Table 11. Lint yield as a function of site and treatment in 2001, 2002 and 2003 sites.

	2001 Field Study Sites							
Site / location	Lint Yield (lbs lint per acre)							
	Trt 1	Trt 2	Trt 3	Trt 4	No N			
Kem Co.	1517a	1542a	1615a	1608 a	984 b			
Shafter	1291 a	1292a	1227ab	1210b	678 c*			
Fresno Co.	1435 b	1689 a	1734a	1504 b	1665 a			
West Side REC	1807b	1815ab	1896a	1767 c	1331 c			
	2002 Field Study Sites							
Shafter	1740 a	1791 a	1784 a	1814 a	1287 b			
Fresno Co.	1293 c	1912ab	2045 a	1877 b	880 d			
West Side REC	1686 b	2005 a	2001 a	1995 a	976 c*			
	2003 Field Study Sites							
Kern	1154 c	1359 b	1487 a	1415 ab	1088 c			
Shafter	1521 be	1615 a	1563 ab	1577 ab	1444 c			
West Side REC	1871 a	1836 ab	1770 c	1787 be	1791 be			
Tulare	1256 b	1387 a	1408 a	1302 ab	1153 c*			

*only 2 replications; ** yields followed by a different letter were significantly different at 5% level by LSDmethod.

Residual Soil N and Relationship to Treatments and Crop .Impacts of specific N fertilization treatments on soil nitrate-N accumulation patterns at depths in the soil profile have been analyzed across years and sites (see Figures 10 and 11). A general trend existed toward higher apparent net depletion (reductions in soil nitrate-N during the growing season) in treatments where lower N rates were applied (such as Treatment #1), as would be expected. The magnitude of these differences was less under some conditions, such as with lower yields (Shafter REC-2001) . Consistently, net changes in soil nitrate-N in the most active part of the root zone (0 to 4 foot depth) were largest (most negative) in the lowest application treatment (Trt. #1) and the least in the higher application treatments.

In the lower soil depths (4 to 8 feet), changes in soil nitrate-N between spring and fall consistently showed more apparent reductions in soil nitrate-N during the season (more negative in Figures 10 and 11) in lower N treatments (Trt #1 versus #3 or Trt #2 versus Trt #4). Conversely, the highest net accumulations of nitrate-N in the 4 to 8 foot depth (measured between the spring and fall sampling dates) were in the higher N application treatments, particularly treatment #4, which received the higher initial N application plus a supplemental 55-60 lbs N/acre application (Figures 10, 11).

There are recognized limits in interpreting soil nitrate data, since values of this soluble, mobile form of N are known to change over time and with processes such as mineralization and denitrification. However, for the purposes of this study, we assume that changes in nitrate-N in the soil still represent a general indicator of changing N status that occurs both with crop N uptake as well as other processes such as leaching that can occur during the growing season. While increases in soil nitrate-N in the lower soil profile averaged about 20 lbs nitrate-N/acre in treatment #4 and did not exceed 40 lbs/acre at any site, these levels still suggest potential for nitrate losses below the root zone if rotation crops are not deeply rooted or if irrigation practices don't eliminate leaching potential.

Soil nitrate distribution patterns exhibited a strong (but not always consistent) trend toward the split application in treatment #3 reducing soil nitrate-N levels in the fall measurements made at the 4 to 8 foot depth when compared with the one time higher application rates used in treatment #2 (Figures 10 and 11). Higher soil nitrate-N levels at greater depths may be related to a number of factors. This trend tended to be most evident at the sites thought to have more permeable soils and higher soil infiltration rates prevailing early and mid-season (such as Shafter REC-2001, West Side REC-2001 and 2002, Fresno-2002, and West Side REC-2003). Split N applications were much more inconsistent in producing any crop growth or yield benefit over one time applications, at least growth that resulted in increased fruit retention or growth and eventual lint and seed yield. Since yields were not generally reduced with timely split nitrogen applications in this trial, however, indications of potential to reduce downward movement of soil nitrate-N through use of split applications may provide some incentive to promote split applications as a better practice to limit nitrate N losses below the active root zone.

Mineralizable Nitrogen Analyses

The relationship between mineralizable N analyses made by the hot KCl method (Gianello and Bremner, 1986 and Picone et al, 2002) and soil nitrate-N measurements for the top two feet of the soil profile during the post-planting and post-harvest periods are shown in Figures 12 and 13, respectively. It must be acknowledged that these analyses have been on low organic matter soils with sandy loam and clay loam textures and with one exception, at sites where land application of dairy waste or large amounts of crop residue were not part of the management.

