# Nitrogen Management Experiments For Upland and Pima Cotton, 1992.

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*Abstract*

*Two field experiments were conducted in Arizona in 1992 at two locations (Maricopa and Safford). The purposes of the experiments were to validate and refine nitrogen (N) fertilization recommendations for both Upland and Pima cotton. The experiments each utilized N management tools such as pre-season soil tests for $NO_3^-$-N, in-season plant tissue testing (petioles) for N fertility status, and crop monitoring to ascertain crop fruiting patterns and crop N needs. Results at both locations revealed a strong relationship between the crop fruit retention levels and N needs for the crop. This pattern was further reflected in final yield analysis as a response to the N fertilization regimes used. The effects of N fertility levels were evident in crop maturity and its relationship to lint yields.*

## Introduction

The management of fertilizer nitrogen (N) is a very important component of any cotton (Gossypium spp.) production program in Arizona. Water, and N are normally the most limiting inputs to successful cotton production in most desert soils. It is important for farmers to use fertilizer N efficiently to maintain optimum return in yield for the amount of fertilizer N provided. Also, from an environmental standpoint, it is important to manage fertilizer N so that downward movement of $NO_3^-$-N in the soil profile, can be minimized.

For cotton production systems in the desert Southwest, there are several N management tools available to manage fertilizer N inputs efficiently in terms of economic, agronomic, and environmental concerns. These tools include: residual soil $NO_3^-$-N levels from preseason soil samples, inputs of $NO_3^-$-N through irrigation water, petiole samples taken in-season for $NO_3^-$-N analysis, consideration of fruit load and growth pattern of the crop in terms of N needs, and the use of split applications of fertilizer N through the course of the season (Silvertooth and Doerge, 1990).

Recommendations from University of Arizona Cooperative Extension personnel concerning N management in cotton usually include these aforementioned tools. Growers are usually discouraged from making fertilizer N applications based purely on conjecture or guesswork. Therefore, two field experiments were conducted in 1992 as an extension of 1989, 1990, and 1991 experiments (Silvertooth et al., 1990; Silvertooth et al., 1991b and Silvertooth et al., 1992) to develop better guidelines for recommendations concerning the integration of N management tools to improve overall efficiency for the grower.

## Materials and Methods

Field experiments were conducted in 1992 at the University of Arizona Maricopa Agricultural Center (MAC), and Safford Agricultural Center (SAC) with the following objectives: 1) to compare several fertilizer N management strategies for cotton in terms of N fertility status of the crop, and yield; and 2) develop refinements in the fertilizer N recommendations associated with in-season N fertility assessments using cotton petiole analysis and fruit load development.

Maricopa

Both Upland (G. hirsutum L., var. DPL 90) and American Pima (G. barbadense L., var. Pima S-6) were planted on a Casa Grande sandy loam on 24 April. The experimental structure was a split plot within a randomized complete block design with three replications. Whole plots were cotton varieties (DPL 90 and Pima S-6), with subplots being N treatments (Table 1). Subplots were eight, 40 inch rows wide and extended the full length of the irrigation run (800 ft.). All pest control and irrigation management practices being carried out on an as-needed basis. Preseason soil test results are shown in Table 2.

Basic plant measurements were carried out within each plot on a regular 14 day basis for the entire season. These measurements included plant heights, number of mainstem nodes per plant, flower numbers per 150 $ft.^2$ areas, and the number of nodes above the top white bloom and the terminal (NAWB). Petioles were also sampled on a routine basis throughout the season and analyzed for $NO_3^-$-N. Plant mapping was performed on each distinct treatment (variety by N treatment) at five dates during the course of the season. Results from the plant mapping provide information concerning the percent total fruit retention (sum of positions one and two on each fruiting branch) for each treatment and a record of the general vegetative/reproductive balance maintained by the various treatments over time, as shown in Fig. 1 and 2. Actual fertilizer N applications are outlined in Table 3. Yield estimates were obtained by harvesting the entire center four rows of each plot with a mechanical picker.

Safford

The experimental design utilized at Safford was very similar to that described for Maricopa (Table 1) and included both DPL 90 and Pima S-6 planted 10 April on a Grabe clay loam soil. The N treatments utilized at Safford are shown in Table 4.

