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Response of an F_1 Interspecific Cotton Hybrid to Nitrogen Fertilization[1]

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ABSTRACT

Response of the high yielding interspecific cotton (*Gossypium hirsutum* L. × *G. barbadense* L.) hybrid, 'NX-1', to four N fertilizer levels (0, 55, 110, and 220 kg ha^{-1}) and 2 years (1979 and 1980) was evaluated. 'Acala 1517-75' and 'McNair 220', *G. hirsutum* L. cultivars, were also included as checks. Data recorded included blooming rate, earliness, lint yield, boll characteristics, and fiber properties. NX-1 was about 9 days earlier to first bloom, compared to the checks, and exhibited a higher blooming rate. NX-1 also showed the largest increases in floral production with the addition of N in 1980, but not in 1979. The flower production of NX-1 was increased by the addition of 55 kg of N ha^{-1}, but not by additions beyond that level. NX-1 was the earliest genotype as measured by the number of days from planting to first bloom, production rate index, and lint yield at first harvest. A significant genotype × N interaction for lint yield was detected. At zero N level, the lint yield of the hybrid was significantly lower than with added N. McNair 220 and Acala 1517-75 did not show a significant response to N. On the average, lint yield of the hybrid was 38 and 27% higher than for Acala 1517-75 and McNair 220, respectively. NX-1 had a smaller boll, fewer seed boll^{-1}, lower lint percentage, and a higher seed index, compared to the checks. The hybrid showed a fiber fineness similar to that of Acala 1517-75, but its fiber was longer and stronger with a higher elongation. Boll characteristics and fiber properties were not significantly influenced by N rates.

Additional index words: **Heterosis, Hybrid vigor, Lint yield, Earliness, Boll characteristics, Fiber properties, Blooming rate, *Gossypium hirsutum* L. × *G. barbadense* L.**

LINT and seed yield of cotton (*Gossypium* spp.) depend on cultural factors and the environment to achieve optimum results. Selection of proper genotype and fertilizer rate are some of the managerial inputs manipulated to increase yield and reduce production costs.

A promising way to increase yield is through development of hybrid cotton to take advantage of hybrid vigor. The commercial production of first-generation cotton hybrids became feasible in 1973 with development of a cytoplasmic-genetic male sterility, fertility-restorer system by Meyer (15). Using her system, New Mexico State University developed 'NX-1' (released in 1979) as an interspecific cotton (*G. hirsutum* L. × *G. barbadense* L.) hybrid. Because of difficulties in commercial-scale seed increases, this hybrid is not yet available to producers. However, it can serve as a prototype for determining production management systems for future hybrids.

Apparently no information is available on response of interspecific hybrids to N fertilizer applications. However, considerable work of this type has been conducted on cultivars of *G. hirsutum*. Reports from fertilizer experiments differ as to effects of N levels on seed and lint cotton yield. Several studies illustrate that applications increase seed and lint cotton yield (8, 11, 14, 20, 22, 24, 27). Hearn (9) reported seed-cotton yield increases of 26 to 75% over the zero (check) N level. He also found a higher lint yield response in 'Deltapine 16' than in 'Acala 1517 BR-1' at all N levels studied. Villamayor (28) found highest seed-cotton yields with the application of 100 kg ha^{-1} N sidedressed at planting time. Wankhede and Sadaphal (29) showed application of 46, 72, and 76 kg N ha^{-1} was optimum for tall, medium-tall, and dwarf cultivars, respectively. McCaslin (14), using 'Acala 1517–75' and 'Acala 1517–70' in a 3-year study reported highly significant differences for seed and lint cotton yield between cultivars and between N applications vs. none. No significant differences resulted from applications between 112 and 224 kg N ha^{-1}, but both were significantly greater than the check.