Table 12. Yield responses to supplemental N in treatments # 3 and # 4 as a function of the range of values in analyses done for concentrations of soil nitrate-N versus Hot KCl mineralizable N at field sites shown. Ranges shown are the lows and high field replicates for the same data represented in figure 12.

Year	Site	Range of Values (lowest field replication average versus high average) for: ***Soil** Nitrate -N (mg N03-N/**kg soil** dry wt.)*		Range of Values (lowest field replication average versus high average) for: *Soil Hot KCl **Mineralizable** N (mg N/kg dry wt.)*		Yield Responses to Supplemental N applied in Treatments #3 and #4 (compared with Trt # I and trt #2) S = significant NS = non-significant	
		LOW	HIGH	LOW	HIGH	Trt #3	Trt #4
2001	Kern	8.0	10.0	17.2	20.8	NS	NS
	Shafter	5.0	5.9	8.7	10.1	NS	
	Fresno	12.6	17.1	18.8	31.4	S	
2002	Fresno	4.5	7.4	5.9	9.1	S	NS
	Shafter	10.4	14.8	17.4	26.9	NS	NS
	West Side	6.3	9.7	9.9	14.2	S	NS
2003	Kern	4.2	6.6	5.7	8.9	S	NS
	West Side	5.0	6.7	7.9	10.4	*	NS
	Tulare	7.6	11.0	15.2	25.7	S	NS

* yields significantly reduced with application of supplemental N (usually associated with more vegetative, rank growth and poorer fruit retention in these cases)

The 1:1 lines shown in Figures 12, 13, and 14 demonstrates that these estimates of mineralizable N in the upper two feet of the soil profile ranged from about 1.1 to over 2.4 times the nitrate-N concentrations determined on duplicate subsamples. The ratio of mineralizable N to nitrate-N showed a trend toward increases at higher soil nitrate-N levels, both in pre-harvest samplingbut the relationship still showed a great deal of scatter rather than a tight relationship. The ratio was lower in the soil samples from the third foot (lower graph in Figure 12) in post-planting sampling, perhaps reflecting less movement and deeper incorporation of crop residue potentially contributing to mineralizable N. Fewer samples were evaluated during the post-harvest period (Figure 14), and soil nitrate and mineralizable N levels were generally significantly lower than at post-planting timing. However, the ratio of mineralizable N to soil nitrate exhibited correlations similar to those at post-planting. Relatively limited comparisons of mineralizable N analyses were made by the incubation method (Franzleubbers et al, 1996) due to greater difficulties in consistency of results in making these measurements at our lab. Values obtained were generally higher than those obtained with the hot KCl method, but differed by as much as 30 percent (data not shown).

Table 12 shows the range of soil nitrate levels and mineralizable N estimates for the upper two feet of soil during the spring, post-planting sample timing.along with an indication of whether or not treatment #3 or treatment #4 plants showed yield responses to the supplemental N applied over and above the one N application treatments (Treatment #1 and Treatment #2).

We hypothesized that those sites where yields did not respond to the supplemental N supplied with treatment #3 could have low soil nitrate-N values, but much higher mineralizable N that could become available during the season. The analyses shown in table 12 demonstrate a high ratio of mineralizable N to nitrate-N in some sites which were unresponsive to supplemental N applications in treatment #3 (Kern-2001, Shafter-2001 and 2002), but also demonstrated that some other sites with a high ratio of mineralizable N to nitrate-N still showed a significant yield response. In this series of experiments, while the mineralizable N data appeared to be useful as an indicator of additional N sources over and above soil nitrate-N measurements alone, it was considerably more time-consuming and expensive currently than soil nitrate-N tests. Based upon the results of this and prior experiments (Hutmacher et al, 2004), we would be more inclined to recommend deeper soil sampling (to 3 or 4 feet where possible) and analysis for nitrate-N at post-planting time to better assess additional potential sources of N. Our mix of test sites was not sufficient to test how variable these results might be at a wider range of soil organic matter levels such as those occurring with different crop rotations or with manure applications. There has been much research activity in recent years in mineralizable N measurement method comparisons (Picone et al, 2002), and these evaluations may help in making decisions regarding the future utility of these tests as part of an N management plan.

