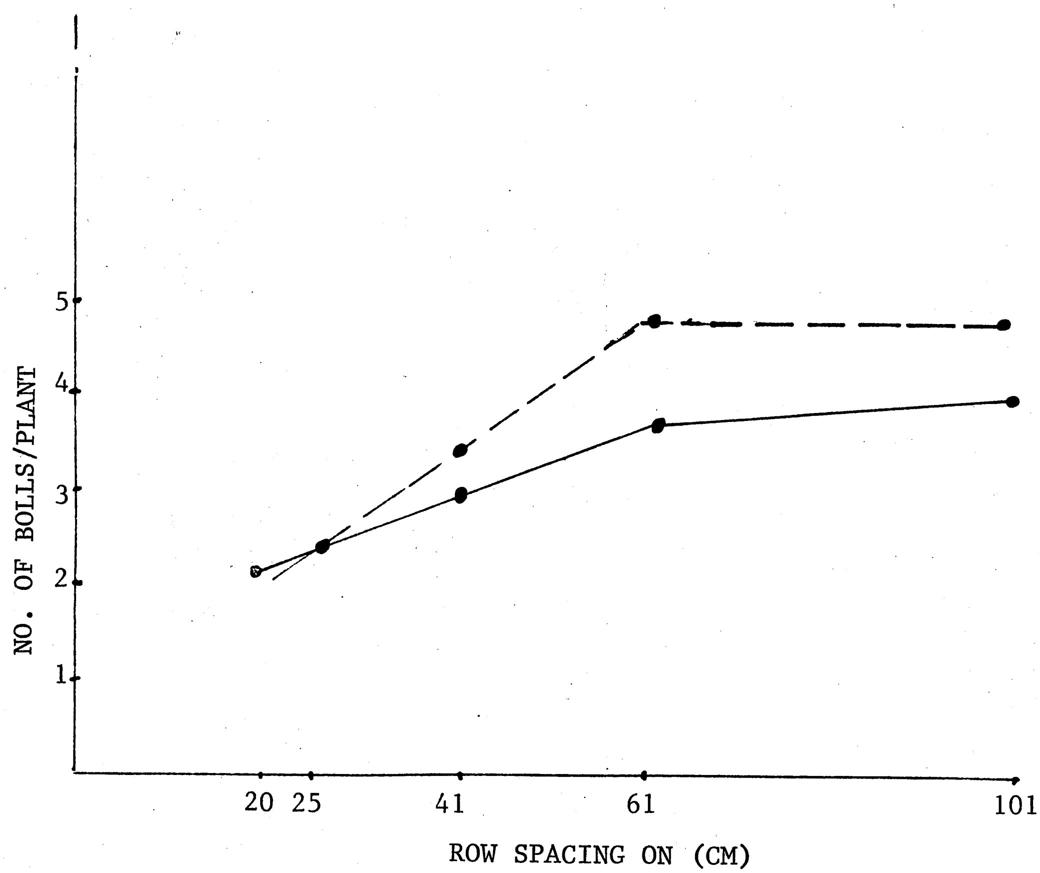

Figure 4. Effects of Row Spacing on Cotton Bolls/per Plant.

-----Dryland Test (Howard's Plots)

