Nitrogen Budget in California Cotton Cropping Systems

FREP Contract # 97-0365 M97-09

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Introduction

Microplots, labeled with ^{15}N, have been established at two locations, one in Kings County and one in Fresno County, and have been used to trace the movement of N in cotton cropping systems. This report summarizes data on the growth and development of cotton as a function of N treatments monitored over a three-year period with Acala at both sites and with Pima for two years at the Fresno county site. Somewhat unique in these experiments is the maintenance of a cotton crop for up to three years, a practice not commonly used in California cotton production systems. A longer rotation period of a single crop as used in these studies is expected to provide a much more detailed analysis of the movement of N in that cropping system. The data reported in this summary provides a basis for determining the distribution of N in cotton, and its relation to yield. The intent of the overall project is to develop a nitrogen budget for cotton produced in the San Joaquin Valley, using the data presented in this report, and to integrate this information with data from a Valley-wide, five-year study of cotton response to N fertilizer. This report focuses on the plant and its response to applied N as preliminary to the ^{15}N study.

Results

Growth and Development.

One aspect of the growth and development of cotton can be expressed as the development of leaf area index (LAI) over time in response to nitrogen. The two sites were compared as were the responses of Acala and Pima cotton (Figures 1 and 2). At both sites, there was little or no effect of 56 kg N per ha when compared with the

control. However, LAI did increase at N levels of 168 kg N per ha. The time of the season when cotton achieved maximal LAI also varied. Maximal LAI occurred 20 days earlier in 1999 as compared to 1998 at the Kings County site (Figure 1). A similar LAI response was observed at the Fresno County site except in 1999 (Figure 2). In that year, an optimal response of LAI extended over a longer period. Pima cotton showed a positive response at all levels of applied N. Two possible differences between Pima and Acala are that Pima appears to develop maximal LAI earlier in the season, and Pima is more
vegetative and as a result shows more dependence on the level of N applied over the growing season.

Lint Yield
Figures 3 and 4 illustrate the lint yield in response to N treatments over years. The Kings county site showed no yield response over the first two levels of applied N (56 and 112 kg per ha), and then an increase in yield which leveled off at the higher rates of applied N. Comparison of yields over the three years in Kings County showed that in 1998, yields were lower than the following two years. Yields of lint increased at all levels of applied N at the Fresno County site over all years. Pima was grown for two years at the Fresno County site as comparison with Acala. As shown in Table 5, yields of Pima responded to 56 and 112 kg ha^{-1} N, however, at 168 kg ha^{-1} and higher, there was no further response to applied N.

Table 1 provides correlation on the relationship between various growth characteristics, including yield of Pima and Acala cotton at the Fresno County site. Leaf dry matter (LDM) development in Acala showed a strong, positive correlation with all the growth characteristics measured at all stages of development. Pima also showed positive correlation with these characteristics except at early square formation. LAI development in Acala was also strongly correlated with ontogeny. LAI of Pima was not strongly correlated, particularly during initial development of the canopy.

The relationship between growth characteristics of Acala in Kings County is shown for two years, 1998 and 1999 in Table 2. Cotton grown in 1998 showed a less positive interaction of growth characteristics. This may be related to the lower yields observed during that season.

Discussion
The results presented are part of a comprehensive data set that will be used to develop fertilizer guidelines for California cotton. The growth and development of cotton in response to N fertilization rates is being defined. Uptake, distribution, and redistribution of N in response to applied N is being documented. These data will be compared across locations and years. Within the larger field sites, we have located ^{15}N sites. The information collected from the experiments described in this report will provide the basis for interpretation of the ^{15}N experiments. Crop maturity and quality will be evaluated. All of these parameters will be correlated with fiber yield.

The data collected will be available for development of a model, which will be used in interpretation of the long term, multi-site research project currently being conducted in the cotton production systems in the San Joaquin Valley.

Results from the two sites have provided the following information:

- Vegetative development of Acala cotton is more closely linked to yield than is Pima cotton.
- Environmental factors affecting yield reduces the linkage with vegetative development more in Pima cotton than in Acala.
- Vegetative development of Pima cotton is more responsive to N than is Acala.

The information presented above provides a better understanding of the responses of current cotton varieties to N. These data will be added to the body of information accumulated over the last five years, will provide the basis for improving the N-use efficiency of cotton, and will assist in establishing guidelines for N fertilization of this crop.

Table 1. Pearson correlation coefficients for the relationships between various growth characteristics of Acala and Pima cotton grown at Fresno Co.

