NITROGEN TREATMENTS, ROW SPACING, AND PLANT POPULATION EFFECTS ON COTTON YIELDS, PLANT, AND FIBER CHARACTERISTICS

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CHAPTER I

INTRODUCTION

Improving crop productivity per unit area by increasing plant populations has been demonstrated repeatedly in crops that exhibit determinate growth habits. The possible advantage of both increased productivity and reduced costs of production exists for an indeterminate crop like cotton also. But for many years, prior to the 1960's, investigation on cotton plant populations in the United States had been conducted mainly on the conventional 91 to 102-cm rows, with varying spacings within the row. Essentially no studies have been conducted on narrow row-high population cotton production. Now, with the development of finger-type self-propelled strip harvester for narrow row cotton, coupled with the use of herbicides and stormproof cotton varieties adapted to narrow row-high population cultivation, it has become possible for researchers to investigate the merits of such systems for cotton production.

Investigations at various cotton research centers have shown that narrow rows have potential for improving cotton production efficiency. Higher populations achieved with narrow rows reduce the number of mature bolls per plant needed to produce a given yield. Because of this, a shorter production period is required. Also, a large leaf area is achieved early in the season and these factors may enhance earliness of crop maturity. This would help the crop escape some pests and disease problems and bad weather conditions such as early frost. All harvesting could also be done in a once-over low cost operation.

With the interest in narrow row-high population cotton production, the other concomittant problem is fertilizer requirement, especially nitrogen. It was, therefore, the objective of the present study to ascertain if nitrogen fertilizer, combined with narrow row and high plant populations, has any effect on yields, plant growth, and fiber characteristics under dryland conditions. The relationship, if any, existing between the level of nitrate-nitrogen found in the plant at various stages of development and the yield of the plant was to be determined also.

CHAPTER II

LITERATURE REVIEW

Spacing Effects

Yield

Several studies on cotton spacing were conducted in the United States as far back as 1886 and Brown (11) has summarized results of such investigations from many locations throughout the Cotton Belt up to 1919. Most of the tests were conducted on the traditional 91 to 102-cm rows with variable number of plants per hill and distances between hills. The tests were evaluated mainly for yields (61). The results showed that in the pre-boll weevil era, 31-cm spacing between hills gave top yields and on rich lands wider spacing gave better yields depending on rainfall, length of growing season and variety. On the other hand, results during the boll weevil era showed that closer spacing, such as 25 cm between hills, was best. On poorer soils more plants, two to four per hill, produced best yields.

Similarly, in the 1920's and 1930's, Cook (15) and several workers (5, 60) found increases in yields due to close spacing. They noted also that close spacing generally promoted earlier maturity and they recommended close spacing as a means of reducing losses due to boll weevil damage. But on the whole, these reports revealed that spacing of cotton plants drilled in rows could vary greatly without significantly affecting yields provided the plants were uniformly distributed.

Reynolds' (51) experiments with 91-cm rows and 12 spacings over a period of 12 years in Texas appeared in the mid 1920's. Generally, he obtained highest yields from the close and medium plant spacings of 15 to 53 cm, but in eastern Texas with high rainfall (129 cm) and sandy soils, wide spacings of 69 to 91 cm, gave the best results. Redding (50) summarizing 17 years of work in Georgia, stated that, "On a land capable of a yield of 402 to 803 kg lint per hectare, the rows should be 107 to 122 cm wide and the plants 31 to 46 cm apart in the drills, the narrower rows and closer spacings for the less productive soils." These results, in general, further show that the cotton plant has the ability to adjust itself to produce satisfactory yields over a comparatively wide range of spacings.

About two decades ago work was started on the High Plains of Texas on varieties sown with high seeding rates in narrow widths. It was found that yields could be increased by 10 to 20% and production costs reduced by 10 to 15% (36, 49, 61). Although these findings were encouraging, work had to be abandoned because of weed control problems and lack of equipment for harvesting narrow row cotton.

By 1962, wide acceptance of the commercial use of herbicides, coupled with the advent of an efficient finger-type narrow-row harvester, kindled interest in narrow row cotton production. In 1969, Briggs and Patterson (9) in Arizona reported the yields from 51-cm row spacing to be higher and the production costs lower than for 76 and 102-cm rows. Several other previous studies showed that narrow row widths and high plant populations produced higher yields at lower production costs. Thus, a 27% reduction in production costs had been observed by Ray and Hudspeth (48).

Plant Characteristics

An explanation for the low production costs could be found in a report by Porterfield et al. (46) which stated that plants were rendered more suitable for machine harvesting when closely spaced. These investigators established that close spacing increased height of the low boll, gin turnout, and it decreased plant heights, plant width, height of the high boll and total machine loss. Furthermore, with a high plant population, fewer bolls per plant were needed to produce a satisfactory yield in a shorter period. The advantage of a shorter season with less production inputs resulted in lower costs.

The question of earliness as determined by the percentage of total yield harvested at the first picking is not clear-cut. Earliness was not affected by row spacing according to some reports (5, 6) whereas Longenecker et al. (41) found an average increase of 15% at first picking due to narrow row spacings. In Australia, Low and McMahon (42) found that closely spaced 18-cm plants increased earliness of the determinate early maturing varieties but not the late maturing ones. It is possible that the combination of spacing, environmental conditions and variety affects maturity. Thus under certain conditions closer plant spacing would hasten maturity, but under other conditions maturity would be delayed. The contribution of spacing to the development of appropriate leaf area index for maximum lint yield has been reported also (1, 35).

In India, Singh et al. (53) found that plants in closer spacing, 30 x 30 cm, was higher yielding, especially in years of water stress, owing to the early establishment of a larger number of bolls per square meter before the stress period. But Douglas and Andries (18) have noted somewhat contrary observation. In an unfavorable year cotton planted in 102-cm row yielded significantly more than that planted in narrower rows for two varieties tested.

The location of experiment makes a difference, but more importantly, varieties suitable for narrow row culture appear to be a key factor, as noted by Texas researchers (8, 47, 49). Ray (47) reported a yield increase of about 15% from one of four commercial varieties, but greater than 30% increase in 20-cm rows for a variety developed specifically for narrow row culture.

There appears to be spacing-population-rainfall interactions on yields in a most recent Texas report by Hudspeth (31). The results of his four-year tests showed that yields were not significantly different between 102-cm row cotton and narrow row dryland cotton when the plant population was held at 99,000 per hectare. However, he found that with above average rainfall, yield increases were obtained in the narrow row patterns if the populations were increased to between 198,000 and 247,500 plants per hectare.

Fiber Characteristics

Several investigators have reported the effects of row spacing and population on fiber properties. The reports appear to be inconsistent and conflicting. Hawkins and Peacock (29) reported that the only fiber characteristic to be affected by row width was fineness or micronaire reading, and this depended on location. They found that plants in rows spaced 51 and 102 cm produced fibers with higher micronaire readings (coarser) than fibers from plants in 76-cm rows. Fibers in 26-cm rows were not different from those grown in any other row width.

In a one-season trial El-Zik et al. (21) found the average micronaire values both in dryland and irrigated plots with narrow rows to increase by 27 and 10%, respectively, over the 102-cm rows. Similarly, Longenecker et al. (41), working with irrigated experimental plots, found that cotton grown in close spacing produced coarser fibers than cotton grown in 102-cm rows. On the other hand, Douglas and Andries (18) in Mississippi showed that the micronaire reading was lower (finer) from cotton produced in 51-cm rows than from that in 102-cm rows. Bridge (7) also reported a trend toward lower micronaire values as the distance between rows was reduced.

Whereas Longenecker et al. (41) reported shorter fibers in close rows, other workers (17, 18, 37) found that fiber length was not influenced by spacing. But Bridge (7) also found fiber produced in 102-cm rows to be significantly longer than that produced in 38-cm rows. Kungkajitr (38) reported that spacing within the row on a 25-cm row had no effect on any fiber characteristics. The few reports on other fiber properties such as strength and uniformity index indicate that these characteristics are not materially affected by row spacing (10, 17, 21).

Plant Population Effects

Yield

The effect that population has on cotton yields is not easily separated from those of spacing, both between and within rows.

Accordingly, most of the literature accounts treat the two effects together.

Reports over the years have shown that yields do not vary significantly over a wide range of plant populations. Thus, Hawkins and Peacock (28) using 102-cm rows, obtained high yields when the population was within a range of 96,000 to 144,000 plants per hectare. But a subsequent publication by the same authors (29) showed that neither of two populations investigated, 128,000 and 256,000 plants per hectare, had any significant effect on yield. They suggested that narrow rows and cotton variety have more effect on yield than plant population per se.

Investigating a range of populations from 24,700 to 222,300 plants per hectare on 1-m rows, Bridge et al. (8) in Mississippi found that the highest yields were obtained with a population of 70,000 to 121,000 plants per hectare. In two out of three years the highest yields were obtained with a population of 114,000 to 121,000 plants per hectare. They also noted that yields tended to decrease at populations above 118,000 plants per hectare. Other researchers, including Douglas et al. (19), have found significant yield differences over a three-year period between populations of 24,700, 74,000, 148,200, and 222,300 plants per hectare. The highest yield was produced by 74,100 plants per hectare. This figure falls in the range reported by the preceding investigators. Similarly, Thomas (56) in Oklahoma recently indicated from a one-year trial that populations of 141,000 to 183,168 plants per hectare were adequate for optimum dryland production. And Kungkajitr (38), working solely on 25-cm rows at a different location in Oklahoma, found that plant populations of 77,700 to 110,900 per hectare gave higher yields compared with those over 128,700 plants per hectare.

A rather low population range, 40,000 to 160,000 plants per hectare, was investigated in Tennessee by Duncan and Pete (20). Their results showed that populations of less than 88,500 plants per hectare reduced yields significantly. A high plant population study in Australia by Low and McMahon (42) showed that in regions with shorter seasons, establishing 500,000 plants in narrower rows, instead of the usual 100,000 plants per hectare in 100-cm rows, gave larger increases in yield. But they noted that in Arizona and California, where the season is longer, a lower density of 250,000 plants per hectare in 35 to 100-cm rows was recommended. These Australian authors (52, 55) further opined that the high density cropping system should be particularly appropriate for areas with a short growing season but could not be easily applied in some regions producing rain-grown cotton.

In the tropics, Gregory et al. (24) and later, Lambert and Crowther (39) found, using conventional 91 and 102-cm rows, that spacing within the row or plant population had little effect when plants were sown early. But there was an increased response to closer spacing (increased population) with late sowing. They suggested that with early sowing the plants were able to compensate extensively for loss of stand and, therefore, plant density was not of great importance in determining final yield. More recently, work by Burhan and Taha (14) has confirmed the results of earlier investigations in the same location indicating that a low population was suitable for early sown cotton whereas a higher population is better suited for delayed sowing.

Similarly, in western Nigeria, Lee (40) conducted trials on 76-cm rows and suggested that evenness of plant distribution, and not plants per hectare per se, was the major factor in yield production, and that populations beyond 23,900 plants per hectare produced little increase in yield. He suggested that under the local conditions a within-row spacing of 46 cm (lower population) for early planting and a 30-cm (higher population) for late planting was adequate.

Plant Characteristics

Hawkins and Peacock (29) found that significantly smaller bolls were produced at high population levels. Similar results were recorded by Burhan (12), and Ray et al. (49). Briggs and Patterson (9) found a reduction in boll size and seed index in population levels above 247,500 plants per hectare. But according to Longenecker et al. (44) boll size was reduced only in narrow rows. Low and McMahon (42) substantiated a report that the number of fruiting forms per plant decreased significantly with increased population. Boll retention decreased to only 10% and boll weights were lower, but a 20% increase of lint was recorded.

In Oklahoma, Thomas (56) observed that with increasing plant population, boll size decreased, square initiation was delayed, period of flowering and fruiting shortened, and there was an increase in the time required for boll maturity. He noted that since all these effects are noted late in the season, it defeated the earlier maturing advantage of the determinate varieties used. A review by Wilkes and Corley (61) showed that plant height decreased as plant population increased and there was an important increase in height of the lowest fruiting limb as population increased.

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, the reports show, are able to maintain most of their inherent fiber properties when produced with high plant populations. Thus, fiber strength, length, and lint percent are not affected by population as reported by Hawkins and Peacock (29), Briggs and Patterson (9). Quite recently, other workers (17, 56) also observed that fiber length and strength are not influenced by plant population. Walhood (59) found only small differences in fiber properties even when cotton was sown at about 200,000 plants per hectare on 25 and 102-cm rows.