Basic plant measurements were carried out within each plot on an approximately 14 day basis for the entire season. These measurements included plant heights, number of mainstem nodes per plant, flower numbers per 50 $ft.^2$ areas, and the NAWB. Yield estimates were obtained by harvesting the entire center four rows of each plot with a mechanical picker, similar to that described at MAC.

Surface soil samples were collected preseason at Maricopa and Safford, to which routine soil analyses were performed. Routine soil test results are shown in Table 2. Soil samples were also collected by one foot depth increments, to a depth of two feet on 28 March and 2 April at Maricopa (Table 5) and Safford (Table 6), respectively.

## Results

Maricopa

Fruit retention levels developed from the plant mapping data are shown in Fig. 1 and 2 for both the DPL 90 and the Pima S-6, respectively. Petiole $NO_3^-$-N concentrations observed for each treatment are illustrated in Fig. 3 and 4 for both DPL 90 and Pima S-6, respectively. Residual soil $NO_3^-$-N from each treatment area preseason are listed in Table 5, to a depth of two feet. Heavy fruiting patterns were experienced throughout the season for both the Upland (DPL 90) and Pima (S-6) crops (Fig. 1 and 2). The development of a substantial boll load is indicative of a strong N sink and a high N demand. Fruit retention levels and $NO_3^-$-N concentration patterns in petioles led to the 10 June and 7 July applications of fertilizer N to treatments 3 and 4 (Table 3). The response to this application of N can be seen by the resultant increases in petiole $NO_3^-$-N levels in late July, followed by a decline in the late season, apparently due to the continued development of a boll load as evidenced by the fruit retention levels.

The DPL 90 check plots (treatment 1) experienced cut-out near 1 August (2200, 86/55°F heat units after planting (HUAP)), possibly due to N deficiency. Visual symptoms of N deficiency became apparent in check plots for both DPL 90 and Pima S-6 near 1 August. The DPL 90 plots for treatment 3 progressed towards cut-out near 15 August (2500 HUAP), which is very much in line with a full season Upland variety supporting a strong boll load, as this crop was. The final irrigation was applied on 11 September in an effort to provide adequate soil moisture to accomplish full development of bolls set by cut-out. Defoliants were applied on 10 October to all plots.

Plots were mechanically harvested on 10 November. Yield data for both the DPL 90, and Pima S-6 are shown in Table 7. No significant differences were detected among the N treatments for the DPL 90, with the check treatment (1) yielding slightly more than any of the other three treatments. Similar to the 1990 and 1991 results (Silvertooth et al., 1991 and Silvertooth et al., 1992), there was no benefit in terms of yield from the 2X feedback treatment (4) which had a total of 116 lbs. N/acre applied over two applications. There was no apparent advantage recognized from the pre-season N application made with treatment 2 based upon the in-season petiole analyses, fruit retention information, or yield. In fact, the trends indicated an increase in yield toward the check treatment (#1, no fertilizer N), and a general decline with increasing N rates (treatment 4). This is particularly interesting from the standpoint of developing strong visual deficiency symptoms in the check plots mid-season and the rather low petiole $NO_3^-$-N levels measured. This information provides a strong statement of support for the Best Management Guidelines for N fertilization of cotton, which advocates the use of petiole testing and plant monitoring in-season, and split applications of fertilizer N based upon plant needs. There is little justification of pre-season fertilizer N applications based upon these studies, particularly considering the pre-season soil test information (Table 5) and the levels of $NO_3^-$-N present to a depth of two feet. This data also shows the generally conservative nature of the petiole guidelines.

The yield data for the N treatments with the Pima S-6 are also shown in Table 7. Statistical differences were declared among treatments based upon the analysis of variance, which had a coefficient of variation (CV) of only 8.2% and a significant F value (OSL = 0.0345). The general trends revealed an interesting pattern very similar to that previously described for the DPL 90. In the case of the Pima S-6, the check treatment was statistically different ($P \leq 0.05$) from other treatments with an average yield increase of 161 lbs. lint/acre compared to the other three N treatments. Based upon fruit retention and plant measurements taken, the primary benefit gained from the check plots was an improvement in earliness. Treatments 2, 3, and 4 all had adequate fruit loads (Fig. 2), but not enough season to mature the crop. It should also be pointed out that final irrigations were made on 3 September, based upon actual crop conditions and a severe sweet potato whitefly infestation which was requiring repetitive chemical control treatments. Differences in whitefly infestation levels among N treatments was not noted. However, specific measurements to quantify whitefly numbers were not taken.