Several workers (1, 3, 5, 13, 21, 26) reported N fertilizer applications did not increase lint cotton yield. In the earliest known research concerning cotton fertilization in New Mexico, Overpeck and Conway (19) in 1926 concluded that commercial fertilizer might not be useful on the heavier types of soil. Aden (1), working with Acala 1517–70 and 'Paymaster 266' in various row widths, several irrigation treatments, and four combinations of N and P, found no lint yield response as a result of fertilization. Anderson and Douglas (3) found no significant differences between the yields of 'Stoneville 7A' (normal leaf) and Stoneville 7A super-okra leaf over N rates from 0 to 270 kg ha^{-1}. Onken and Sunderman (18) observed a wide range of effects and interactions between cultivars, irrigation levels, row spacings, and rates of N on the Texas High Plains. Responses to N applications differed between row spacings and locations. Gerard and Reeves (7) in the lower Rio Grande Valley and Koli and Morrill (12) in Oklahoma found a significant N × plant population interaction for earliness and yield. At low plant densities, N increased yields; but at high densities, N delayed maturity and decreased earliness and yield. However, Aden (1) in New Mexico and Rao and Weaver (21) in Georgia were unable to detect significance for this interaction.

Fertilizer influences on boll size have been reported from several cotton growing areas. Most results indicate increases in boll size resulting from N applications (11, 17, 18, 20). Several researchers demonstrated that the increases in boll size were primarily the result of larger seed because lint percentage declined with higher N rates (1, 20, 23). Inconsistent effects of N were also noted on cotton fiber properties. Increased fiber length resulting from N application has been found (1, 10, 16, 17), while negative effects of fertilizer on fiber length were reported by Hughes (11). On the other hand, several workers (2, 21, 26) reported no effects of N fertilizer on fiber length. Aden (1) and Nelson (17) found higher fiber strength resulting from N applications;

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yet, El-Zik et al. (6) found fiber strength was not affected by row spacing, date of first irrigation, or N rate. Tucker and Tucker (25) and Tugwell and Waddle (26) indicated that N supply did not cause variations of practical importance in fiber fineness.

The purpose of this study was to evaluate the response of the high yielding interspecific cotton hybrid, NX-1, to four N fertilizer application levels relative to two high-yielding commercial cultivars of *G. hirsutum*.

MATERIALS AND METHODS

This research consisted of two studies conducted at the New Mexico State Univ. Plant Sci. Res. Center at Las Cruces during the 1979 and 1980 seasons. The experiments were established on an Armijo clay loam soil (fine, montmorillonitic, thermic Typic Torrert). The 1979 study included three genotypes, 'NX-1' (an interspecific F_1 hybrid) and the *G. hirsutum* cultivars Acala 1517–75 and McNair 220 as checks, grown at four N rates, i.e., 0. 55, 110, and 220 kg ha^{-1}. A uniform plant density of 80 000 plants ha^{-1} (32 400/A) was used. The 1980 experiment consisted of the same genotypes and N rates at plant densities of 40 000, 80 000, and 120 000 plants ha^{-1}. These populations represent plant spacings of 25, 12.5, and 8.3 cm, respectively, when planted in 102-cm rows. In 1979, the experimental design used was a 4 × 3 factorial in a split-plot arrangement. In 1980, the design was a 4 × 3 × 3 factorial in a split-split-plot. Main plots were distributed in a randomized, complete block experimental design with four replications. In both seasons, N levels were assigned to main plots and genotypes to sub-plots. In the 1980 study, plant densities were assigned to sub-sub-plots and pooled for the overall analyses. The 1979 experiment was planted on 27 April and the 1980 experiment on 9 May. In both years, N fertilizer treatments were applied as urea when the plants were at approximately the first square stage. All plots received a uniform rate of 45 kg ha^{-1} P. One preplant (about 20 cm) and four postplant (each about 10 cm) irrigations were applied to the experiments. Plots were four rows and 8 m long. The two center rows of each plot were harvested twice using a spindle picker, and plot weights were converted to lint yield in kg/ha.