_____Irrigated Test (Bond's Plots)

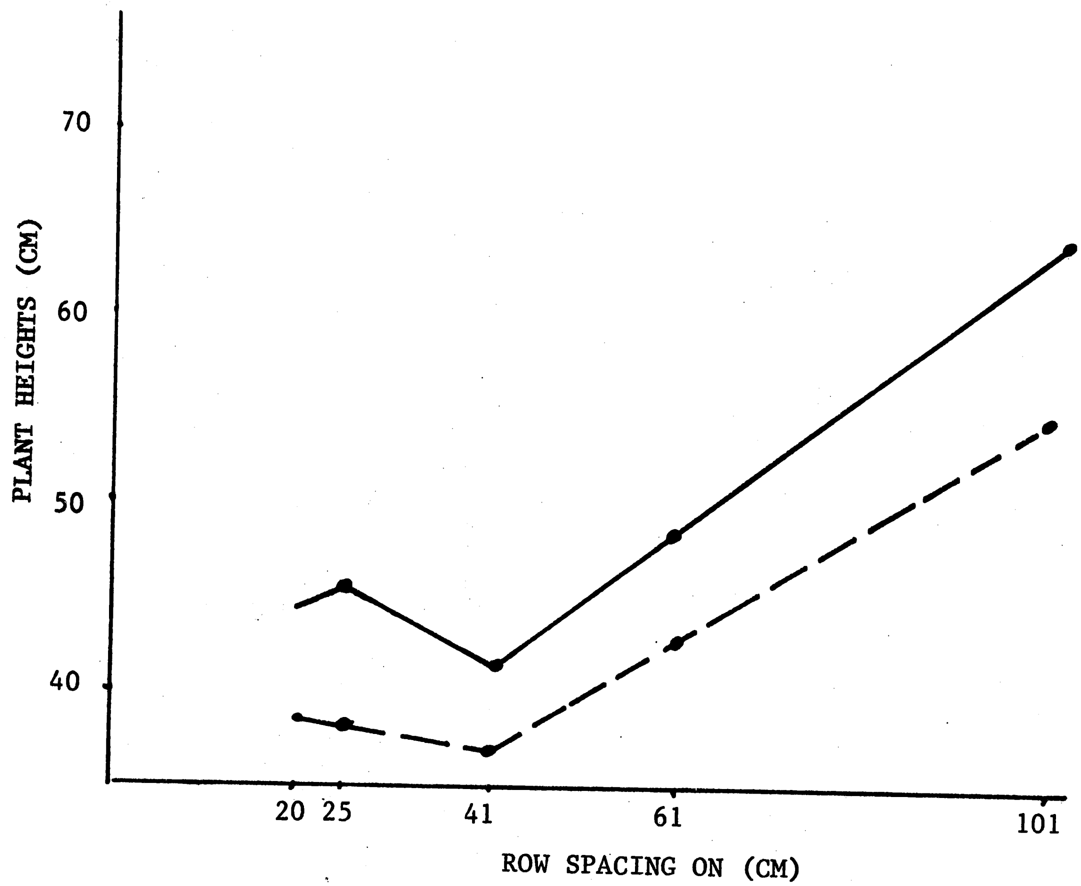

Figure 5. Effects of Row Spacing on Plant Height for the Dryland and Irrigated Tests: (Howard's and Bond's Plots).