Another interesting feature that is apparent from the data obtained over the course of this past season and also from the 1990 and 1991 seasons (Silvertooth et al., 1991b and Silvertooth et al., 1992) is the N supplying power of the check plots which have received no fertilizer N for four seasons, yet have the capacity of supporting 3.1 and 1.8 bales/acre yields from the DPL 90 and the Pima S-6, respectively in 1992. All check plots expressed substantial visual deficiency symptoms (overall plant chlorosis, beginning first with lower, older portions of the plants and covering the entire plants in most cases by late-season) from mid July throughout the remainder of the season. The residual $NO_3^-$-N available to all N treatment plots at MAC in 1992 averaged about 65 lbs. N/acre for DPL 90, in the top two feet of the soil profile preseason (Table 5). In the plots receiving fertilizer N there was a slight trend towards higher residual soil $NO_3^-$-N in the top two feet in the higher N treatments, particularly as compared to treatment 1 (check).

This information indicates an area of research that is in need of further study concerning the N mineralization/immobilization transformations and the dynamics associated with mineralizable soil-N inherent in such soils of the Sonoran Desert. To better understand the N supplying power of agricultural soils of this region and the management implications associated with production systems such as cotton and N fertilization details such as these, there is a need for more specific research and experimentation.

<u>Safford</u>

Fruit retention data for the DPL 90 and the Pima S-6 at Safford are shown in Fig. 5 and 6. The early season fruit retention levels were high, relative to baseline figures (Silvertooth et al. 1991a) for both DPL 90 and Pima S-6. General plant measurements did not indicate an excessive vegetative tendency for any N treatment. Petiole concentrations of $NO_3^-$-N are outlined in Fig. 7 (DPL 90) and Fig. 8 (Pima S-6). Both figures describe patterns of petiole $NO_3^-$-N which are indicative of a situation in which the N sink has been well developed. Based upon petiole information obtained, the crop appeared to maintain a strong N demand throughout the season and N fertilization on 30 July and 21 July (Table 3) was in line with general petiole guidelines. From the N treatments used, treatment 3 received only 50 lbs. N/acre, applied by sidedress on 10 June, at approximately 950 HUAP, which was prior to first bloom. This treatment was entirely adequate in terms of providing sufficient N to the crop. Treatment 2, utilized two separate applications (29 April and 7 July) and a total of 218 lbs. N/acre was applied. No benefit was derived from this higher level of N input to either the Upland or Pima crop.

The lint yield results shown in Table 8 did not reveal statistically significant differences among N treatments at Safford for either DPL 90 or Pima S-6 in 1992. This fact is particularly interesting in relation to this particular experiment in that the integrity of these plots have been maintained since 1989. Therefore, the checkplots (N treatment one) have not received any fertilizer N for four consecutive cotton seasons over 1989, 1990, 1991 and 1992 (Silvertooth et al., 1990; Silvertooth et al., 1991b and Silvertooth et al., 1992). A very slight trend indicating higher levels of residual $NO_3^-$-N (Table 6) with high rates of fertilizer N can be seen. Residual levels of $NO_3^-$-N in 1992 ranged from 77 to nearly 120 lbs. N/acre. Checkplots had 58 to 66 lbs. $NO_3^-$-N/acre, in the top two feet of the soil profile. The source of this residual $NO_3^-$-N is likely from the soils inherent mineralization capacity and irrigation water inputs. Irrigation water provided by a groundwater well provided 2.1 acre feet of the irrigation water provided to this crop. Analyses of this water revealed an average concentration of 4.75 ppm $NO_3^-$-N. Therefore, approximately 27 lbs. $NO_3^-$-N/acre were provided in roughly 3 lb. $NO_3^-$-N/acre increments over the season through the irrigation system. The lack of a yield response to any of the N treatments by DPL 90 or Pima S-6 at this location illustrates the necessity of monitoring both crop and soil conditions in an effort to maintain efficient use of N and other crop production inputs, and also the importance of timeliness in management responses.