Recently Low and McMahon (42) in Australia found no significant population effect on either 2.5% span length or on uniformity ratio over three seasons. There was no effect on micronaire value, yarn strength and appearance. But they further noted that fiber strength and elongation were significantly influenced by population in the first two harvests, the 100-cm row samples being stronger than the 18-cm row samples. Also, adverse effects were observed only in one variety on micronaire value, lint length, and strength but these were very small.

The only other adverse effect reported in the literature was that micronaire readings tended to be lower (finer) with increasing plant density (12, 17, 18). Baker (3) reported similar results but added that all population treatments had acceptable micronaire values.

Nitrogen Effects

Nitrogen Level in the Plant

The amount of soil and applied nitrogen available to the plant is usually reflected in the level of nitrate-nitrogen in the plant tissue. It has been found by Joham (34) that the plant tissue which best reflected this relationship was the main stem petiole near the apex of the plant. The level of nitrate-nitrogen 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 phosphorus deficiency. The "critical concentration" of nitrate-nitrogen was found to be 0.03% (300 ppm) of fresh weight at the 13-week growth stage.

MacKenzie and his coworkers (43) found that nitrate-nitrogen content of petioles was highest at the early stages of growth and levels up to 18,000 ppm 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 to variety or soil moisture. Later, similar findings were reported by Gardner and Tucker (23). Baker (2) also found the level of nitrate-nitrogen in the petioles to be highest at the mid-square stages of growth and was affected by rates and times of nitrogen application. Recently Grimes et al. (26) reported that nitrate-nitrogen concentrations from the most recently matured leaves were influenced by N fertilization level, time of sampling in the season and water management. Plant population did not alter the nitrate-nitrogen levels of petioles.

Yield

The yield response reported due to nitrogen application varies depending on the site, previous cropping history, soil nitrogen status and rate of application. Thus, Baker (2) obtained significant increases in yield only at one location in one trial out of four in two years. Murray et al. (44) also have obtained some yield responses to N fertilization. After more than thirty years work in the Sudan, Jackson and Burhan (32) found that the net response to nitrogen 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 nitrogen rates have been known to cause excessive vegetative growth and severe pest problem (13, 30, 57). With regard to the pest problem, Burham (12) recently confirmed previous reports that there was a significant nitrogen by pest control interaction. He obtained only 24% increase in yields when fertilizer nitrogen was applied to cotton not sprayed with pesticide whereas 63% yield increase was recorded when pest controlled cotton was fertilized. 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 the season. This resulted in low yields, especially in areas where early frost occurred (12).

There appears to be agreement that nitrogen applied at planting or early in the season is the most effective in increasing yield (23). Baker (2) found application prior to the 8-leaf stage to be more beneficial than later dressings. But in areas with longer seasons, such as southwestern and far western United States, and with good pest control measures, later nitrogen application could lead to new growth and additional boll production and, therefore, increased yield.

A review report by Tucker and Tucker (58) observed that the overall effect of nitrogen appears to be an increase in total yield brought about by prolonging of the fruiting period. The increases in yield were therefore usually in the form of late harvests. In Australia Evenson (22) found that attempts to increase yield by applying extra nitrogen extended the growing period into onset of unfavorable weather associated with the end of a season, and thus would adversely affect quality.

Fiber Quality

The influence that fertilizer nitrogen has on fiber characteristics has not been given detailed attention and the reported results are inconsistent. Length, strength, and fineness are the fiber properties most commonly reported. Crowther (16) reported increases in lint length from nitrogen application. Nelson (45) reported that nitrogen and potash application increased length. But Tucker and Tucker (58) stated that fiber length has been shown to increase where severe nitrogen shortages occurred. More specifically, the interaction of nitrogen and water on fiber length has been noted. Thus, Grimes et al. (25) observed that increments of nitrogen improved fiber length slightly only when water was severely limiting, but had no effect when water supply was adequate, and decreased fiber length when water additions were excessive.

On the other hand, Murray et al. (44) made reference to the work of Gulati in India indicating that an increase in lint length was obtained from nitrogen treatments. The preponderance of evidence indicates that nitrogen intrinsically has little effect on fiber length and strength (26, 44, 58). With regard to fiber fineness, a review by Tucker and Tucker (58) indicated that nitrogen supply has not been observed to cause a variation in fiber fineness of practical importance. Results of the work of Grimes et al. (25) and Murray et al. (44) also support this assertion.

CHAPTER III

MATERIALS AND METHODS

Field Plot Technique

Experiments were conducted in 1973 and 1974 on a Teller fine sandy loam at the Agronomy Experiment Station, Perkins, Oklahoma. The soil classifies as fine-loamy, mixed, thermic, Udic Argiustolls (54). The cotton variety, "Westburn 70" (Gossypium hirsutum L.) was grown in three row spacings--25, 51, and 76 cm; three nitrogen levels--0, 45, and 90 kg per hectare; and at two populations--123,550 and 172,970 plants/ha. The rows and populations were established by eliminating undesired drilled 25-cm rows and thinning the seedlings. The experiment was conducted as a factorial arrangement in a randomized complete-block design with four replications. A standard application of 45 kg P_2O_5/ha was made on all plots.

Additional treatments were set up to observe the possible effects of high levels of nitrogen (90 and 134 kg/ha) combined with 45 and 90 kg P_2O_5/ha at populations of 172,970 and 222,390 plants/ha. The two plant populations were established in 25 and 51-cm rows, respectively. After preliminary observations in 1973, this additional experiment was modified the following season to contain three nitrogen levels (0, 45, and 90 kg N/ha), two phosphorus levels (45 and 90 kg P_2O_5/ha) at a plant population of 222,390/ha in 25-cm rows. In the first year, the observation plots were replicated twice, and in the second season the treatments were replicated four times. A key to the various treatment combinations is found in Table I.

In all the experiments nitrogen was applied as ammonium nitrate and phosphorus as triple superphosphate. Soil test values at this site showed available potassium to be adequate for growth of the cotton plant (Appendix, Table XXI). In 1973, fertilizer was applied on May 30, and the seeds were drilled in 25-cm rows on June 8. Germination and stands were good. Two to three weeks later at the 3 to 4-leaf stage, unwanted rows were removed and seedlings were thinned manually to establish the desired row widths and plant populations. In the second growing season, the field was fertilized on May 22. Emergence was poor because of heavy rain. The experiment was replanted on June 17, but seed germination was poor because of drought. Skips between plants were resown with a hand-operated planter. About 51 mm irrigation water was also applied to aid germination. It was irrigated four weeks later, and at the squaring-flowering stage also. A total of 142 mm irrigation water was applied in 1974 to sustain the plants. No irrigation was necessary in 1973. No herbicides were applied, but weeding was done as necessary. Periodic observations of pest and insect damage indicated no need for spraying the test during either growing season.

Plant Analyses

Petioles of the most recently matured leaf were sampled at the squaring, flowering and bolling stages from plants in the middle of the plots. The petioles were dried at 80 C for 24 hours and ground in a

TABLE I

TREATMENT COMBINATIONS*

Basic Treatments, Four Replicates (1973 and 1974)		Observation Treatments, Two Replicates (1973)		Revised Observation Treatments, Four Replicates (1974)
1. N_1 R_1 Pl_1 P_2	10. N_1 R_1 Pl_2 P_2	19. N_3 R_2 Pl_2 P_1	25. N_4 R_2 Pl_2 P_1	19. N_1 R_1 Pl_3 P_2
2. N_1 R_2 Pl_1 P_2	11. N_1 R_2 Pl_2 P_2	20. N_3 R_1 Pl_3 P_1	26. N_4 R_1 Pl_3 P_1	20. N_3 R_1 Pl_3 P_2
3. N_1 R_3 Pl_1 P_2	12. N_1 R_3 Pl_2 P_2	21. N_3 R_2 Pl_2 P_2	27. N_4 R_2 Pl_2 P_2	21. N_1 R_1 Pl_3 P_3
4. N_2 R_1 Pl_1 P_2	13. N_2 R_1 Pl_2 P_2	22. N_3 R_1 Pl_3 P_2	28. N_4 R_1 Pl_3 P_2	22. N_2 R_1 Pl_3 P_2
5. N_2 R_2 Pl_1 P_2	14. N_2 R_2 Pl_2 P_2	23. N_3 R_2 Pl_2 P_3	29. N_4 R_2 Pl_2 P_3	23. N_2 R_1 Pl_3 P_2
6. N_2 R_3 Pl_1 P_2	15. N_2 R_3 Pl_2 P_2	24. N_3 R_1 Pl_3 P_3	30. N_4 R_1 Pl_3 P_3	24. N_3 R_1 Pl_3 P_2
7. N_3 R_1 Pl_1 P_2	16. N_3 R_1 Pl_2 P_2			
8. N_3 R_2 Pl_1 P_2	17. N_3 R_2 Pl_2 P_2			
9. N_3 R_3 Pl_1 P_2	18. N_3 R_3 Pl_2 P_2			

*N_1, N_2, N_3, and N_4 refer to 0, 45, 90, and 134 kg N/ha, respectively.
R_1, R_2, and R_3 refer to 25, 51, and 76-cm rows, respectively.
Pl_1, Pl_2, and Pl_3 refer to 123,550, 172,970 and 222,390 plants/ha, respectively.
P_1, P_2, and P_3 refer to 0, 45, and 90 kg P_2O_5/ha, respectively.

Wiley mill to pass a 40-mesh sieve. A weight of 0.2 gm was placed into a flask containing 50 ml of a 0.1 N $CuSO_4$ solution and heated in a steam bath for ten minutes to extract the nitrates. After that, 0.1 gm $Ca(OH)_2$ and 0.2 gm $MgCO_3$ were added and the flasks were shaken for five minutes to decolorize the solution and flocculate the organic matter (27). The flask contents were then filtered, and the filtrate analyzed for NO_3-N using the Brucine method of Jenkins and Medsker (33), and the report of De Martini as modified by Finger (J. H. Finger, unpublished report).

Characteristics Measured

Immediately prior to harvest in early December and after vegetative growth had completely ceased, heights of 10 consecutive plants in the middle of each plot were taken. The total number of bolls on those plants were also counted. Of the total bolls, all that had reached maturity and had opened either fully or partially were determined as good. Thus, all immature bolls (or those that were partly open, but badly damaged by insects or weather) were counted and discarded as "bad" bolls. Visual observations among treatments on their relative period of plant maturity and boll opening were also made. On the basis of apparent number of open bolls/plot in late October, plots were ranked in four categories. Vegetation in late October was also rated in three categories according to the state of senescence of the leaves (Appendix, Table XXII).

In 1973 the plots were harvested December 7 and 8, and in 1974 they were harvested December 14. Harvest of the yield plots, 9.3 square meters in size, was done by hand. The snapped cotton from each plot was then weighed. Weighed samples of 15 mature bolls from each plot were deburred, weighed, ginned on an 8-saw laboratory type gin, and re-weighed to permit the estimation of picked and pulled lint percents. Using the pulled lint percents, the plot yield for the various treatments could be calculated and then adjusted to a kg/ha basis.

Measurements of fiber characteristics were made on the lint obtained from the 15 boll samples from each plot. The fiber data taken were fineness as measured on the micronaire in micronaire values (μg/in.); strength as measured with the stelometer at the 0- and 1/8-inch gauge settings (g/tex); fiber length measured on the digital fibrograph as 2.5% span length (in inches); and length uniformity determined indirectly on the digital fibrograph as the ratio of 50%/2.5% span length (expressed as a percentage).

Statistical analyses of all measurements taken were accomplished using the system devised for computers by Barr and Goodnight (4). Analyses of variance and linear correlation coefficients among all response variables were calculated. Each variable was fixed and all mean squares were tested against error mean square.

CHAPTER IV

RESULTS AND DISCUSSION

First, it should be emphasized that weather conditions during the 1973 and 1974 growing seasons were quite different. Rainfall distribution was more favorable in the first season than in the second. As a result, notable differences were obtained for most characters between the two years. There were significant interactions between year and several of the response variables. These cases will be discussed separately for each year. But where no such interactions were noted, both years will be discussed together (Appendix, Tables XXXI and XXXII).