Summary

A three year study with three to four field sites per years was conducted to evaluate a proposed feed-back approach to improve nitrogen management decision-making in Acala cotton production in the San Joaquin Valley. Under conditions where soil nitrate-N levels in the upper two to four feet of the soil profile were in the low to moderate range as determined from prior cotton nitrogen management studies, treatments were established to supply a total of residual N plus applied N of either 115 or 180 lbs of N/acre, with supplemental applications of an additional 55 to 60 lbs N/acre made during early bloom. Plant petiole nitrate-n was monitored during bloom, and limited plant mapping was done during the same period to assess crop growth vigor and fruit retention. Methods were proposed in which these plant measurements could be used in combination with soil nitrate-N measurements to assess likelihood of positive yield response to supplemental N. An evaluation comparing soil mineralizable N measurements with soil nitrate-N demonstrated a way to measure additional N sources over and above nitrate-N, but was somewhat difficult to measure.

Advantages could be gained in soil sampling to greater depths as an alternative way to also account for other potential crop-available N sources. Although this approach would require a targeted number of soil nitrate, petiole nitrate and plant mapping measurements and associated costs, this feedback management approach could reduce occurrences of un-needed fertilizer applications, or conversely, N deficiencies damaging to yield potential.

PUBLICATIONS

Hutmacher, R.B., R.L. Travis., D.W. Rains, R.N. Vargas, B.A. Roberts, B.L. Weir, S.D. Wright, D.S. Munk, B.H. Marsh, M.P. Keeley, F.B. Fritschi, D.J. Munier, R.L. Nichols, and R. Delgado. 2004. Response of Recent Acala Cotton varieties to Variable Nitrogen Rates in the San Joaquin Valley of California. Agron. J. 96: 48-62. (based in part on this research, and on prior study)

Hutmacher, R.B., R.L. Travis, B.A. Roberts, R.N. Vargas, S.D. Wright, B.H. Marsh, D.S. Munk, B.L. Weir, D.W. **Rains**, R.L. Nichols, M.P. Keeley, F. Fritschi, D.J. Munier, R. Delgado. Nitrogen **Management** Guidelines for Acala Cotton in the San Joaquin Valley. In preparation: publication to be jointly sponsored by Cotton incorporated and the University of CA , based on this and other recent UC research by the authors on revisions to N management practices to consider under CA conditions. Text is in preparation, should go to co-authors for review during April,

2005.

Other publications may be planned, based upon co-author comments and review of data, including petiole nitrate data and patterns of soil N uptake and concentrations.

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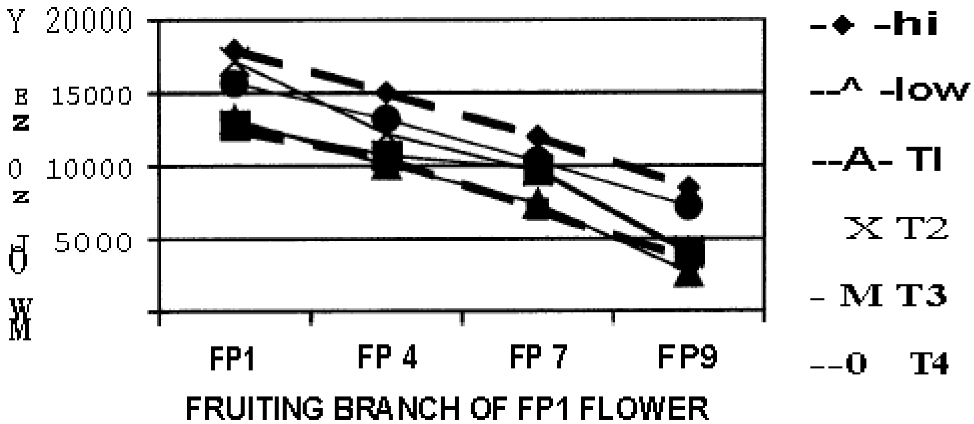


Figure 1. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site A (Kern County) in 2001. Residual spring soil nitrate-N in the upper 2 feet and upper 4 feet of soil profile during first weeks after planting averaged 69 and 116 lbs nitrate-N/acre, respectively, at this site.