## Summary


The 1991 experiments at Maricopa and Safford demonstrate the value and utility of incorporating various N and crop management tools into cotton production systems of Arizona. The dynamic nature of the cotton crop (Upland and Pima) requires management of inputs such as fertilizer N that are critical in attaining optimum efficiency agronomically, economically, or environmentally. The difficulty in predicting crop N needs for any given season in advance, in combination with the residual soil $NO_3^-$-N levels commonly experienced for these experiments, indicate the need to exercise extreme caution in pursuit of any preseason N fertilization. In-season crop monitoring techniques for fruit load development and N fertility status compliment each other for managing N inputs for better efficiency, but must be used in a timely manner.

Results from 1992 are consistent with many of the earlier years work on this project. Higher rates of fertilizer N, as commonly used in treatments 2 and/or 4, are not providing the basis for higher yields. In fact, the rather consistent trend has been for higher N treatments to cause a depression in yields. This is often attributed to a delay in crop maturity from high N fertility levels and an increase in general vegetative tendencies. This represents a management factor which needs to be considered within the context of the current interest on the part of cotton growers to improve the earliness of a crop. Incentives to achieve improved earliness includes whitefly populations, late season pink bollworms, and the limits in the length of the growing season at higher elevations.

These experiments also reveal the intriguing aspects of soil N mineralization capacities in Sonoran Desert soils, which are often considered as having virtually negligible N supplying potentials. Monitoring of $NO_3^-$-N inputs through irrigation water also represents an important component in crop management that can be very important, such as shown at Safford.

## References


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Table 1. Nitrogen fertilization treatments used at the Maricopa and Safford Agricultural Centers, 1992.

| N Treatments No. | Fertilizer N Management |
|---|---|
| 1 | Check (No fertilizer N) |
| 2 | Standard: Preplant & Side dress |
| 3 | Feedback approach from soil and petiole $NO_3^-$-N analysis, 1X rate. |
| 4 | 2X rate from soil and petiole $NO_3^-$-N feedback |

Table 2. Preseason soil test results for each N treatment at Maricopa and Safford, Az, 1992.

| Treatment | Ca* | Mg | Na | K | Zn** | $NO_3^-$-N*** | P† | pH | EC | ESP§ |
|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | | | | | | | (1:1 $H_2O$) | ds/m | -%- |
| | | | Maricopa | | | | | | | |
| 1 | 5250 | 332 | 267 | 390 | .9 | 15 | 10.0 | 8.4 | 1.9 | 3.7 |
| 2 | 5200 | 340 | 242 | 430 | 1.0 | 24 | 12.0 | 8.4 | 1.9 | 3.4 |
| 3 | 4590 | 315 | 224 | 410 | 1.0 | 12 | 7.9 | 8.5 | 1.6 | 3.5 |
| 4 | 4560 | 302 | 235 | 415 | .9 | 18 | 13.0 | 8.4 | 1.9 | 3.7 |
| | | | Safford | | | | | | | |
| 1 | 6630 | 613 | 857 | 666 | 1.6 | 17 | 10.0 | 8.1 | 4.3 | 8.5 |
| 2 | 6230 | 670 | 910 | 754 | 1.9 | 16 | 8.1 | 8.2 | 3.5 | 9.3 |
| 3 | 5810 | 600 | 977 | 680 | 1.5 | 16 | 6.8 | 8.3 | 3.5 | 10.6 |
| 4 | 6000 | 615 | 940 | 720 | 1.4 | 18 | 6.6 | 8.2 | 3.5 | 10.0 |

* Exchangeable cations using neutral molar ammonium acetate.
** DTPA extractable Zn.
*** $NO_3^-$-N using specific ion electrode.
† $NaHCO_3$ extractable P
§ Computed - exchangeable sodium percentage.