Plant Characteristics

Height

The most noticeable effects of the various treatments were on plant height and vegetative growth. Plant height was highly and significantly affected in both years by row spacing and nitrogen, and in 1973, by plant population and nitrogen-population interactions.

Plant height was significantly affected by spacing by year interactions (Appendix, Table XXXI). In both years, the 25-cm rows produced the shortest plants, and the 76-cm rows produced the tallest plants (Figure 1). There was no significant difference between heights of plants in the 25- and 51-cm rows in 1974, but apart from that comparison all possible differences in plant heights in the row treatments were all

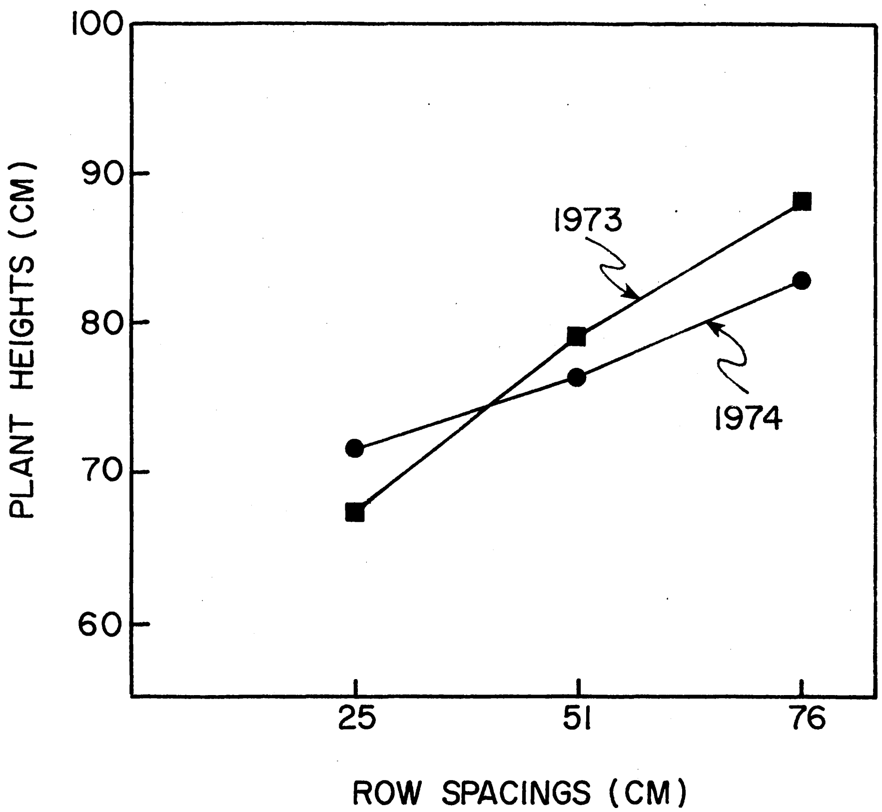

Figure 1. Row Spacing Effects on Plant Height

significant in both years (Table II). Similar results have been obtained by previous investigators. Thus, Kirk et al. (37) noted that plants became shorter as row width decreased.

Nitrogen application significantly increased plant heights (Table III). No year by N interaction was noted (Appendix, Table XXXI). In both years there was a significant difference between the check and 90 kg N/ha, and between 45 and 90 kg N levels, but no significant differences were evident between the check and the 45 kg N/ha rate. Another visible effect of N application was a production of luxuriant and prolonged vegetative growth coupled with a somewhat protracted and delayed fruiting period. This was indicated by the relative degree of senescence and number of boll openings in the various treatment plots at the time of harvest (Appendix, Table XXII). Plants in the plots with high nitrogen treatments had numerous immature bolls at harvest time. In a longer season, it is probable that those bolls would have matured and contributed to yields.

In 1973 there was a significant reduction in plant height as plant population was increased from 123,550 to 173,000/ha (Appendix, Table XXIII). However, the nitrogen-population interaction effects were even more striking as can be seen in Figure 2.

As far as the relationship of height with yields is concerned, there was a highly significant negative correlation of height with lint and seed cotton yields in 1974 (Appendix, Table XXV). Thus, as plant height decreased, seed cotton and lint yield increased in that year. In 1973 no significant correlation was present even at the 0.10 probability level.

TABLE II

ROW SPACING EFFECTS ON PLANT HEIGHT

Spacing (cm)	Plant Heights (cm) 1973	1974
25	68c*	72b*
51	78b	76b
76	86a	82a
LSD at 5%	3	5
LSD at 1%	4	7

*Figures followed by the same letter in the same year are not significantly different at the 5% probability level.

TABLE III

NITROGEN TREATMENT EFFECTS ON PLANT HEIGHT

Nitrogen (kg/ha)	Plant Heights (cm) 1973	1974
0	73b*	72b*
45	75b	75b
90	83a	81a
LSD at 5%	3	5
LSD at 1%	4	7

*Figures followed by the same letter in the same year are not significantly different at the 5% probability level.

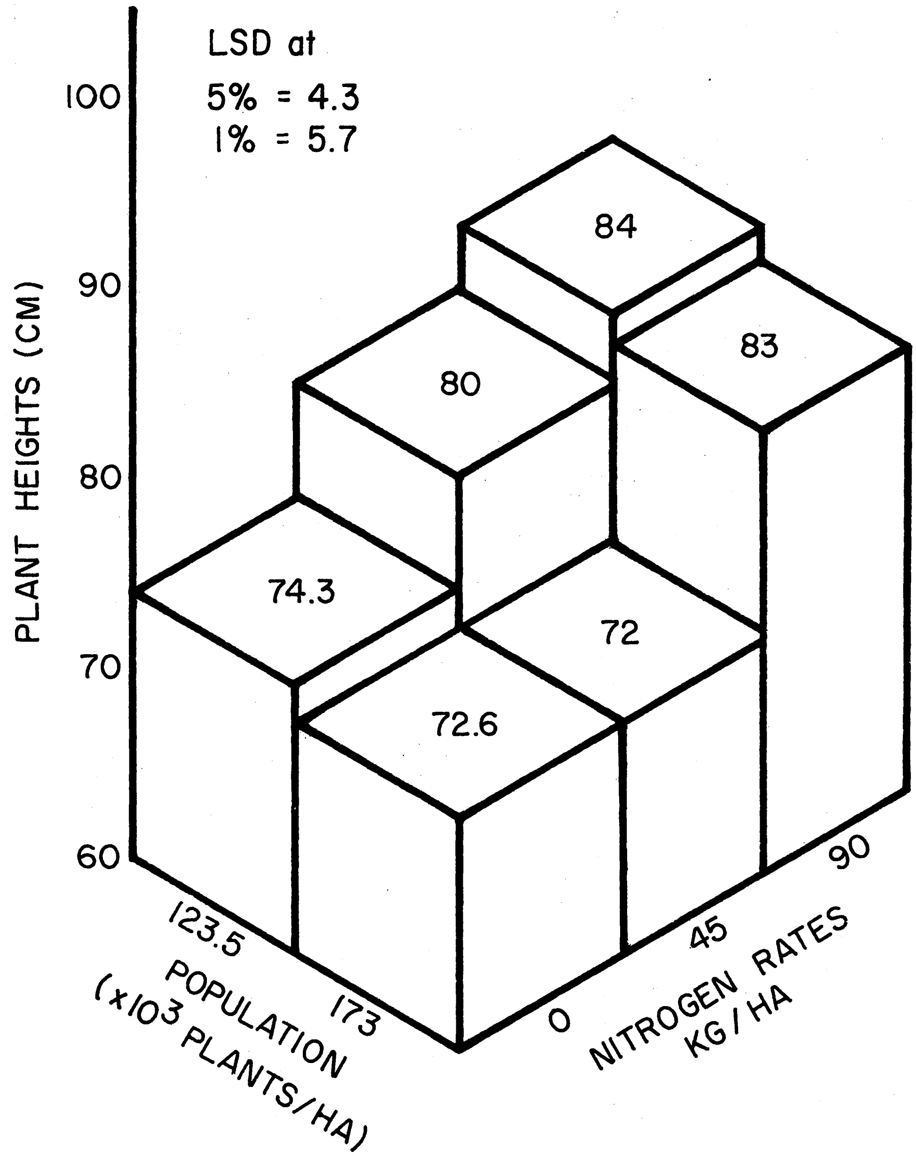

Figure 2. Nitrogen-Population Effects on Plant Height in 1973

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. In both years the highest NO_3-N level was generally at the squaring stage which declined sharply as plants approached bolling stage. This trend supports earlier findings (2, 24, 43). By the method used, mean NO_3-N levels as high as 90,000 ppm were measured in the petioles at the squaring stage of plant growth, and this later declined to about 17,000 and 11,000 ppm, respectively, at the flowering and bolling stages of plant growth, respectively, in 1973 (Figure 3). These general trends held for both growing seasons; nevertheless the levels of NO_3-N for 1974 were nearly twofold higher than for 1973 (Table IV). This yearly difference could be due to a number of factors. It is possible that there was a carry-over effect from the previous season as could be seen from the increase in soil NO_3-N levels in 1974 (Table XXI). The dry weather conditions minimized leaching and denitrification losses of soil nitrate and, especially, retarded the conversion of accumulated nitrates to protein in the plants.

Other investigators (2, 24, 34, 43), using the phenoldisulfonic acid procedure, obtained lower levels of NO_3-N in petioles, but the general trend of high levels at squaring stage that decreased sharply as the plant matured also held true for their findings.

At the square stage, plants in the few check plots which did exhibit nitrogen deficiency symptoms contained less than 3000 ppm NO_3-N in their petioles. In this regard, MacKenzie et al. (43) and Baker (2) have suggested that yield reductions were related to the length of time NO_3-N

TABLE IV

SEASONAL EFFECT ON NO_3-N CONTENT OF PETIOLES

Year	Stages of Plant Growth (ppm) Squaring	Flowering	Bolling
1973	93,096a*	17,008a	11,036a
1974	224,236b	133,016b	30,166b
LSD at 1%	14,949	11,326	4,956

*Figures followed by the same letter in the same growth stage are not significantly different at the 5% probability level.

TABLE V

ROW SPACING EFFECTS ON BOLLS PER PLANT

Spacing (cm)	1973 Total Bolls	1973 Good Bolls	1974 Total Bolls	1974 Good Bolls
25	30a*	15a*	58a*	14a*
51	36bc	18b	61a	18a
76	40c	19b	76b	15a
LSD at 5%	4	3	9	5
LSD at 1%	6	4	12	6

*Figures followed by the same letter in the same column and year are not significantly different at the 5% probability level.

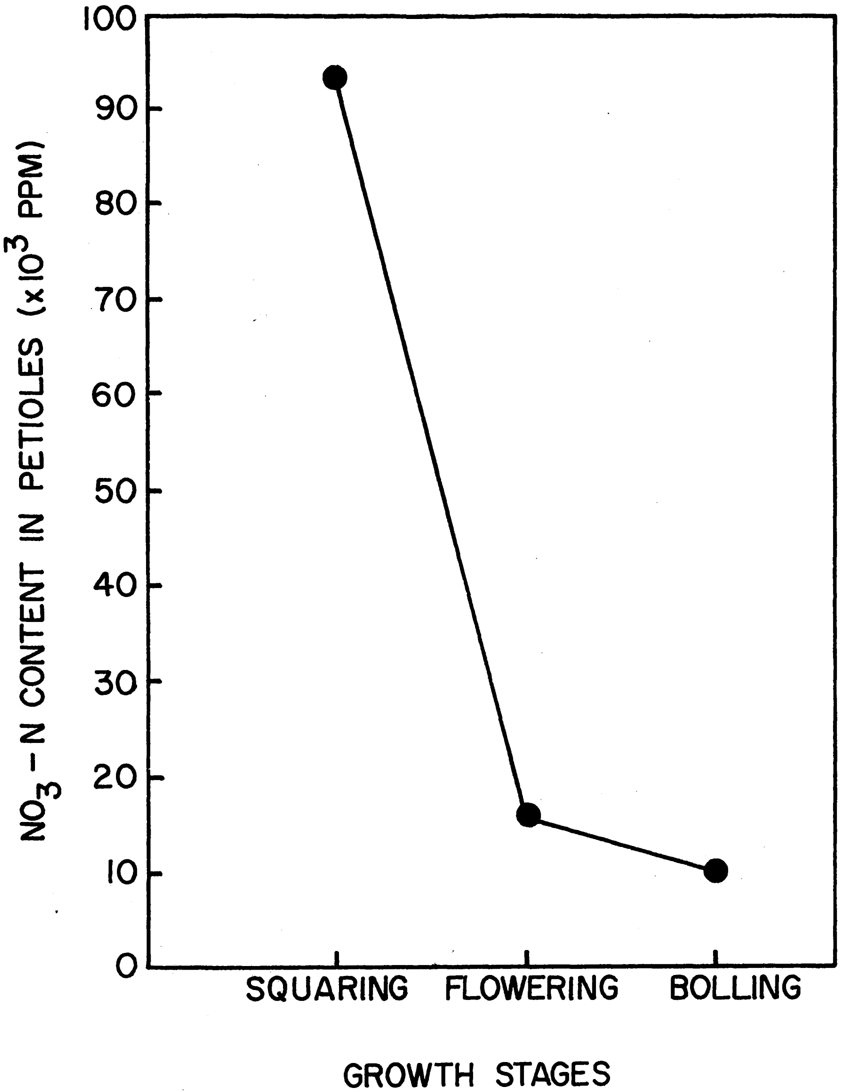

Figure 3. Levels of NO_3-N in Cotton

levels fall below 2000 ppm "during the early-, mid-, and late-bloom stages." Deficiency symptoms appear at this critical NO_3-N level (24).