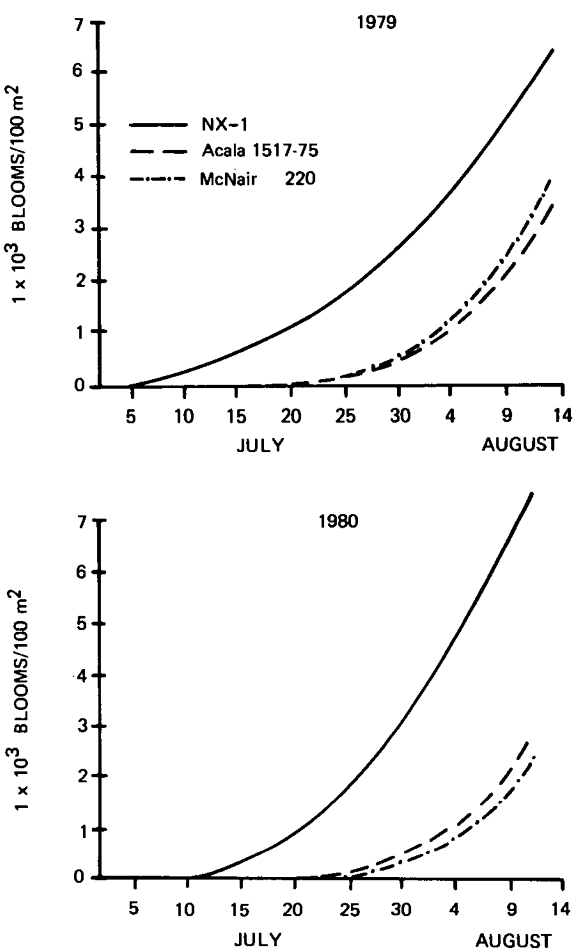

Fig. 1. Cumulative flower production of three cotton genotypes averaged over N rates as a function of time in 1979 and 1980.

Data recorded included blooming rate, earliness, lint yield in kg/ha, boll characteristics, and fiber properties. Cumulative flower production was recorded from the two center rows of each plot for the first 5 weeks after blooms first appeared and was used as a measure of fruiting capacity. Earliness was measured as number of days from planting to first flower (DFF), as percent of total lint yield picked at the first of two harvests (PCH), as weight of total lint yield produced at first harvest (LFH), and as production rate index (PRI). The DFF was analyzed statistically in 1980 only. The PRI was defined by Bilbro and Quisenberry (4) as the amount of yield per unit area per unit of time. Boll characteristics measured were boll size in g boll^{-1}, lint percentage, seed and lint index in g 100^{-1} seed, and number of seed boll^{-1}. Fiber analyses included 50 and 2.5% span lengths in mm, elongation in %, fiber strength (T_1 in mN tex)$^{-1}$, and fineness (micronaire in μg in^{-1}).

Combined analyses of variance were conducted for each trait to determine the relative performance of the hybrid vs. the upland cultivars to the four N rates and two seasons. Duncan's Multiple Range Test was used to make comparisons among treatment means.

RESULTS AND DISCUSSION

Blooming Rate. Cumulative bloom curves for NX-1, Acala 1517–75, and McNair 220, averaged over N rates, are shown in Fig. 1. In both seasons, NX-1 was approximately 9 days earlier in blooming and considerably superior in total flower production to either Acala 1517–75 or McNair 220. If the end of the 30-day period following the first bloom of the hybrid is used for comparison, the hybrid produced three times as many blooms as the check cultivars. Acala 1517–75 and McNair 220 are penalized in flower production by the delay in their first bloom because 20 August is about the last effective bloom date in New Mexico. Moreover, the month of July is the optimum period at this location in terms of incoming solar radiation and high temperatures. July conditions are ideal for more rapid boll development and better yields in high-altitude cotton-production areas. Fertilizer effects of N on flower production varied in different years (Fig. 2). In 1979, bloom production was not influenced by N fertilization. In 1980, the interspecific hybrid NX-1 showed a large flower production response to the first increment of application of N; whereas, the Acala and McNair cultivars did not. Flower production of NX-1 did not differ significantly among the 55, 110, and 220 kg ha^{-1} rates. There was no apparent reason why the re-