		Acala Fresno Co.†			Pima Fresno Co.		
Variable		TDM_g‡	FDM_g	Yield§	TDM_g	FDM_g	Yield
		r					
LDMg	S_1¶	0.70 ***	0.64 ***	0.43 **	0.39 NS	0.44 *	0.27 NS
LDMg	S_2	0.91 ***	0.88 ***	0.81 ***	0.89 ***	0.84 ***	0.77 ***
LDMg	S_3	0.87 ***	0.82 ***	0.75 ***	0.87 ***	0.85 ***	0.82 ***
LDMg	S_4	0.97 ***	0.92 ***	0.61 ***	0.89 ***	0.84 ***	0.78 ***
LAI	S_1	0.55 **	0.55 **	0.32 NS	0.16 NS	0.21 NS	0.15 NS
LAI	S_2	0.75 ***	0.74 ***	0.87 ***	0.87 **	0.74 *	0.71 *
LAI	S_3	0.85 ***	0.79 ***	0.62 **	0.88 **	0.80 *	0.75 *
LAI	S_4	0.93 ***	0.88 ***	0.41 *	0.75 *	0.54 NS	0.52 NS
LAD		0.88 ***	0.84 ***	0.81 ***	0.89 **	0.77 *	0.73 *
TDM_g		1.00	0.99 ***	0.72 ***	1.00	0.92 ***	0.86 ***
FDM_g		0.99 ***	1.00	0.74 ***	0.92 ***	1.00	0.92 ***

*, **, *** Significant at the 0.05, 0.01,and 0.001 probability levels, respectively; NS is not significant.

† Correlations based on leaf area information for Acala reflect 1998 and 1999 data while those based on dry matter data include all three years of the study. Similarly for Pima, correlations of LAI and LAD only include 1999 data while those of LDM_g and TDM_g include 1999 and 2000 data.

‡ TDM_g = total dry matter at last sampling, FDM_g = fruit dry matter at last sampling, LDM_g = leaf dry matter at respective sampling, LAI = leaf area index at respective sampling, LAD = leaf area duration.

§ Yield data from microplot plant samples, not yield from machine harvest.

¶ Sampling times S_1, S_2, S_3, and S_4 refer to samples at early square, early bloom, near peak bloom, and near defoliation.

Table 2. Pearson correlation coefficients for the relationships between various growth characteristics of Acala cotton grown at Kings Co.

Variable		1998			1999		
		TDM_g†	FDM_g	Yield‡	TDM_g	FDM_g	Yield
		---------- r ----------					
LDMg	S_1§	0.22 NS	0.36 NS	-0.07 NS	0.74 **	0.68 *	0.78 **
LDMg	S_2	0.65 *	0.60 *	0.75 **	0.69 *	0.59 *	0.77 **
LDMg	S_3	0.72 **	0.64 *	0.53 NS	0.82 **	0.74 **	0.61 *
LDMg	S_4	0.90 ***	0.69 *	0.67 *	0.84 ***	0.74 **	0.51 NS
LAI	S_1	0.19 NS	0.34 NS	-0.20 NS	0.73 **	0.66 *	0.72 **
LAI	S_2	0.50 NS	0.49 NS	0.63 *	0.62 *	0.50 NS	0.80 **
LAI	S_3	0.81 **	0.73 **	0.52 NS	0.77 **	0.71 **	0.52 NS
LAI	S_4	0.89 ***	0.70 *	0.63 *	0.92 ***	0.80 **	0.52 NS
LAD		0.88 ***	0.78 **	0.63 *	0.81 **	0.70 *	0.71 **
TDM_g		1.00	0.93 ***	0.53 NS	1.00	0.97 ***	0.62 *
FDM_g		0.93 ***	1.00	0.37 NS	0.97 ***	1.00	0.57 NS

*, **, *** Significant at the 0.05, 0.01,and 0.001 probability levels, respectively; NS is not significant.
† TDM_g = total dry matter at last sampling, FDM_g = fruit dry matter at last sampling, LDM_g = leaf dry matter at respective sampling, LAI = leaf area index at respective sampling, LAD = leaf area duration.
‡ Yield data from microplot plant samples, not yield from machine harvest.
§ Sampling times S_1, S_2, S_3, and S_4 refer to samples at early square, early bloom, near peak bloom, and near defoliation.