The effect of nitrogen treatment was a highly significant increase in level of NO_3-N in the petioles at all stages of sampling in 1973 and 1974 (Appendix, Table XXVI). The combined effects of N in both years can also be seen in Figure 4. It appears that the cotton plant continued to absorb nitrogen from the soil in proportion to the amount applied. In 1973 there were no interactions of various treatments (nitrogen, row spacing and plant population) on the NO_3-N content of petioles. In the 1974 season, however, there was evidence of nitrogen-spacing and nitrogen-population interactions at the squaring and flowering stages, respectively (Appendix, Tables XXIX, XXX).

The general effect of row spacing for the two years was that as the row width increased, higher NO_3-N content was found in the petioles (Figure 5). The differences between the NO_3-N levels in petioles from the three row spacings were highly significant at squaring, flowering and bolling stages (Appendix, Table XXVII).

The two plant populations studied gave small and inconsistent effects on NO_3-N Levels in the petioles. In both years the levels of NO_3-N in petioles at squaring stage as affected by plant populations were not different. In 1973 higher NO_3-N levels, though nonsignificant, were noted in the petioles from the high plant population during the flowering and bolling stages of growth. No such differences between populations were observed in 1974 (Appendix, Table XXVIII).

No relationship existed between NO_3-N content of petioles and yields. In both years there were no correlations between NO_3-N levels in the petioles and seed cotton or lint yields. In 1973 there was a

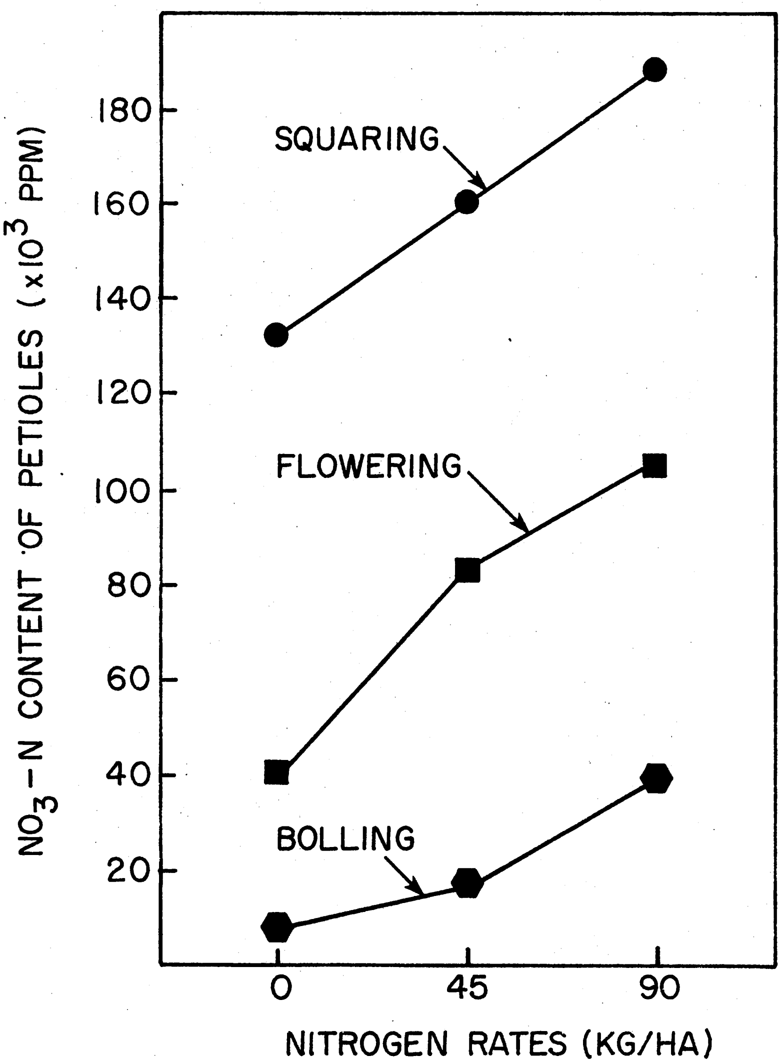

Figure 4. Effect of N Rates on NO_3-N Content of Cotton Petioles

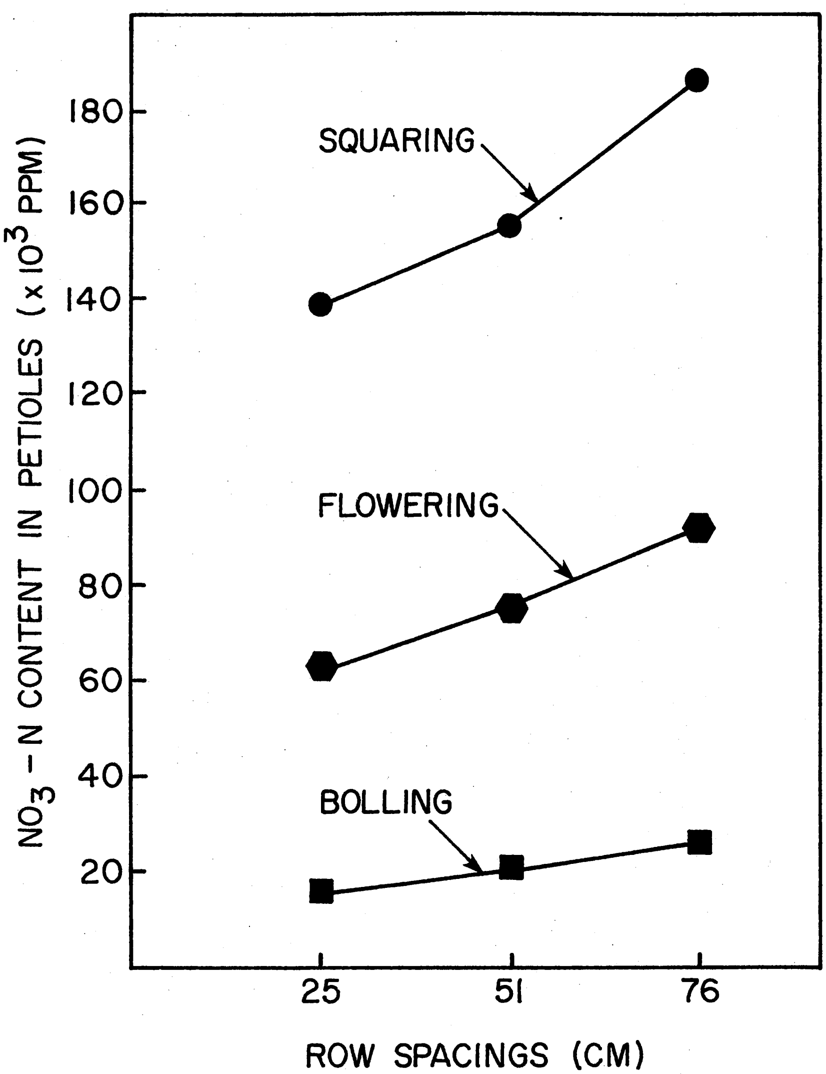

Figure 5. Effect of Row Spacing on NO_3-N Content of Petioles

significant negative correlation between the NO_3-N content of petioles at the bolling stage and percent pulled lint and percent picked lint (Appendix, Table XXV). In the second season there was some evidence of a positive correlation between NO_3-N level at bolling stage and lint yields.

Total Bolls

The total number of bolls/plant was significantly affected by row spacing in the two seasons, and by plant population in 1973. There was a highly significant increase in the number of bolls/plant as row spacing was increased from 25 to 51 to 76 cm, except in 1974 when the total boll difference between 25 and 51-cm row spacings was not significant (Table V). It must, however, be noted that there was no significant relationship between the total number of bolls/plant and seedcotton or lint yields.

In 1973 the total number of bolls decreased significantly as plant population increased from 123,550 to 173,000 per hectare (Table VI).

Good Bolls

The only treatment variable that affected the number of "good" bolls produced per plant was row spacing. In 1973 as row spacing increased, the number of "good" bolls increased significantly except for the difference between 51 and 76-cm rows (Table V). But in 1974 there was only a nonsignificant increase in the number of good bolls per plant at the 51-cm row spacing compared with the other two rows.

There were positive significant correlations between the number of good bolls per plant and lint and seedcotton yields for both seasons

(Appendix, Table XXV). However no such relationship existed between total bolls and yields. This implies that as the number of good bolls borne by the plant increased, the seedcotton and lint yields also increased. Not all the total bolls per plant matured to contribute to yields.

In 1974 the number of good bolls increased as plant height decreased and vice versa. This negative relationship was highly significant (Appendix, Table XXV). No significant correlation was observed in 1973.

<u>Percent Pulled Lint and Picked Lint</u>

Statistical analysis showed that none of the treatments had any significant effects on the above two characters except in 1973 when the nitrogen-population interaction effects on percent picked lint approached significance. In the following year, the percent picked lint increased at the higher plant population level but this was not significant only at the 8% level.

Lint and Seedcotton Yields

Lint and seedcotton yields were significantly affected by nitrogen and row spacing treatments in both years. However, the two seasons were significantly different.

Generally, N application depressed cotton yields. In both years, the application of 45 kg/ha did not produce a significant change in yields from the check, but 90 kg N/ha reduced yields significantly and the yields from the two levels (45 and 90) were significantly different from each other (Table VII). Because of unfavorable weather conditions, the 1974 yields were significantly poorer.

TABLE VI

PLANT POPULATION EFFECTS ON BOLLS PER PLANT IN 1973

Plants/ha	Total Bolls	Good Bolls
123,550	39a*	18a*
173,000	33b	16a
LSD at 5%	3	2
LSD at 1%	5	3

*Figures followed by the same letter in the same column are not significantly different at the 5% probability level.

TABLE VII

NITROGEN TREATMENT EFFECTS ON YIELD

Nitrogen (kg/ha)	1973 Lint	1973 Seed Cotton	1974 Lint	1974 Seed Cotton
		(kg/ha)		
0	412a*	1086a	156a	432a
45	403a	1079a	137a	384a
90	341b	926b	78b	274b
LSD at 5%	40	106	35	106
LSD at 1%	54	142	47	142

*Figures followed by the same letter under the same column and year are not significantly different at the 5% probability level.

A highly significant reduction in yield was noted in 1973 as row spacing was increased from 25 to 76-cm. There was no significant difference between yeilds from 25 and 51-cm row spacings but the further decrease in yield as row spacing was increased from 51 to 76-cm approached significance (Table VIII).

In 1974 the narrower rows (25 and 51 cm) again produced higher lint yields than the 76-cm rows and the 51-cm rows produced significantly higher yields than the 76-cm rows. But the difference between 25-cm and 51-cm rows was significant only at the 6% level. There was also strong evidence of a spacing-population interaction and the highest lint yield obtained from the 51-cm row and 173,000 plants/ha treatment. No significant effects on seedcotton yields were observed (Table IX).

Plant population per se did not have any significant effect on yields which may be due to the narrow population range tested. Nevertheless, in both seasons, there were significant interactions between N and population. In 1973, N applications at the 123,550 plant population/ha level progressively decreased yields, though not significantly. At the higher population some N application seemed desirable but the high N level was not beneficial as the highest significant reduction in yield was obtained at the high N and higher population levels (Figure 6). A similar relationship held for the 1974 season also (Table X).