Table 3. Fertilizer N applications for each N management treatment, MAC, 1992.*

| Date | Form | Method** | Treatment Number 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| | | | ------------lbs N/acre------- | | | |
| 21 April | Urea (46-0-0) | SD | 0 | 45 | 0 | 0 |
| 10 June | Urea (46-0-0) | SD | 0 | 0 | 41 | 82 |
| 7 July | Urea (46-0-0) | SD | 0 | 41 | 41 | 82 |
| | | TOTAL | 0 | 86 | 82 | 164 |

** SD = sidedress

Table 4. Fertilizer N applications for each treatment, SAC, 1992.

| Date | Form | Method* | Treatment Number 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| | | | ------------lbs N/acre------- | | | |
| 21 April | Urea (46-0-0) | SD | 0 | 45 | 0 | 0 |
| 10 June | Urea (46-0-0) | SD | 0 | 0 | 41 | 82 |
| 7 July | Urea (46-0-0) | SD | 0 | 41 | 41 | 82 |
| | | TOTAL | | 86 | 82 | 164 |

* SD = sidedress

Table 5. Preseason soil NO3--N mean concentrations for two, one foot depth increments for each N treatment at Maricopa, Az, 19 March, 1992.

| Treatment | Depth | NO3--N | | |
|---|---|---|---|---|
| | -feet- | -ppm- | -lbs./acre- | Total (lbs./acre)* |
| | | DPL 90 | | |
| 1 | 1 | 10.8 | 43.2 | |
| 1 | 2 | 5.2 | 20.8 | 65.0 |
| 2 | 1 | 18.7 | 74.8 | |
| 2 | 1 | 8.9 | 35.6 | 110.4 |
| 3 | 1 | 11.2 | 44.8 | |
| 3 | 2 | 7.6 | 30.4 | 75.2 |
| 4 | 1 | 21.5 | 86.0 | |
| 4 | 2 | 14.3 | 57.2 | 143.2 |
| | | Pima S-6 | | |
| 1 | 1 | 10.1 | 40.4 | |
| 1 | 2 | 3.9 | 15.6 | 56.0 |
| 2 | 1 | 21.3 | 85.2 | |
| 2 | 2 | 24.0 | 96.0 | 181.2 |
| 3 | 1 | 9.6 | 38.4 | |
| 3 | 2 | 9.2 | 36.8 | 75.2 |
| 4 | 1 | 19.9 | 79.6 | |
| 4 | 2 | 10.1 | 40.4 | 120.0 |

* Sum of depth one and two, for each N treatment.

Table 6. Preseason soil NO3--N mean concentrations for two, one foot depth increments for each N treatment at Safford, Az, 2 February, 1992.

| Treatment | Depth | NO3--N | | |
|---|---|---|---|---|
| | -feet- | ppm | lbs./acre | Total (lbs/acre)* |
| | | DPL 90 | | |
| 1 | 1 | 9.1 | 36.4 | |
| 1 | 2 | 5.2 | 20.8 | 57.2 |
| 2 | 1 | 15.9 | 63.6 | |
| 2 | 2 | 14.0 | 56.0 | 119.6 |
| 3 | 1 | 9.8 | 39.2 | |
| 3 | 2 | 6.9 | 27.6 | 66.8 |
| 4 | 1 | 10.2 | 40.8 | |
| 4 | 2 | 7.6 | 30.4 | 71.2 |
| | | Pima S-6 | | |
| 1 | 1 | 9.7 | 38.8 | |
| 1 | 2 | 6.7 | 26.8 | 65.6 |
| 2 | 1 | 13.3 | 53.2 | |
| 2 | 2 | 7.9 | 31.6 | 84.8 |
| 3 | 1 | 10.2 | 40.8 | |
| 3 | 2 | 9.0 | 36.0 | 76.8 |
| 4 | 1 | 11.0 | 44.0 | |
| 4 | 2 | 8.9 | 35.6 | 79.6 |

* Sum of depths one and two, for each N treatment.

Table 7. Lint yield means for each N management treatment, Maricopa, Az, 1992.

| Treatment | Yield | |
|---|---|---|
| | DPL 90 | Pima S-6 |
| | ------------lbs.lint/acre------------ | |
| 1 | 1502 | 886 a* |
| 2 | 1484 | 753 b |
| 3 | 1443 | 744 b |
| 4 | 1384 | 679 b |
| LSD 0.05 | NS | 126 |
| OSL † | 0.2984 | 0.0345 |
| CV (%) § | 5.04 | 8.24 |

* Means followed by the same letter are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.