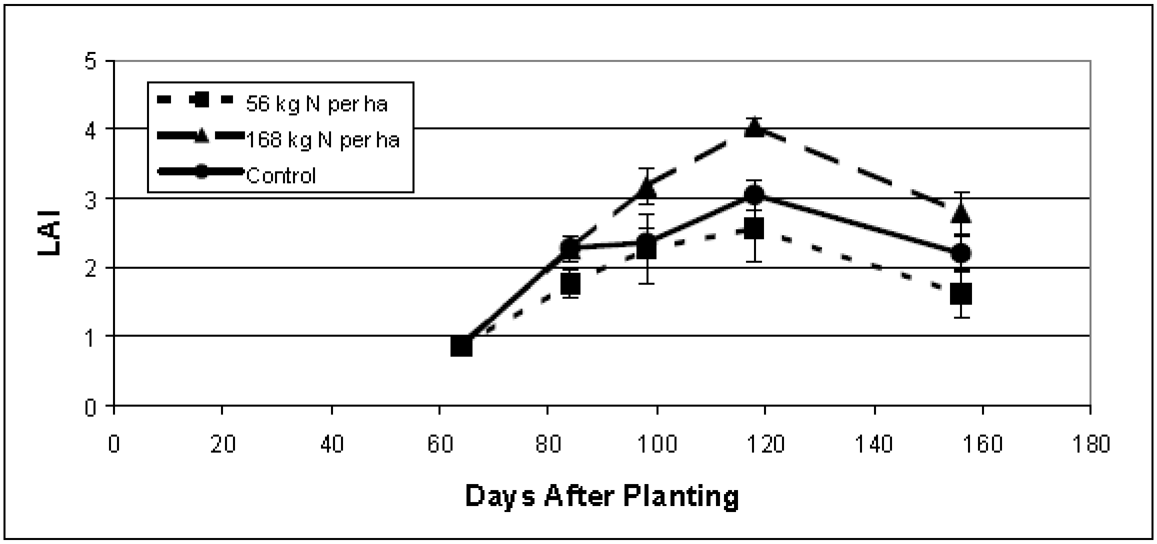

Figure 1a. Development of leaf area index(LAI) of Acala cotton over the 1998 season in response to N at the Kings County site.

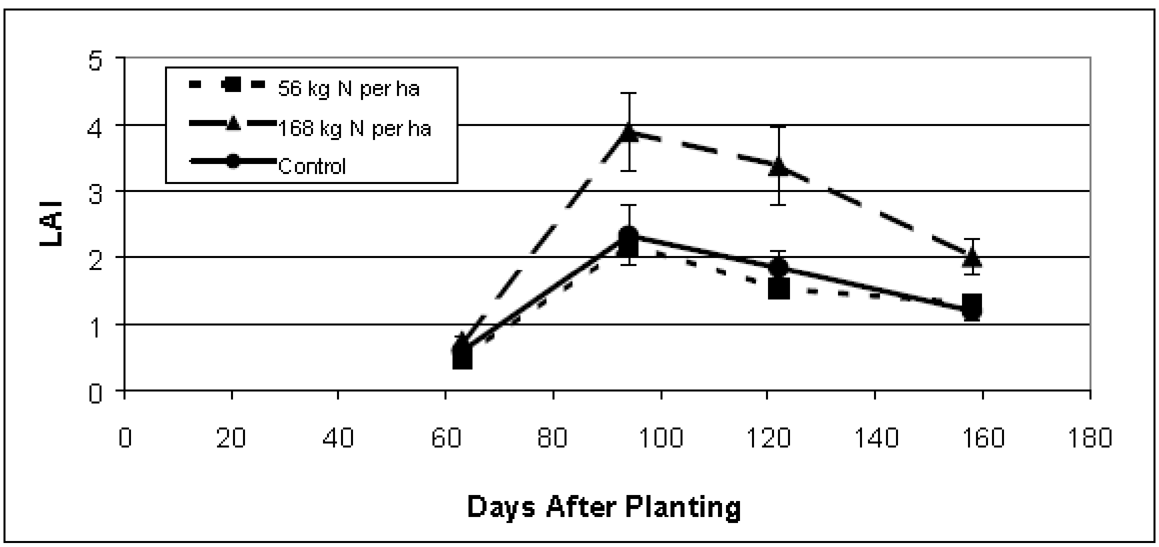

Figure 1b. Development of leaf area index(LAI) of Acala cotton over the 1999 season in response to N at the Kings County site.