There was significant correlation between percent pulled lint and lint yields in 1973 but not in 1974. In both years, however, there was a significant positive correlation between seedcotton and lint yields (Appendix, Table XXV).

TABLE VIII

ROW SPACING EFFECTS ON YIELD

Rows (cm)	1973 Lint	1973 Seed Cotton	1974 Lint	1974 Seed Cotton
		(kg/ha)		
25	418a*	1094a	121a	352a
51	389ab	1045a	146a	386a
76	350b	926b	104ab	352a
LSD at 5%	40	106	35	106
LSD at 1%	54	142	47	142

*Figures followed by the same letter under the same column and year are not significantly different at the 5% probability level.

TABLE IX

ROW SPACING-PLANT POPULATION EFFECTS ON LINT YIELD IN 1974

Plants/ha	Row Spacing (cm) 25	51	76
123,550	140ab*	124b	96b
173,000	101b	169a	113b
LSD at 5%: 50			
LSD at 1%: 66			

*All figures followed by the same letter are not significantly different at the 5% probability level.

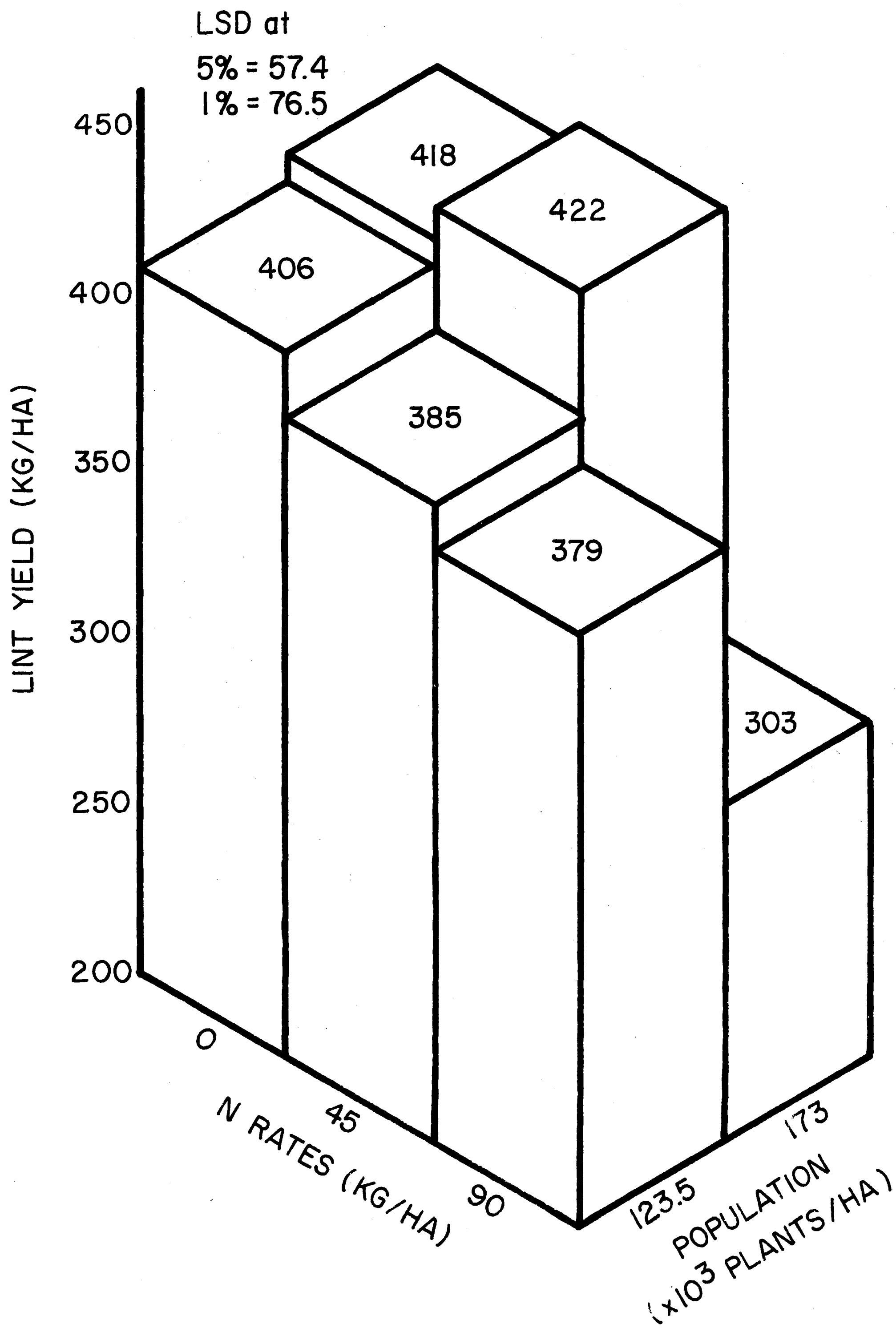

Figure 6. Nitrogen Treatment-Plant Population Interaction Effects on Lint Yields in 1973

Fiber Characteristics

The effects of treatments on the various fiber characters were inconsistent and in most cases statistically nonsignificant. The only fiber character that was consistently and significantly affected by the same treatment in both years was the uniformity index. The more important fiber properties such as length, strength and fineness (52) were not materially affected.

Uniformity Index

In the first season, nitrogen application produced fibers with significantly lower uniformity index though there was no difference between the two nitrogen levels. In 1974 the effect of 45 kg N application was to increase the uniformity index significantly at the 1% level but all other N treatments did not cause a significant change (Table XI). Also in 1974, there was evidence of spacing-population interactions. There was a tendency for the uniformity index to decrease at the 25-cm row spacing as plant population was increased from 123,000 to 173,000 per hectare. Similarly, the uniformity index decreased at the low plant population as row spacing was increased from 25 to 76-cm (Table XII).

In both 1973 and 1974 there were positive significant correlations between uniformity index and percent pulled lint, and also between the uniformity index and fiber fineness as measured by micronaire value (Appendix, Table XXV).

TABLE X

NITROGEN TREATMENT-PLANT POPULATION EFFECTS ON LINT YIELD IN 1974

Plants/ha	Nitrogen (kg/ha) 0	45	90
123,550	178a*	98bc	84c
173,000	135a	176a	73c
LSD at 5%: 50			
LSD at 1%: 66			

*All figures followed by the same letter are not significantly different at the 5% probability level.

TABLE XI

EFFECTS OF NITROGEN TREATMENT ON UNIFORMITY INDEX

Nitrogen (kg/ha)	Uniformity Index 1973	1974
0	45a*	48b*
45	44b	50a
90	44b	49ab
LSD at 5%	0.6	0.9
LSD at 1%	0.8	1.3

*Figures followed by the same letter are not significantly different at the 5% probability level.

Fiber Fineness

Fiber fineness or coarseness was not significantly affected by any treatment variable in 1973. There was only weak evidence of nitrogen-spacing-population interactions (0.09 probability level). There was some evidence that nitrogen application decreased micronaire value (finer fiber). The decrease in micronaire value by the low N application approached significance at the 5% level (Table XIII). Additional application did not change it materially.

In the following season, the nitrogen-spacing and nitrogen-population interactions were significant. At the 25-cm row spacing, nitrogen application lowered the micronaire value (finer), but this was highly significant only when 90 kg N was applied. At the intermediate row spacing, no significant effects were noted. And at the 76-cm row spacing, there was a highly significant increase in micronaire value (coarser fiber) at the low N application level, but it decreased significantly at the higher N level (Figure 7). It was apparent from the results that where no nitrogen was applied, decreasing the row spacing from 76 to 25-cm increased the micronaire values (coarser) by about 12%. This was highly significant. Contrarily, increasing both the N level and row spacing to 90 kg and 76-cm, respectively, significantly decreased micronaire value (finer) by 10%.

In the reports of El-Zik et al. (21) and Longenecker et al. (41) coarser fibers were obtained when row spacing was decreased to 25-cm. However, these workers did not report nitrogen as one of their treatment variables.

TABLE XII

ROW SPACING-PLANT POPULATION EFFECTS ON UNIFORMITY INDEX IN 1974

	Row Spacing (cm)		
Plants/ha	25	51	76
123,550	50.7a*	49.7b	49.2b
173,000	49.1b	49.6b	49.7b
LSD at 5%: 1.4			
LSD at 1%: 1.9			

*Figures in all columns followed by the same letter are not significantly different at the 5% probability level.

TABLE XIII

NITROGEN TREATMENT EFFECT ON FIBER FINENESS IN 1973

Nitrogen (kg/ha)	Micronaire Value
0	4.02*
45	3.87
90	3.88
LSD at 5%: 0.16	

*Statistically nonsignificant at the 5% probability level.

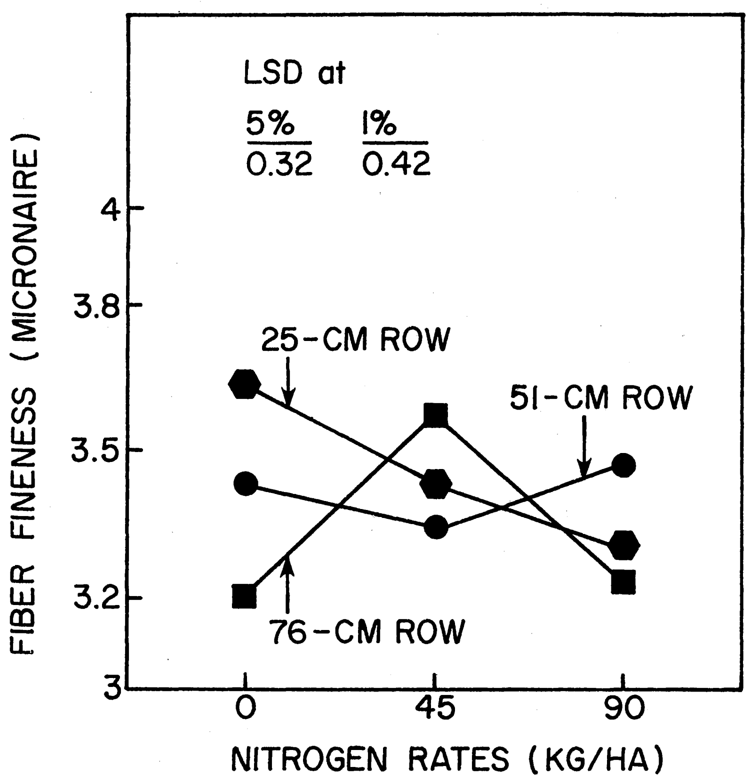

Figure 7. Nitrogen-Spacing Effect on Fiber Fineness in 1974

The effects of nitrogen-population interaction appeared to be similar to that of nitrogen-row-spacing. Again, where nitrogen was not applied, decreasing plant population from 173,000 to 123,550/ha significantly increased micronaire value (coarser) by 9%. Conversely, applying 90 kg N and increasing plant population from 123,550 to 173,000/ha significantly decreased micronaire value (finer) by about 9% (Figure 8).

In both years of the experiment there were highly significant positive correlations between micronaire values and seedcotton and lint yields. Treatments with higher yields also displayed higher micronaire values (coarser fibers). A significant negative correlation with the 2.5% span length was noted (Appendix, Table XXV).

Fiber Strength

Fiber strength as determined on the 0-inch gauge was affected only by spacing-population interactions in the first season. The greatest fiber strengths were obtained at the 25-cm row-lower population and the 51-cm row-higher population levels (Table XIV). Increasing row spacing without increasing the plant population and vice versa led to significantly lower fiber strength.

With the 1/8-inch gauge, fiber strength was significantly affected by row spacing and also by nitrogen-row-spacing-population interactions in 1974. No effects were noted in 1973. Increasing row spacing from 25 or 51 to 76-cm produced a highly significant increase in fiber strength as shown in Table XV. As for interactions, the lowest fiber strength was obtained from the higher population treatment on the 25-cm row but without nitrogen application (Table XVI). Decreasing the plant population at this treatment level to 123,000 plants/ha led to a highly

TABLE XIV

ROW SPACING-PLANT POPULATION EFFECTS ON O-INCH GAUGE FIBER STRENGTH IN 1973

	Row Spacing (cm)		
Plants/ha	25	51	76
		(g/tex)	
123,550	38.0ab*	37.0b	37.0b
173,000	37.2ab	38.2a	37.6b
LSD at 5%: 1.1			
LSD at 1%: 1.4			

*Figures followed by the same letter are not significantly different at the 5% probability level.