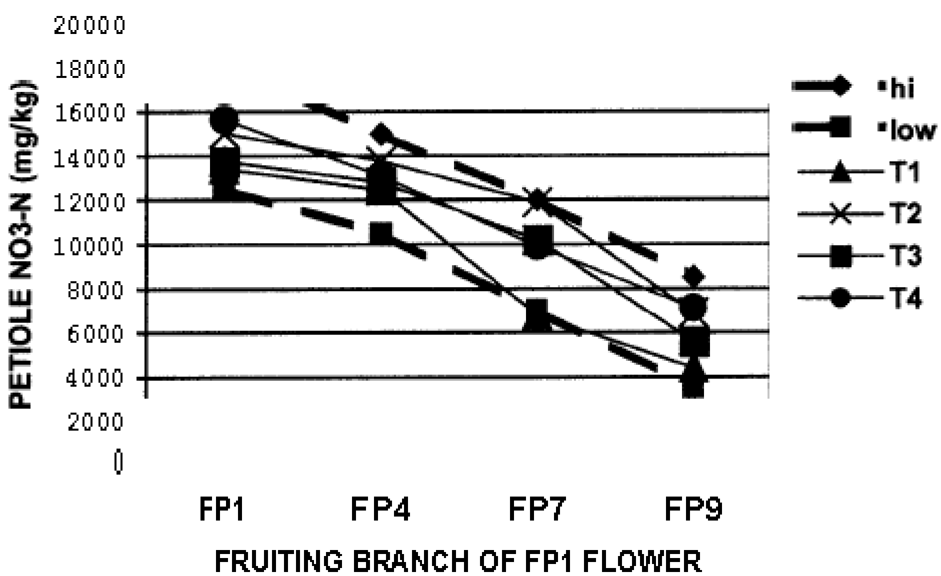


Figure 2. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site B (Shafter REC) in 2001. Residual spring soil nitrate-N in the upper 2 feet and 4 feet of soil profile during first weeks after planting averaged 41 and 86 lbs nitrate-N/acre, respectively, at this site

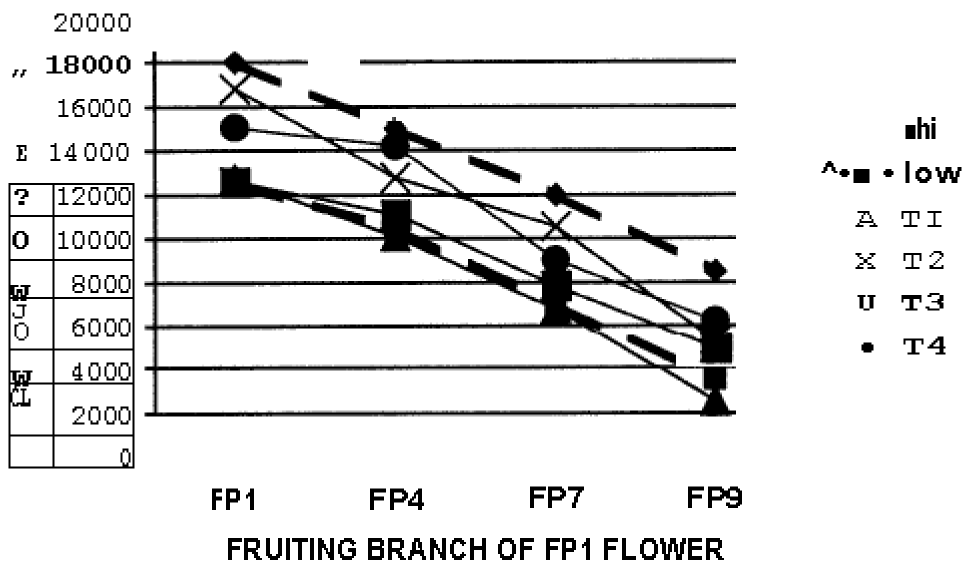


Figure 3. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site D (West Side REC) in 2001. Residual spring soil nitrate-N in the upper 2 feet and 4 feet of soil profile during first weeks after planting averaged 58 and 97 lbs nitrate-N/acre, respectively, at this site

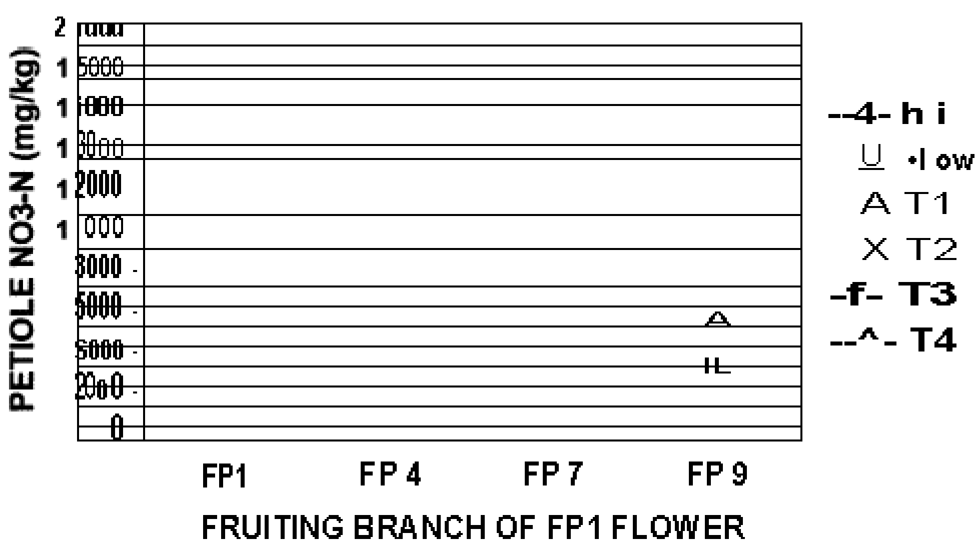


Figure 4. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site B (Shafter REC) in 2003. Residual spring soil nitrate-N in the upper 2 feet and 4 feet of soil profile during first weeks after planting averaged 58 and 89 lbs nitrate-N/acre, respectively, at this site.