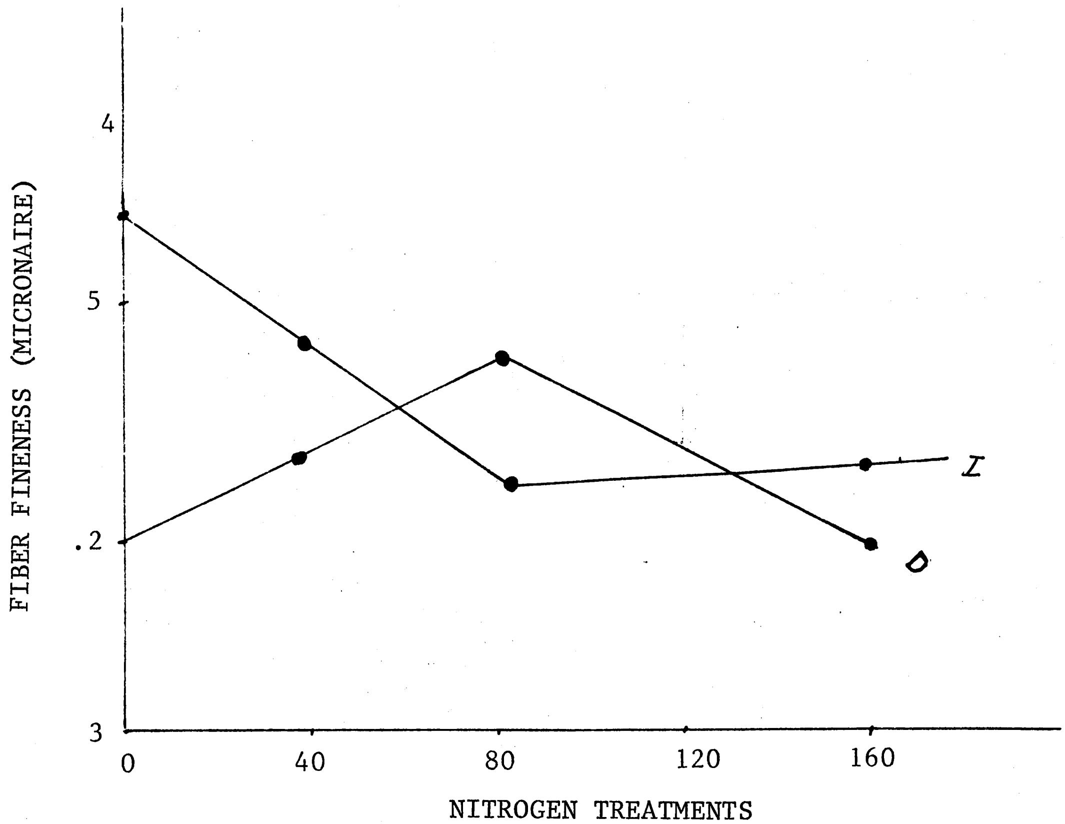

Figure 6. Effects of Nitrogen Rates on Fiber Fineness.
I - Irrigated Test (Bond's Plots)
D - Dryland Test (Howard's Plots)

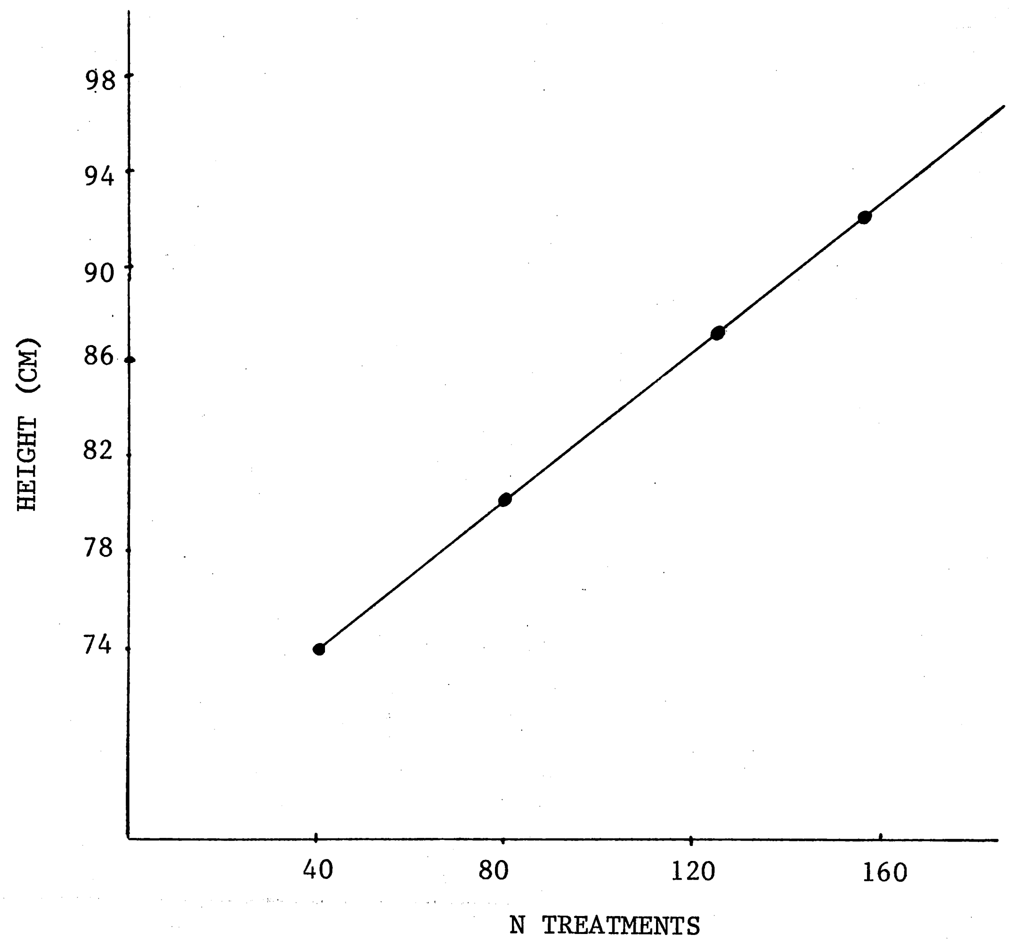

Figure 7. Effects of Nitrogen Rates on Plant Height (Howard's Plots).