TABLE XV

ROW SPACING EFFECTS ON 1/8-INCH GAUGE FIBER STRENGTH IN 1974

Row Spacing (cm)		
25	51	76
18.6a*	18.9a	19.3b
LSD at 5%: 0.5		
LSD at 1%: 0.6		

*Figures followed by the same letter are not significantly different at the 5% probability level.

TABLE XVI

NITROGEN TREATMENT-ROW SPACING-PLANT POPULATION EFFECTS ON 1/8-INCH GAUGE FIBER STRENGTH IN 1974

Plants/ha	Nitrogen (kg/ha) 0			45			90		
	Row Spacing (cm)								
	25	51	76	25	51	76	25	51	76
	(g/tex)								
123,550	19.2ab	18.8ab	19.1ab	18.2bc	19.0ab	19.4ab	19.3ab	19.3ab	18.9abc*
173,000	17.8c	18.5bc	19.7a	18.9abc	19.4ab	18.9abc	18.4bc	18.5bc	20.0a
LSD at 5%:	01.2								
LSD at 1%:	01.6								

*Figures followed by the same letter are not significantly different at the 5% probability level.

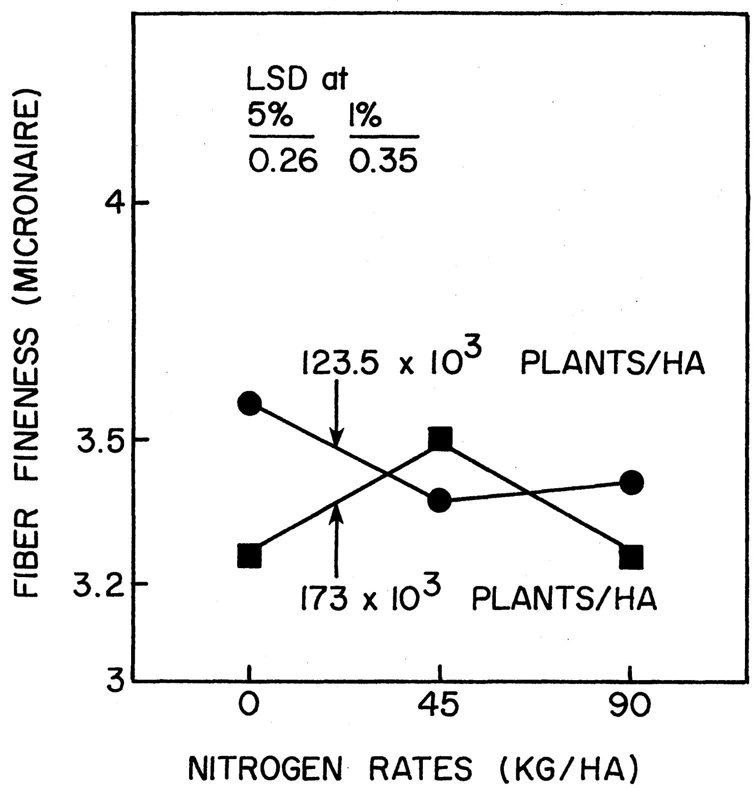

Figure 8. Nitrogen Treatment-Plant Population Interaction Effects on Fiber Fineness in 1974

significant increase in fiber strength. Other treatments which significantly increased fiber strength were increasing the row spacing to 76-cm or increasing both the nitrogen level and row spacing to 90 kg/ha and 76-cm, respectively.

Observation Trial--1973

Yields

This trial was designed to observe the effects of high P and N levels. Whereas there were no significant differences in yields between the two high N levels or between the two P levels applied, there was evidence that application of P beyond 45 kg/ha depressed seedcotton and lint yields. However, the combined effects of high N and P could be seen when a comparison of the average yields from the N treatments is made with the 1973 main trial. It became apparent that application of moderate amounts of P enhanced the yields by about 29% when moderately high levels of N (i.e., 90 kg of N/ha) were applied. This could best be illustrated with Figure 9. Plant population effects showed a similar trend. Increasing the population the 222,000 plants/ha increased seedcotton and lint yields. The presence of moderately high amounts of P and N increased yields by 16% at the 173,000 plant population level when compared to the mean yield in the main experiment. This is illustrated in Figure 10.

Plant Characteristics

The only other plant characteristics affected by the treatments were total bolls and plant heights. The number of total bolls decreased

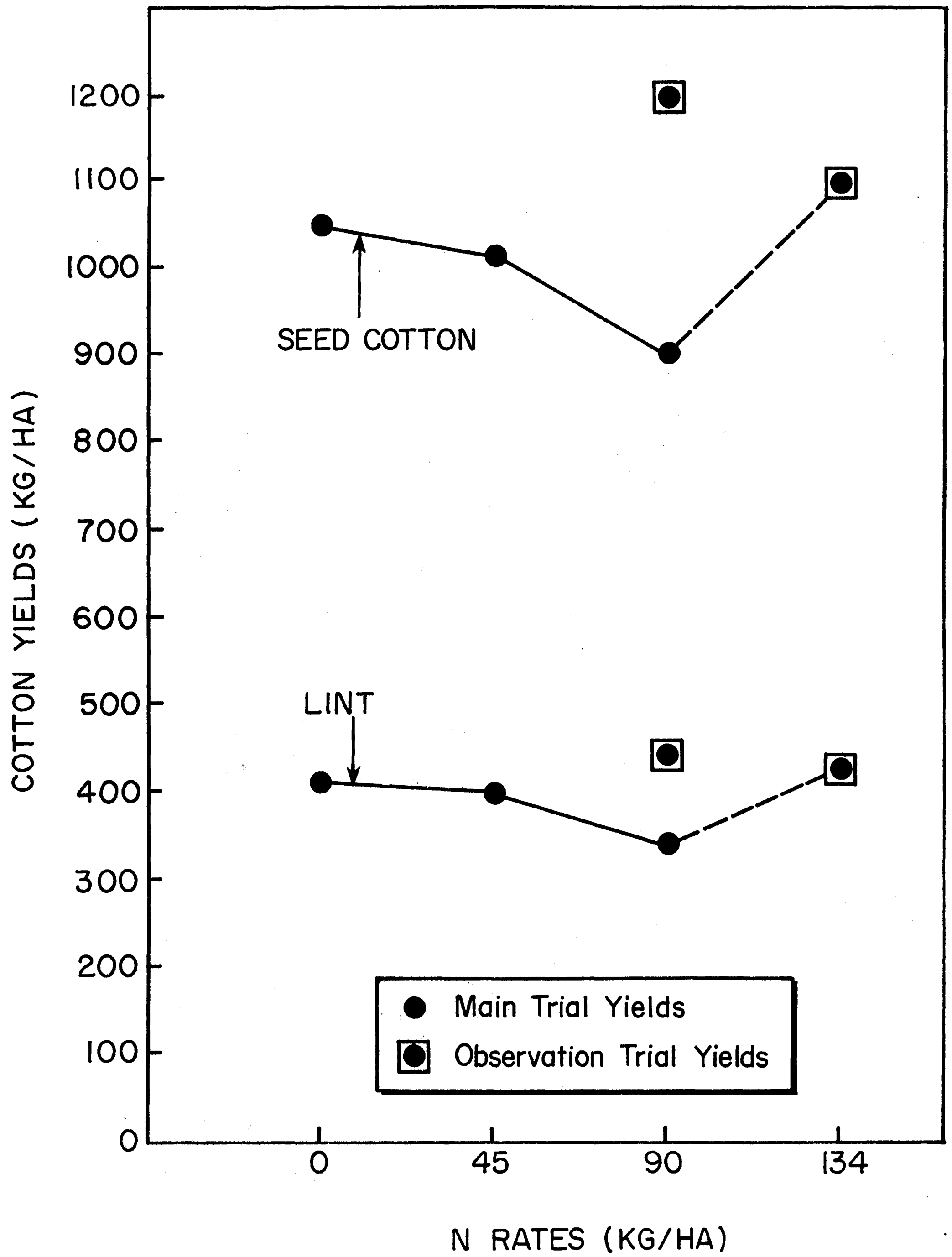

Figure 9. High Nitrogen and Moderate Phosphorus Treatment Effects on Yield in 1973

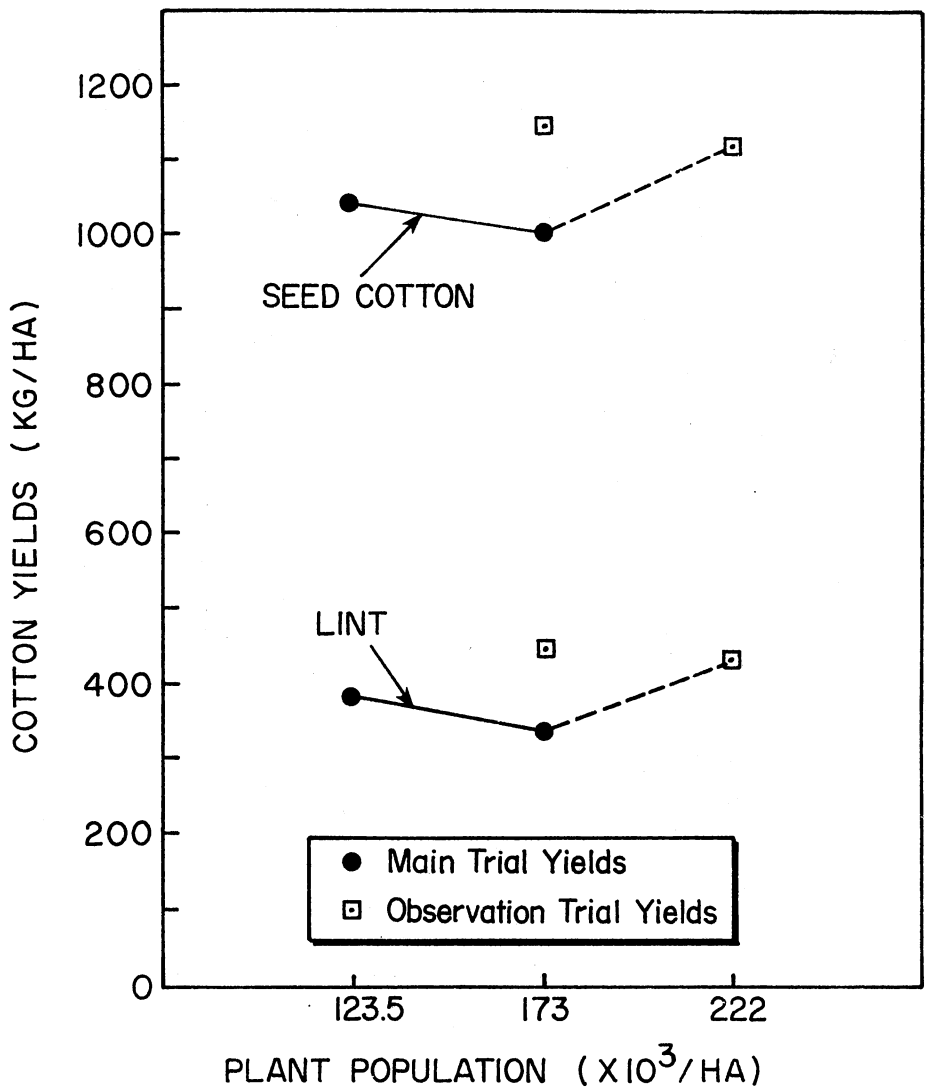

Figure 10. Plant Population Effects on Yield in 1973

as plant population increased but this was significant only at the 8% level. There was a highly significant decrease in plant height as population increased. This was the case in the main treatments also (Appendix, Table XXIII and Figure 11). At the high P level, a nonsignificant decrease of NO_3-N level in petiole at the squaring stage of plant growth was noted.

Fiber Characteristics

The only fiber characteristics affected were uniformity index, micronaire value and fiber strength as measured on the 1/8-inch gauge but these were affected in the presence of very high N application (134 kg N/ha).

Increasing the plant population to 222,000/ha significantly decreased the micronaire reading (finer fiber). At the 90 kg/ha N level, the decrease was not significant. More importantly, there was strong evidence that a very high N level combined with high plant population decreased micronaire (Table XVII).