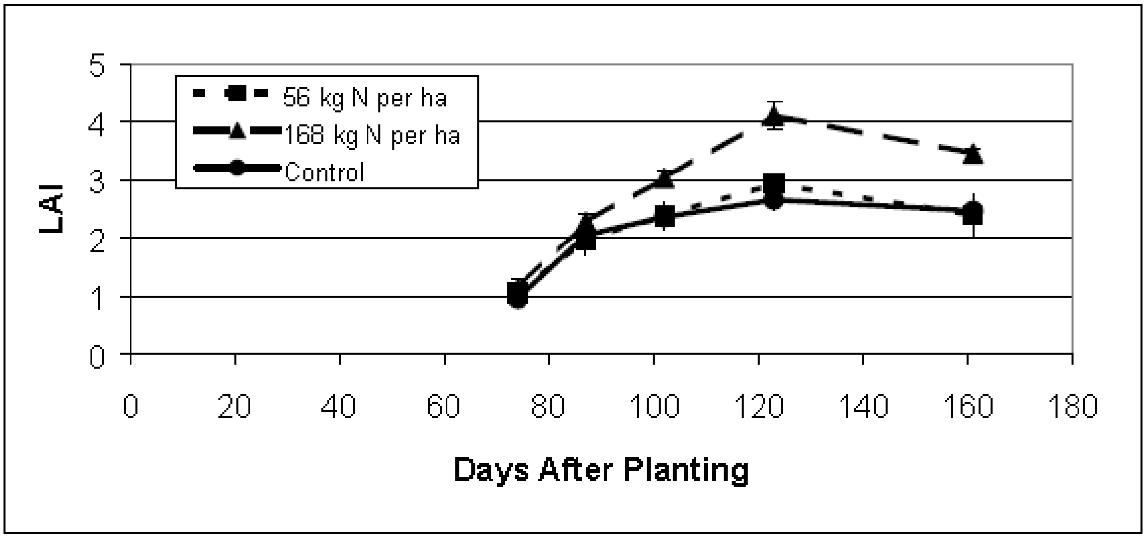

Figure 2a. Development of leaf area index(LAI) of Acala cotton over the 1998 season in response to N at the Fresno County site.

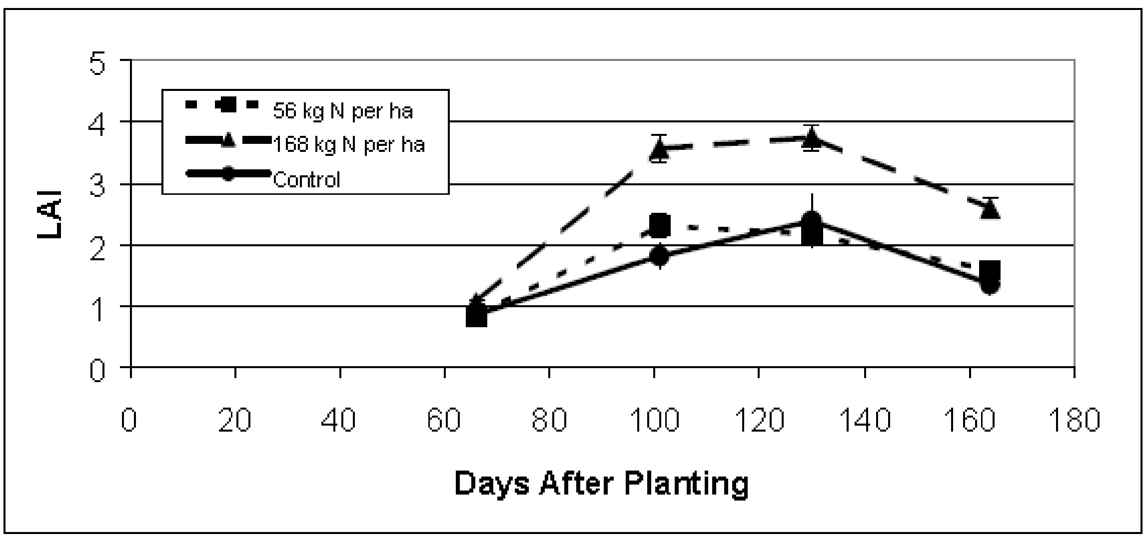

Figure 2b. Development of leaf area index(LAI) of Acala cotton over the 1999 season in response to N at the Fresno County site