† OSL = observed significance level.

§ CV = Coefficient of variation.

Table 8. Lint yield means for each N management treatment at Safford, Az, 1992.

| Treatment | Yield | |
|---|---|---|
| | DPL 90 | Pima S-6 |
| | --------------------lbs. lint/acre-------------------- | |
| 1 | 1417 | 668 |
| 2 | 1415 | 657 |
| 3 | 1363 | 623 |
| 4 | 1244 | 552 |
| LSD 0.05 | NS | NS |
| OSL † | 0.2686 | 0.4096 |
| CV (%) § | 9.6 | 16.2 |

* Means followed by the same letter are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.

† OSL = observed significance level

§ CV = Coefficient of variation

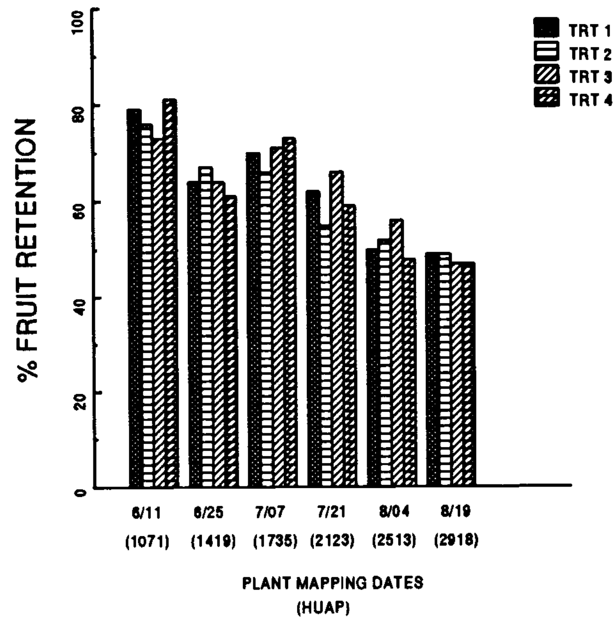


Fig. 1. Fruit retention levels, DPL 90, Maricopa Nitrogen Management, 1992.

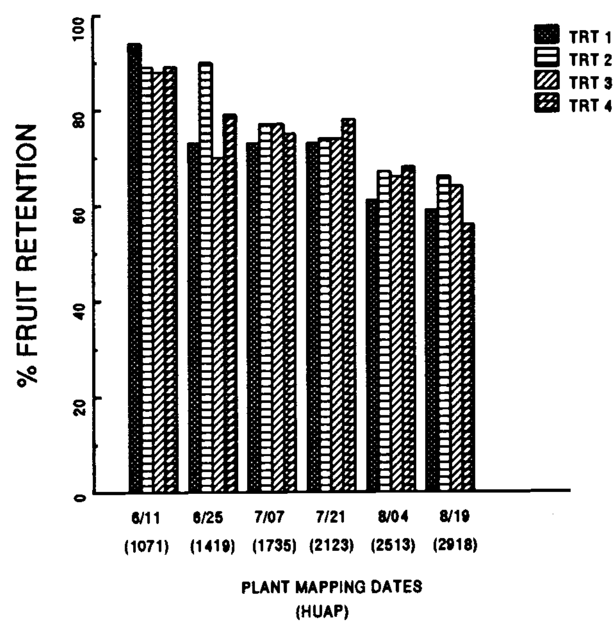


Fig. 2. Fruit retention levels, Pima S-6, Maricopa Nitrogen Management, 1992.