Fiber strength as measured on the 1/8-inch gauge stelometer was significantly affected by phosphorus-plant population interaction. Without application of P and at the 135 kg/ha N level, increasing the population from 173,000 to 222,000 plants/ha lowered fiber strength significantly. But at this high population level, applying 90 kg P/ha increased fiber strength significantly at the 1% level. Similarly, at the high P level, raising the population, increased fiber strength (Table XIX).

Fiber character was significantly affected by P and also by P and plant population interactions. Although P application decreased the

TABLE XVII

PLANT POPULATION EFFECTS ON FIBER FINENESS
(OBSERVATION TRIAL IN 1973)

Plants/ha	Nitrogen (kg/ha) 90	135
	Micronaire Reading	
173,000	4.1a*	3.9a*
222,000	3.9a	3.5b
LSD at 5%:	0.45	0.40
LSD at 1%:	0.53	0.68

*Figures followed by the same letter under the same nitrogen level are not significantly different at the 5% probability level.

TABLE XVIII

NITROGEN TREATMENT EFFECTS ON NO_3-N CONTENT OF COTTON PETIOLES AT FLOWERING AND BOLLING STAGES
(OBSERVATION TRIAL IN 1974)

Nitrogen (kg/ha)	Flowering	Bolling
	(NO_3-N PPM)	
0	96,168a*	11,562a*
45	137,461ab	11,616a
90	202,097b	53,367b
LSD at 5%:	66,300	22,300
LSD at 1%:	91,700	30,800

*Figures followed by the same letter and in the same column are not significantly different at the 5% probability level.

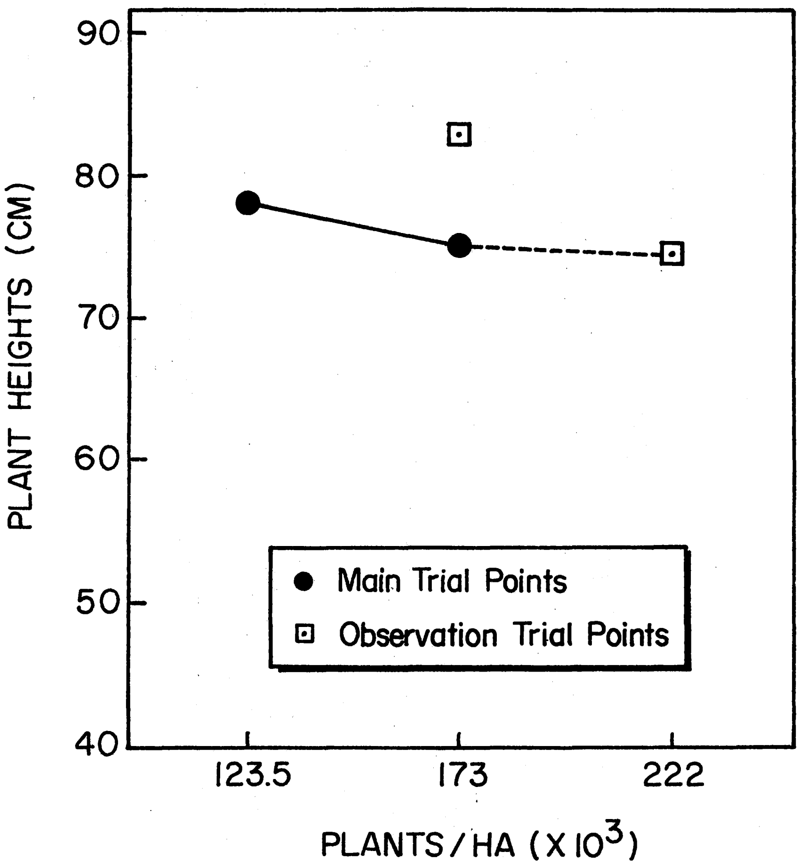

Figure 11. Plant Population Effects on Plant Height

uniformity index significantly at the higher N (135 kg/ha) level, there was no difference in uniformity index between the 45 and 90 kg/ha P levels (Appendix, Table XXIV). Also, with P application (90 kg/ha), increasing plant population levels to 222,000/ha at the 135 kg/ha N rate lowered the uniformity index significantly (Table XIX).

Additional Experimentation in 1974

Based on the results of the observation trial in 1973, the 134 kg/ha N level was eliminated and other N and P combinations were established with 222,000 plants/ha on 25-cm rows.

The only response variable significantly affected in 1974 was the NO_3-N level at the flowering and bolling stages of plant growth. At both stages, NO_3-N content of petioles increased as nitrogen application increased. The increase at the 90 kg N/ha level compared to the check were highly significant (Table XVIII).

Seedcotton and lint yields decreased as nitrogen application increased to 90 kg/ha but this was not statistically significant (Table XX).

Neither of the measurements on fiber characteristics was significantly affected by any of the treatment combinations for the observation trial in 1974.

TABLE XIX

PHOSPHORUS TREATMENT-PLANT POPULATION EFFECTS ON UNIFORMITY INDEX AND 1/8-INCH GAUGE FIBER STRENGTH (OBSERVATION TRIAL IN 1973)

Phosphorus (kg/ha)	Plants/ha (x 10^3) 173		222	
	Nitrogen (kg/ha)			
	90	135	90	135
	Uniformity Index			
0	45.8a*	45.1ab	44.3a	46.4a
45	46.3a	45.1ab	45.6a	43.4b
90	45.4a	45.6a	44.3a	43.8b
LSD at 5%:	2.8	1.6	2.8	1.6
LSD at 1%:	4.3	2.5	4.3	2.5
	Stelometer 1/8-in. Gauge (g/tex)			
0	17.3b*	19.5ab	18.3ab	17.6c
45	18.3ab	18.7bc	19.2a	19.1ab
90	19.7a	18.7bc	18.8ac	21.0a
LSD at 5%:	1.9	1.7	1.9	1.7
LSD at 1%:	23.0	2.7	23.0	2.7

*Figures under the same nitrogen level or fiber property, and followed by the same letter are not significantly different at the 5% probability level.

TABLE XX

NITROGEN TREATMENT EFFECTS ON COTTON YIELD
(OBSERVATION TRIAL IN 1974)

Nitrogen (kg/ha)	Seedcotton	Lint
	(kg/ha)	
0	455a*	156a*
45	468a	155a
90	340a	116a
LSD at 5%:	272	96
LSD at 1%:	376	133

*Figures followed by the same letter and in the same column are not significantly different at the 5% probability level.

CHAPTER V

SUMMARY AND CONCLUSIONS

Under the conditions of the experiment at Perkins, cotton yields were significantly affected by N treatment, row spacing and nitrogen-population interactions. In both seasons, low N treatments (45 kg/ha) produced no significant change in yields but high N application reduced lint and seed cotton yields significantly. The range of plant populations tested per se did not materially affect yields. The narrower row spacings produced significantly higher yields than the 76-cm rows. High N (90 kg/ha) treatments at the 173,000 plants per hectare level produced the lowest yields compared to treatments receiving low amounts of N (45 kg N/ha) and no N, all at the lower or higher populations. This trend prevailed in both seasons.

Plant heights were significantly increased by increasing levels of N treatments, wider row spacing; and reduced significantly by increasing plant population in 1973. The height was also affected in 1973 by nitrogen-plant population interactions. High N rates combined with the higher plant population (173,000 plants/ha) tended to produce taller plants.

The NO_3-N levels in the petioles increased significantly with increasing N rates. The NO_3-N levels were considerably higher at the squaring-flowering stages of plant growth and decreased sharply at the bolling stage. Relating NO_3-N levels of petioles with yields did not provide any meaningful correlation. However in one season, 1973, there was positive correlation (P = 7%) between NO_3-N levels at the bolling stage and lint yields. In both years there were highly significant positive correlations between the NO_3-N levels at flowering and bolling stages of plant growth.

The observation trials revealed that at the high N levels, the presence of additional P increased yields. At the high P rate, a non-significant decrease in NO_3-N level of petiole at the squaring stage of plant growth was noted.

On the whole the major fiber properties were not consistently and materially affected by treatment variables. But in 1973 the uniformity index was significantly reduced as the N treatment increased whereas it was increased in the following season. Micronaire readings decreased (finer fiber) with increasing N application in 1973, but nonsignificantly. The mirconaire readings were also affected by N treatment-row spacing interactions in that same year. The narrowest row spacing (25 cm) with 90 kg of N/ha treatment produced fibers with low micronaire readings. Similarly, the same effects were obtained at the 76-cm row level when no N was applied, or when 90 kg N/ha was applied.

Fiber strength as measured on the 1/8-inch gauge increased significantly as row spacing was widened from 25 to 76-cm in 1974, but not in 1973. It was also affected by nitrogen-spacing-population interactions.

In conclusion, N application did not increase yields, but narrow row spacing produced shorter plants and higher yields. The range of plant populations tested did not materially affect yields directly. The overall average yields were relatively low because of unfavorable weather conditions and delayed sowing. It is suggested that the trial be continued for another season with sowing being effected in the latter part of May to the first week of June, and should also be repeated elsewhere in the state before broad practical application is made.

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TABLE XXI

CHEMICAL ANALYSES OF SOIL SAMPLES FROM THE EXPERIMENTAL SITE

Test	1973*	1974*
NO_3-N	14.6	19.6
P	129	152
K	503	402
P^H (B.1. = 6.8)	5.7	5.3

*Mean values in kg/ha from five soil samples in 1973 and from 28 soil samples in 1974 (samples taken from the top 15 cm of soil).

TABLE XXII

VISUAL RATINGS AMONG TREATMENTS FOR NUMBER OF OPEN BOLLS/PLOT AND LEAF COLORATION

Treatments*	Ratings		Treatments	Ratings	
1. $N_1R_1Pl_1P_2$	2[†]	D[‡]	16. $N_3R_1Pl_2P_2$	3	B
2. $N_1R_2Pl_1P_2$	2	D	17. $N_3R_2Pl_2P_2$	3	B
3. $N_1R_3Pl_1P_2$	2	B	18. $N_3R_3Pl_2P_2$	3	B
4. $N_2R_1Pl_1P_2$	3	B	19. $N_3R_2Pl_2P_1$	3	B
5. $N_2R_2Pl_1P_2$	3	B	20. $N_3R_1Pl_3P_1$	3	B
6. $N_2R_3Pl_1P_2$	2	B	21. $N_3R_2Pl_2P_2$	3	B
7. $N_3R_1Pl_1P_2$	3	B	22. $N_3R_1Pl_3P_2$	2	B
8. $N_3R_2Pl_1P_2$	3	B	23. $N_3R_2Pl_2P_3$	3	B
9. $N_3R_3Pl_1P_2$	4	G	24. $N_3R_1Pl_3P_3$	4	B
10. $N_1R_1Pl_2P_2$	2	B	25. $N_4R_2Pl_2P_1$	4	G
11. $N_1R_2Pl_2P_2$	2	B	26. $N_4R_1Pl_3P_1$	4	G
12. $N_1R_3Pl_2P_2$	2	B	27. $N_4R_2Pl_2P_2$	4	G
13. $N_2R_1Pl_2P_2$	3	B	28. $N_4R_1Pl_3P_2$	4	G
14. $N_2R_2Pl_2P_2$	2	B	29. $N_4R_2Pl_2P_3$	3	B
15. $N_2R_3Pl_2P_2$	3	B	30. $N_4R_1Pl_3P_3$	4	G

*For treatment codes, refer to Table I.

†Numerical ratings 1, 2, 3, and 4 were assigned to plots with > 75%, 50-75%, 10-25%, and < 10% bolls open/plot, respectively.

‡Alphabetical ratings were assigned as D = dead leaves, < 25% green leaves; B = brown leaves, about 50% green leaves; G = green leaves, 75% or more green leaves, respectively.

TABLE XXIII

PLANT POPULATION EFFECTS ON PLANT HEIGHT IN 1973

Plants/ha	Main Trial	Observation Trial 90 kg N/ha	Observation Trial 135 kg N/ha
123,550	79a*	--	--
173,000	75b	82a*	83a*
222,000	--	71b	77a
LSD at 5%:	2.5	4.3	6.5
LSD at 1%:	3.3	6.8	10.2

*Figures followed by the same letter and in the same column are not significantly different at the 5% probability level.