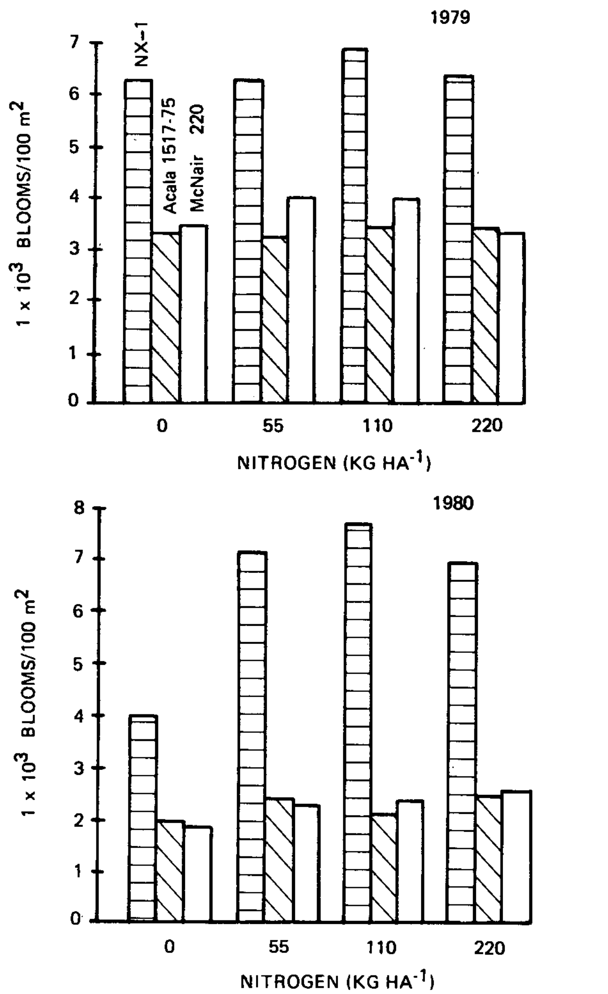

Fig. 2. Influence of genotypes and N rates on the 5-weeks total flower production in 1979 and 1980.

Table 1. Earliness of cotton as influenced by genotype and N rate.

Factor	Earliness index† PCH	PRI	LFH
	%	g lint^{-1} ha^{-1} day^{-1}	kg ha^{-1}
Genotype			
NX-1	69 a*	5.54 a	975 a
Acala 1517-75	65 b	3.80 c	673 c
McNair 220	71 a	4.50 b	793 b
Nitrogen (kg ha^{-1})			
0	67 a	3.99 a	699 a
55	68 a	4.74 a	830 a
110	69 a	4.78 a	836 a
220	70 a	4.90 a	858 a

* Within the two categories (genotype and N), means within columns followed by the same letter are not statistically different at the 0.05 level of probability (according to Duncan's Multiple Range Test).
† PCH = percent of total lint yield at first harvest, PRI = production rate index, and LFH = weight of total lint yield at first harvest.

Table 2. Lint yield of cotton as influenced by year, genotype, and N rate.

Factor	Genotype NX-1	Acala 1517-75	McNair 220	Mean
	kg ha^{-1}			
Year				
1979	1548 a*	1137 a	1103 a	1263 a
1980	1263 b	906 b	1114 a	1094 b
Nitrogen (kg/ha)				
0	1158 b	1017 a	977 a	1051 a
55	1396 a	1075 a	1178 a	1217 a
110	1554 a	948 a	1150 a	1217 a
220	1514 a	1044 a	1129 a	1229 a
Mean	1406 A†	1021 B	1109 B	

* Within the two categories (year and nitrogen), means within columns followed by the same lower-case letter are not statistically different at the 0.05 level of probability (according to Duncan's Multiple Range Test).
† Genotype means within the row followed by the same upper-case letter are not statistically different at the 0.05 level of probability (according to Duncan's Multiple Range Test).

sponse should have differed between years. At all N rates in both years, NX-1 was far superior in flower production to Acala 1517–75 and McNair 220.

Earliness. Significant differences among genotypes were obtained for all four earliness indices (Table 1). The hybrid was significantly the earliest genotype when DFF, PRI, and LFH were used as earliness indicators. There was a significant year × genotype interaction for PCH. The DFF (measured properly for statistical analysis in 1980 only) showed NX-1 to be 9 days earlier in bloom than either check (66 vs. 75 and 75 days, respectively). Analyses of variance failed to show significant differences in earliness among N rates, regardless of the earliness index employed. However, large differences in earliness between the zero N treatment and the treatments that received N were observed with PRI and LFH earliness indicators.