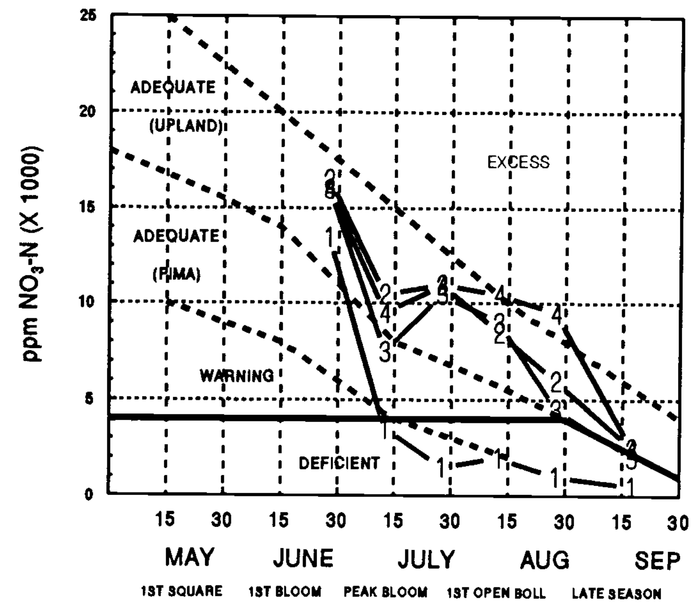


Figure 3. $NO_3$-N Levels in Cotton Petioles, Maricopa Agricultural Center (DPL 90), 1992.

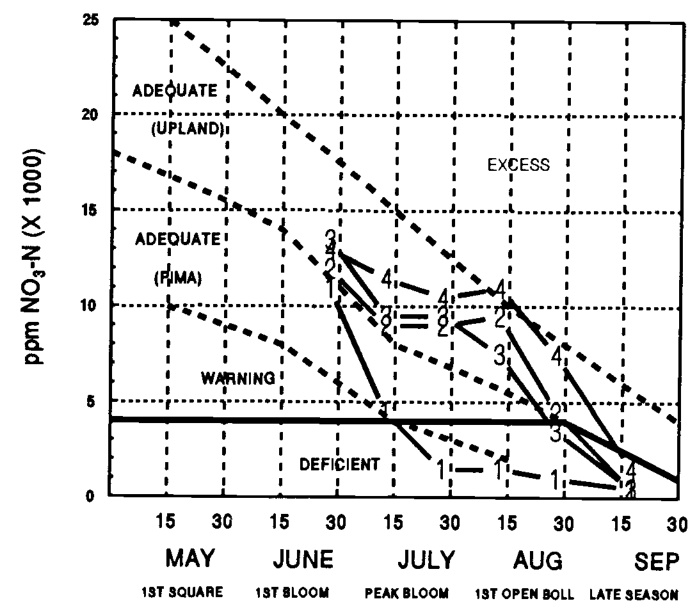


Figure 4. $NO_3$-N Levels in Cotton Petioles, Maricopa Agricultural Center (Pima S-6), 1992.

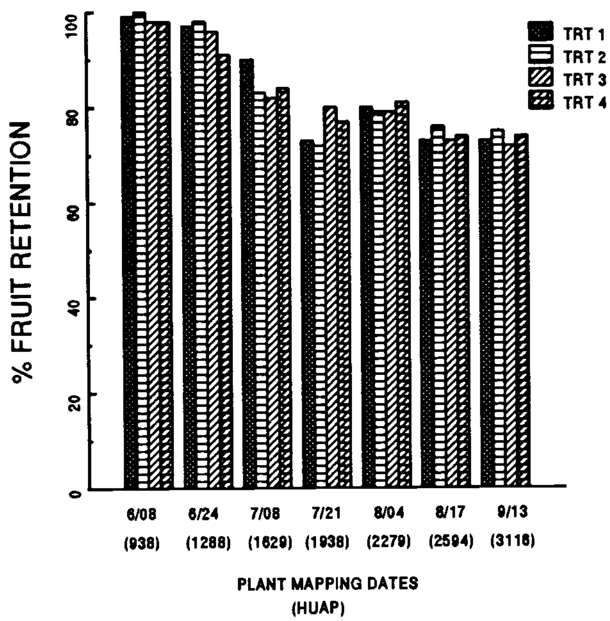


Fig. 5. Fruit retention levels, DPL 90, Safford Nitrogen Management, 1992.