TABLE XXIV

PHOSPHORUS TREATMENT EFFECTS ON UNIFORMITY INDEX (OBSERVATION TRIAL IN 1973)

Phosphorus (kg/ha)	Nitrogen (kg/ha) 90	Nitrogen (kg/ha) 135
0	45.1a	45.8a*
45	45.9a	44.3b
90	44.8a	44.7ab
LSD at 5%:	1.9	1.2
LSD at 1%:	3.1	1.8

*Figures followed by the same letter and in the same column are not significantly different at the 5% probability level.

TABLE XXV

PARTIAL CORRELATION COEFFICIENTS FROM ADJUSTED Y'Y DATA

Characters‡	Lint Yield	Picked Lint,%	Pulled Lint,%	Plant Height	Total Bolls	Good Bolls	NO_3-N Square	NO_3-N Flowers	NO_3-N Bolls	Micro-naire	Uni-formity Index	2.5% Span Length	Strength 0-in. Gauge	Strength 1/8-in. Gauge
Seedcotton	+0.95** +0.71**	-0.09 -0.43**	+0.22 -0.33**	-0.01 -0.67**	-0.05 -0.06	+0.25† +0.57**	-0.09 -0.22†	-0.07 +0.05	+0.08 +0.12	+0.42** +0.53**	+0.14 -0.04	-0.36** -0.26*	+0.13 +0.01	-0.24 -0.12
Lint Yield		+0.21 +0.12	+0.30* +0.15	+0.03 -0.56**	+0.10 +0.01	+0.29* +0.50**	-0.05 -0.19	-0.08 +0.05	+0.00 +0.25†	+0.44** +0.44**	+0.17 +0.17	-0.47** -0.05	+0.11 +0.01	-0.17 -0.23
Picked Lint, %			+0.29* +0.98**	+0.10 +0.30*	+0.13 -0.10	+0.12 -0.29*	+0.10 +0.08	-0.04 -0.21	-0.31* -0.04	+0.15 -0.31*	+0.09 +0.25*	-0.43** +0.26*	-0.02 -0.18	+0.14 +0.04
Pulled Lint, %				+0.03 +0.27*	-0.08 -0.16	-0.24† -0.30*	-0.14 +0.06	0.02 -0.25†	-0.31 -0.05	+0.23 -0.26*	+0.30* +0.27*	-0.17 +0.25†	+0.09 -0.22†	-0.04 +0.07
Plant Height					+0.24† +0.14	+0.15 -0.59**	+0.31* +0.23†	+0.11 -0.19	-0.09 -0.30*	-0.13 -0.39**	+0.15 -0.00	-0.06 -0.02	+0.08 -0.11	+0.21 +0.14
Total Bolls						+0.54 +0.24†	+0.21 +0.08	-0.10 +0.13	+0.04 +0.19	+0.03 -0.05	-0.12 -0.00	-0.08 -0.04	-0.08 +0.34	-0.10 -0.05
Good Bolls							+0.17 -0.00	-0.26 +0.16	-0.00 +0.22	+0.11 +0.34	-0.02 -0.12	-0.07 -0.03	-0.00 +0.03	-0.10 -0.21
NO_3-N Square								-0.24† +0.25*	+0.05 +0.17	+0.09 +0.04	-0.03 +0.07	+0.12 -0.05	-0.11 -0.07	+0.15 +0.26*
NO_3-N Flowers									+0.49** +0.49**	+0.09 +0.13	+0.03 -0.14	-0.10 -0.20	+0.19 +0.25†	+0.06 +0.13
NO_3-N Bolls										-0.04 +0.30*	+0.05 +0.15	+0.19 -0.14	+0.06 +0.16	+0.15 +0.10
Micronaire											+0.28* +0.44**	-0.44** -0.27*	+0.14 +0.03	-0.33** +0.12
Uniformity Index												+0.04 -0.03	-0.05 -0.10	+0.16 +0.22
2.5% Span Length													+0.10 -0.03	+0.32** -0.01
Strength 0-in. Gauge														+0.22 +0.02

*,**,† Significantly different from zero at the 0.05, 0.01 and 0.10 levels of probability, respectively.

‡ Top and bottom r values are for 1973 and 1974, respectively. Degrees of freedom in each case were 124.

TABLE XXVI

NITROGEN TREATMENT EFFECTS ON NO_3-N CONTENT OF PETIOLES AT THREE GROWTH STAGES OF THE COTTON PLANT

Nitrogen (kg/ha)	Plant Growth Stages		
	Squaring	Flowering	Bolling
		1973 (ppm)	
0	68,401	6,228	4,721
45	94,000	13,864	8,567
90	116,885	30,934	19,820
LSD at 5%:	13,918	5,159	6,262
LSD at 1%:	18,550	6,876	8,346
		1974 (ppm)	
0	193,882	71,039	9,595
45	223,112	149,141	23,664
90	255,713	178,868	57,239
LSD at 5%:	33,182	24,647	13,270
LSD at 1%:	44,226	32,849	17,687

TABLE XXVII

EFFECT OF ROW SPACING ON NO_3-N CONTENT OF PETIOLES AT THREE GROWTH STAGES OF THE COTTON PLANT

Spacing (cm)	Plant Growth Stages: Squaring	Flowering	Bolling
		1973 (ppm)	
25	68,485	17,049	11,233
51	95,354	19,332	10,937
76	115,448	17,049	10,937
LSD at 5%:	13,918	5,159	6,262
LSD at 1%:	18,550	6,875	8,346
		1974 (ppm)	
25	206,820	106,833	19,810
51	212,708	128,386	29,387
76	253,179	163,828	41,301
LSD at 5%:	33,182	24,646	13,270
LSD at 1%:	44,226	32,849	17,687

TABLE XXVIII

PLANT POPULATION EFFECT ON NO_3-N CONTENT OF PETIOLES AT THREE GROWTH STAGES OF THE COTTON PLANT

	Plant Growth Stages		
Plants/ha	Squaring	Flowering	Bolling
		1973 (ppm)	
123,550	92,745	15,477	8,954
173,000	93,438	18,540	13,118
LSD at 5%:	11,364	4,212	5,113
		1974 (ppm)	
123,550	224,988	140,000	29,540
173,000	223,483	126,000	30,792
LSD at 5%:	27,000	20,124	10,835

TABLE XXIX

NITROGEN TREATMENT-ROW SPACING EFFECTS ON NO_3-N CONTENT OF PETIOLES AT THREE GROWTH STAGES OF THE COTTON PLANT IN 1974

Growth Stages	Nitrogen (kg/ha) 0			45			90		
	Row Spacing (cm)								
	25	51	76	25	51	76	25	51	76
Squaring	147,164	181,664	252,820	228,562	187,953	252,820	244,734	268,507	253,898
Flowering	50,590	70,347	92,180	108,890	143,390	195,140	161,000	171,421	204,164
Bolling	7,816	9,298	11,671	18,274	21,886	30,834	33,340	56,978	81,398
		Squaring			Flowering			Bolling	
LSD at 5%:		57,473			42,689			22,984	
LSD at 1%:		76,601			56,897			30,634	

TABLE XXX

NITROGEN TREATMENT-PLANT POPULATION EFFECTS ON NO_3-N CONTENT OF PETIOLES AT THREE GROWTH STAGES OF THE COTTON PLANT IN 1974

Growth Stages	Nitrogen (kg/ha) 45					
	Plants/ha					
	123,550	173,000	123,550	173,000	123,550	173,000
	(ppm)					
Squaring	187,953	199,812	218,739	227,484	268,273	243,153
Flowering	61,453	80,625	149,141	149,141	209,422	148,314
Bolling	7,618	11,572	24,078	23,251	56,925	57,553
	Squaring		Flowering		Bolling	
LSD at 5%:	46,927		34,856		18,767	
LSD at 1%:	62,545		46,456		25,013	

TABLE XXXI

COMBINED ANALYSES OF VARIANCE FOR 1973 AND 1974

Source	Degrees of Freedom	NO_3-N Square	NO_3-N Flower	NO_3-N Boll	Plant Height	Total Bolls	Good Bolls	Picked Lint,%	Pulled Lint,%	Seedcotton Yield	Lint Yield	Micro-naire	Uniformity Index	2.5% Span Length	Strength 0-in. Gauge	Strength 1/8-in. Gauge
									Mean Squares							
Replicates (Rep)	3	11172	18034	4611	117	63	66	0.29	0.12	151744	22137	0.0986	5.665	0.0033	0.0791†	0.0341
Nitrogen (N)	2	36508**	54212**	12534**	1047**	23	95	2.50	1.60	408673**	75197**	0.1480	1.415	0.0013	0.0797	0.0062
Spacing (Spac)	2	2690**	10632**	1354*	2318**	2591**	160*	2.19	0.86	103420†	27149**	0.1722	0.444	0.0005	0.0116	0.0213
N x Spac	4	5146*	725	794	44	76	111*	0.45	0.21	41112	4147	0.1260	3.965	0.0007	0.0393	0.0018
Population (Pop)	1	6	1072	264	194	339	51	4.50	0.92	18443	15	0.4011†	4.803	0.0001	0.0002	0.0030
N x Pop	2	1776	5195**	17	183	168	98	1.30	1.60	317149**	32789**	0.2504	0.449	0.0005	0.0309	0.0169
Spac x Pop	2	2583	1938	262	65	164	2	1.48	0.74	2101	2851	0.1522	3.019	0.0000	0.0674	0.0218
N x Spac x Pop	4	814	689	20	50	197	88	0.86	0.34	67687	5621	0.1178	0.470	0.0017	0.0921**	0.0063
Year (Yr)	1	619116**	484476**	13175**	43	31476**	69	1.06	0.04	15591079**	2462792**	10.1336**	788.206**	0.0138*	0.3297**	0.0113
N x Yr	2	571	24070**	3324**	8	59	77	2.75	0.52	14402	372	0.1120	13.550**	0.0014	0.0001	0.0028
Spac x Yr	2	1711	9375**	1428**	211**	359	71	2.69	1.30	84917	11336	0.0203	0.687	0.0009	0.0016	0.0088
N x Spac x Yr	4	4508	660	382	30	218	46	0.60	0.40	44912	4305	0.2726*	0.728	0.0006	0.0076	0.0028
Pop x Yr	1	43	2613	76	76	253	1	5.40†	2.80†	4389	2645	0.0069	0.210	0.0004	0.0452	0.0144
N x Pop x Yr	2	879	5352**	38	20	377	38	2.27	0.80	56966	11956	0.1058	0.460	0.0011	0.0009	0.0009
Spac x Pop x Yr	2	3714	702	177	5	141	2	1.34	1.00	66736	9424	0.0034	3.938	0.0005	0.0168	0.0038
N x Spac x Pop x Yr	4	1080	489	124	36	203	14	0.75	0.25	19017	395	0.1018	1.261	0.0008	0.0063	0.0208*
Error	51	1938	1044	425	71	163	45	1.71	0.87	34883	4361	0.1081	1.936	0.0009	0.0283	0.5051

*,**Significantly different from zero at the 0.05, 0.01 levels of probability, respectively.

†Significance approaching 0.05 level.

TABLE XXXII

ANALYSIS OF VARIANCE FOR SEPARATE YEARS

Source	Degrees of Freedom	NO_3-N Flower	NO_3-N Boll	Plant Height	Micronaire Reading	Strength $\frac{1}{8}$-in. Gauge
		Response Variables				
		Mean Squares†				
Nitrogen	2	3840	1477**	603**	0.185	0.0054
(N)		74442**	14380**	452**	0.075	0.0037
Spacing	2	132	0.698	1938**	0.098	0.0024
(Spac)		19876**	2782**	591**	0.094	0.0278*
Population	1	169	312	257**	0.151	0.0153
(Pop)		3517	28	13	0.257	0.0021
N x Spac	4	26	76	12	0.123	0.0009
		--	1101	62	0.275*	0.0037
N x Pop	2	0.64	20	90*	0.016	0.0117
		10546**	36	113	0.341*	0.0061
Spac x Pop	2	158	14	18	0.068	0.0130
		2483	426	52	0.087	0.0126
N x Spac x Pop	4	76	73	22	0.165	0.0069
		1104	71	63	0.055	0.0202*
Error	51	79	118	28	0.077	0.0092
		1808	524	83	0.101	0.0079

*,**Significantly different from zero at the 0.05, 0.01 levels of probability, respectively.

†Top and bottom figures for each source are for 1973 and 1974, respectively.

VITA

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