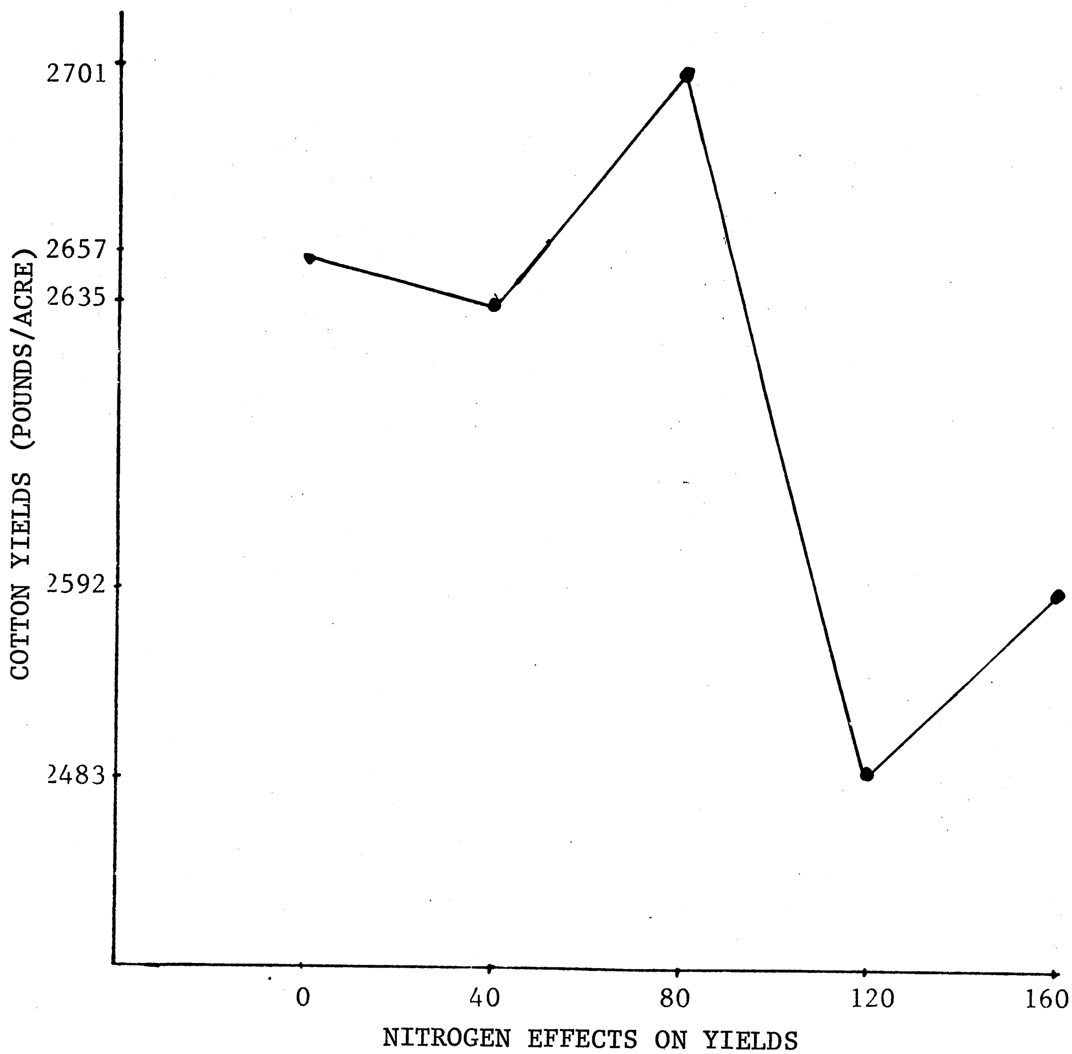

Figure 8. Effect of Nitrogen Rates on Cotton Yields (Lint and Seed) Howard's Plots.

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