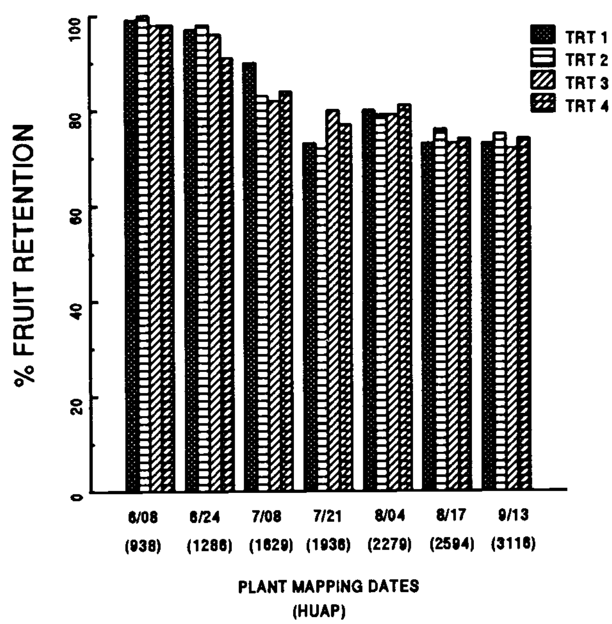


Fig. 6. Fruit retention levels, Pima S-6, Safford Nitrogen Management, 1992.

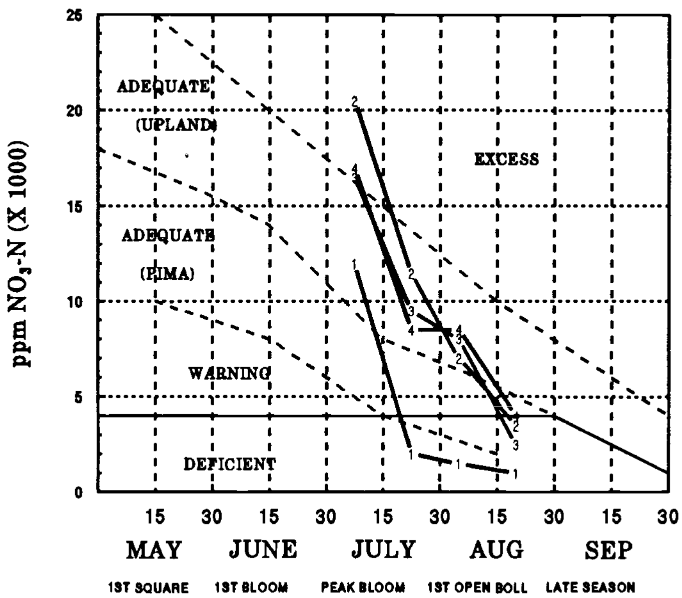


Figure 7. $NO_3$-N Levels in Cotton Petioles, Safford (DPL 90), 1992.

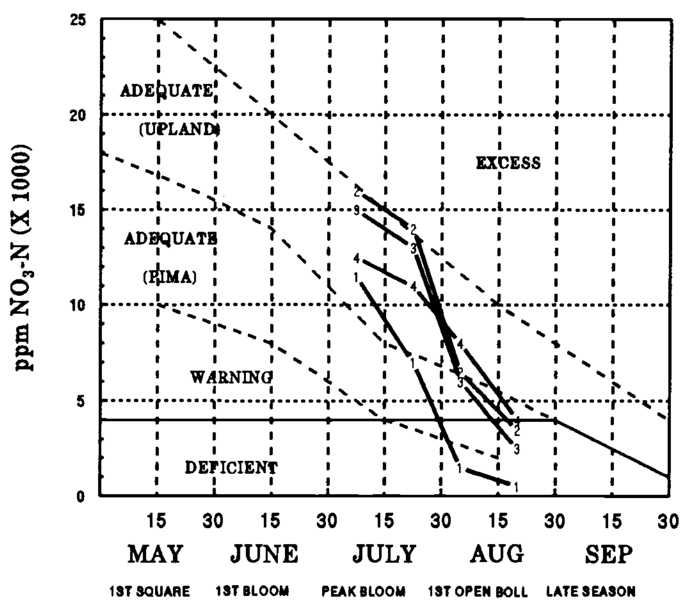


Figure 8. $NO_3$-N Levels in Cotton Petioles, Safford (Pima S-6), 1992.