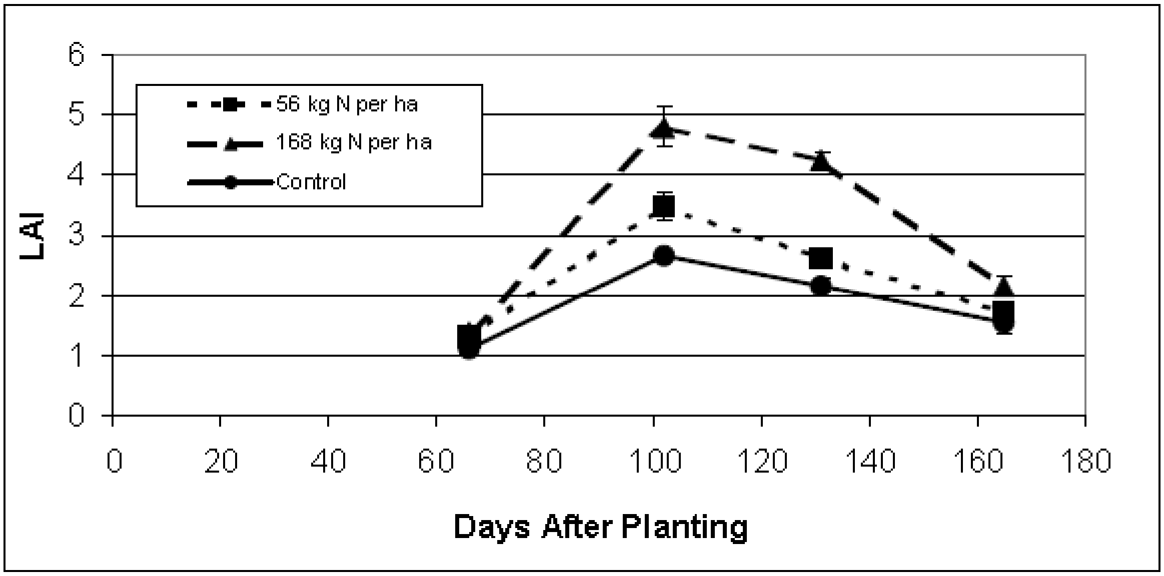

Figure 2c Development of leaf area index(LAI) of Pima cotton over the 1999 season in response to N at the Fresno county site

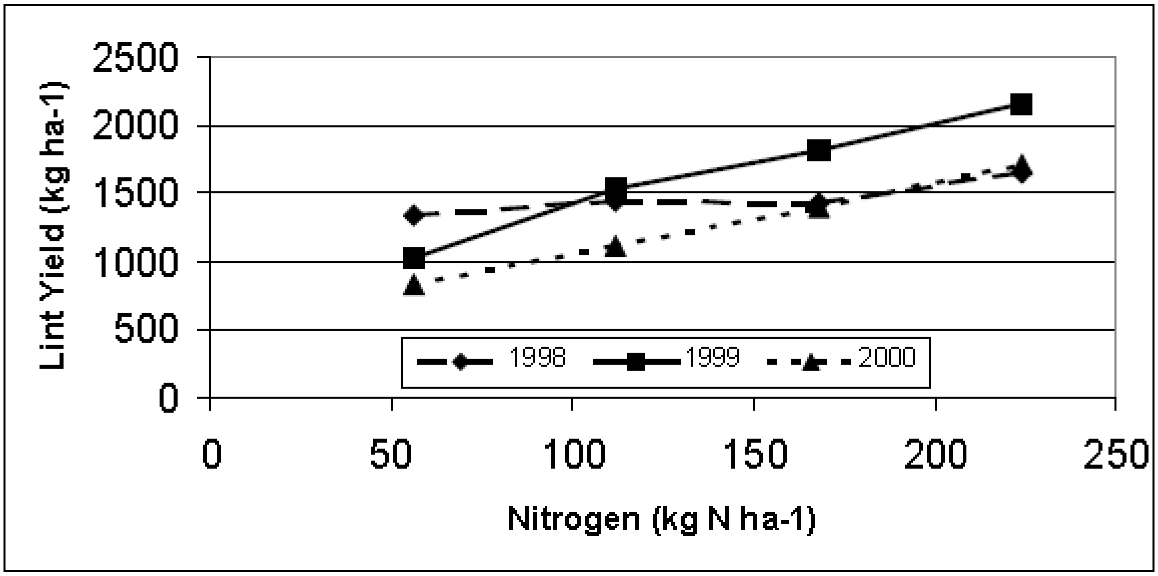

Figure 3a. Lint yields of Acala cotton over three seasons at the Fresno County site.