Lint Yield. Significant differences in lint yield between years and among genotypes were measured (Table 2). On the average, lint production of NX-1 was 38 and 27% greater than Acala 1517–75 and McNair 220, respectively. A highly significant genotype × N rate interaction was detected. At zero N, yield differences between the hybrid and Acala 1517–75 were not statistically different; but at higher N rates, lint yield of NX-1 was significantly higher than those of both Acala 1517–75 and McNair 220. Aden (1) and Harris and Smith (8) did not report a significant genotype × N interaction for this trait. On the other hand, McCaslin (14) using Acala 1517–75 and Acala 1517–70 detected significance for that interaction in 2 of 3 years. His results and those from this study suggest genotypes with superior yield potential may not express that potential when subjected to suboptimal conditions.

Boll Characteristics. Data in Table 3 show that NX-1 had a significantly lower boll size, lint percentage, and number of seed boll^{-1} and a significantly higher seed index than Acala 1517–75 and McNair 220. The three genotypes did not differ significantly in lint index values. The smaller boll size, lower lint percentage, and fewer seed boll^{-1} of this hybrid clearly indicate its higher yielding capacity must be due to its earlier blooming, higher blooming rate, and higher boll set. This prolificacy is ultimately manifested in a greater number of mature bolls unit area^{-1}. Increased N levels did not influence boll parameter values.

Fiber Properties. The hybrid produced significantly longer and stronger fiber with a greater elongation value, compared to both Acala 1517–75 and McNair

Table 3. Boll characteristics of cotton as influenced by year, genotype, and N rate.

Factor	Boll size	Lint	Seed index	Lint index	Seed/boll
	g boll^{-1}	%	— g 100 seed^{-1}	—	no.
Year					
1979	5.59 a†	37.9 a	11.9 b	7.18 a	29.9 a
1980	5.54 a	37.3 a	12.8 a	7.56 a	27.3 b
Genotype					
NX-1	4.79 b	35.3 c	13.8 a	7.53 a	22.5 c
Acala 1517-75	6.08 a	37.7 b	12.4 b	7.53 a	30.6 b
McNair 220	5.84 a	39.7 a	10.7 c	7.07 a	32.8 a
Nitrogen (kg ha^{-1})					
0	5.49 a	37.7 a	12.1 a	7.29 a	28.6 a
55	5.57 a	37.7 a	12.3 a	7.42 a	28.6 a
110	5.57 a	37.4 a	12.4 a	7.37 a	28.4 a
220	5.63 a	37.6 a	12.5 a	7.42 a	28.8 a

† Within the three categories (year, genotype, and N), means within columns followed by the same letter are not statistically different at the 0.05 level of probability (according to Duncan's Multiple Range Test).

Table 4. Fiber properties of cotton as influenced by year, genotype, and N rate.

Factor	Span length 50%	Span length 2.5%	Micronaire	Elongation	Strength T_1
	mm	mm	μg in^{-1}	%	mN tex^{-1}
Year					
1979	14.0 b*	29.5 b	3.7 b	7.2 a	219.7 b
1980	15.0 a	31.2 a	4.3 a	6.6 b	242.3 a
Genotype					
NX-1	15.7 a	33.5 a	3.8 b	8.3 a	267.8 a
Acala 1517-75	14.2 b	29.7 b	3.9 b	6.6 b	232.5 b
McNair 220	13.0 c	27.9 b	4.3 a	5.8 c	192.3 c
Nitrogen (kg ha^{-1})					
0	14.5 a	30.2 a	4.0 a	6.9 a	230.5 a
55	14.2 a	30.5 a	4.0 a	6.7 a	231.5 a
110	14.5 a	30.2 a	4.0 a	7.0 a	230.5 a
220	14.5 a	30.5 a	4.0 a	7.0 a	231.5 a

* Within the three categories (year, genotype, and N), means within columns followed by the same letter are not statistically different at the 0.05 level of probability (according to Duncan's Multiple Range Test).

220 (Table 4). None of the fiber properties were affected by N applications. There were no interactions of genotypes × year or N, except in the case of micronaire. McNair 220 had the higher micronaire in all cases. Acala 1517–75 and NX-1 were affected differentially in the two seasons although their overall means were not different. These results agree with the general findings of Tugwell and Waddle (26).

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