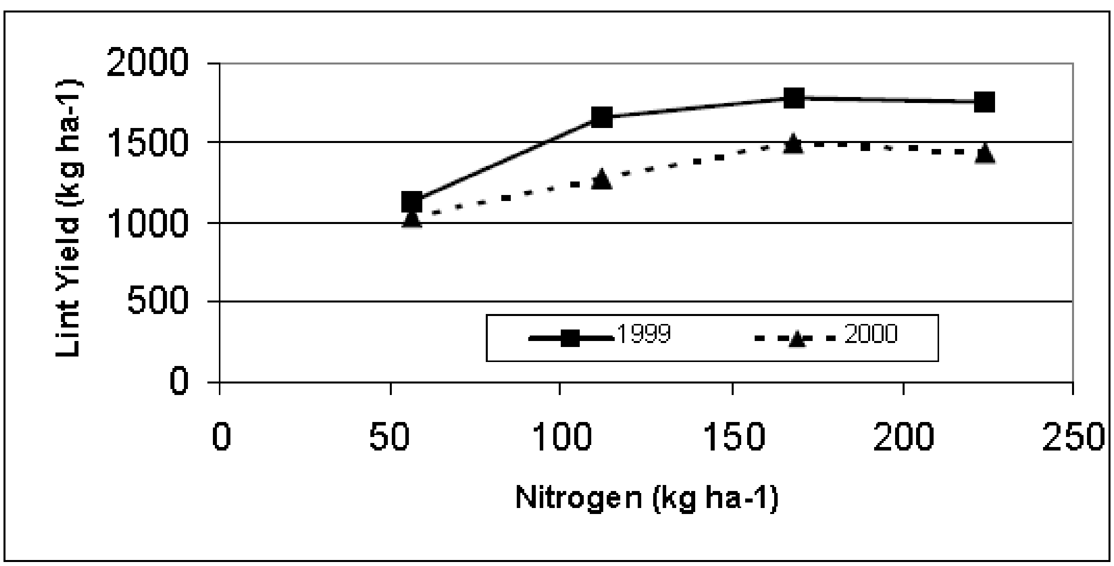

Figure 3b. Lint yields of Pima cotton over two seasons at the Fresno County site.

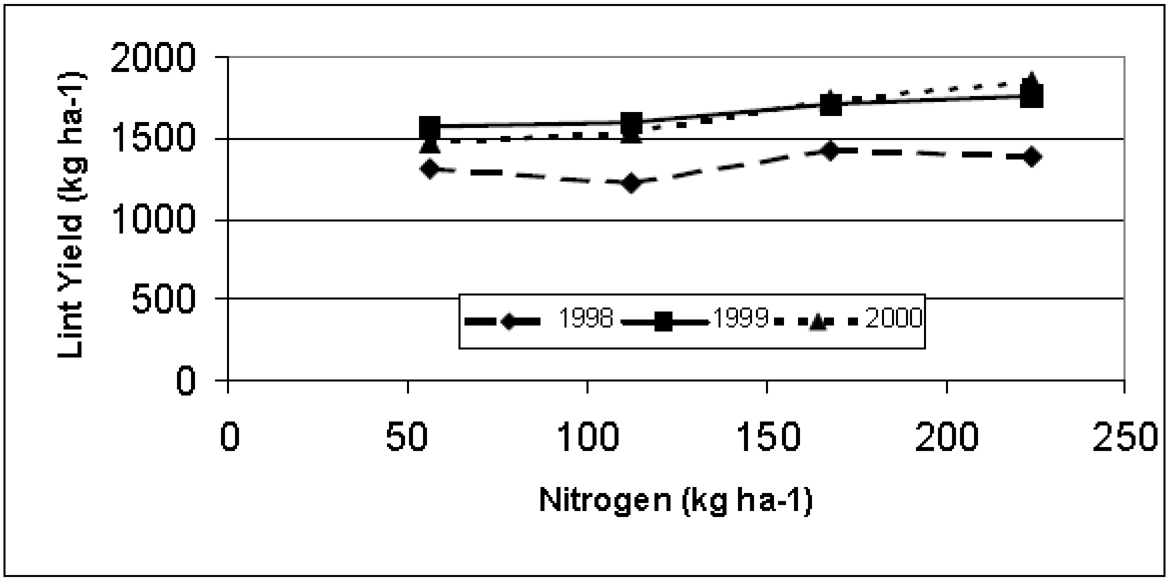

Figure 4. Lint yields of Acala cotton over three seasons at the Kings County site.