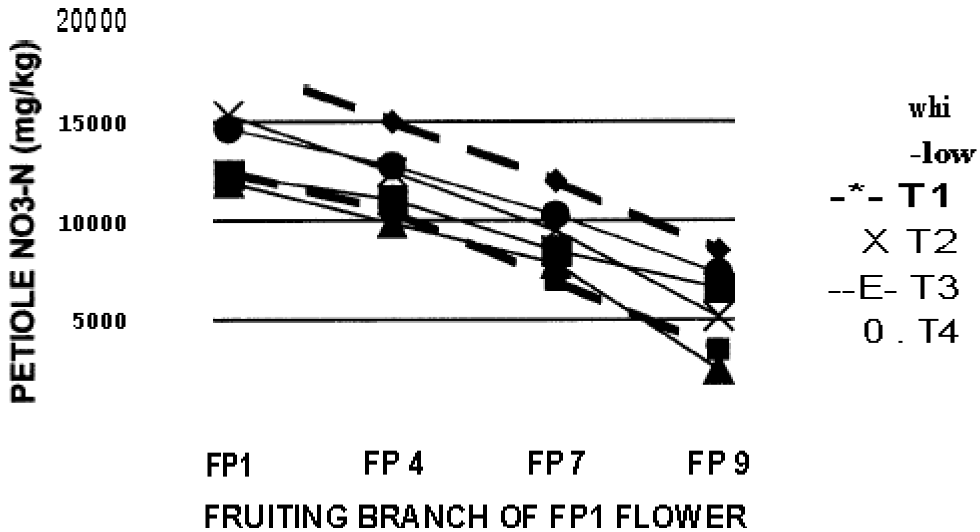


Figure 5. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site A (Kern Co.) in 2003. Residual spring soil nitrate-N in the upper 2 feet and 4 feet of soil profile during first weeks after planting averaged 41 and 83 lbs nitrate-N/acre, respectively, at this site

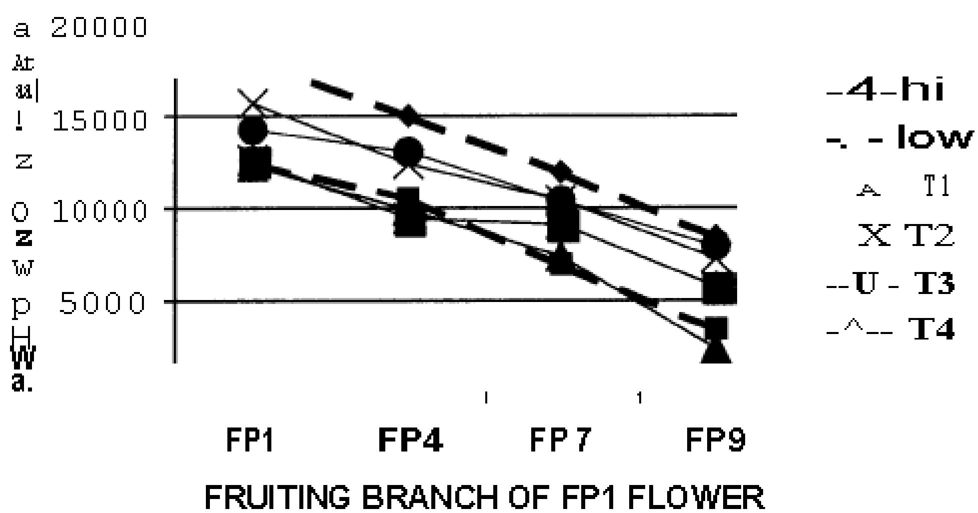


Figure 6. Petiole nitrate-N as a function of nitrogen treatment and growth stage (fruiting branch of first position open bloom) at Site D (Tulare Co.) in 2003. Residual spring soil nitrate-N in the upper 2 feet and 4 feet of soil profile during first weeks after planting averaged 69 and 132 lbs nitrate-N/acre, respectively, at this site

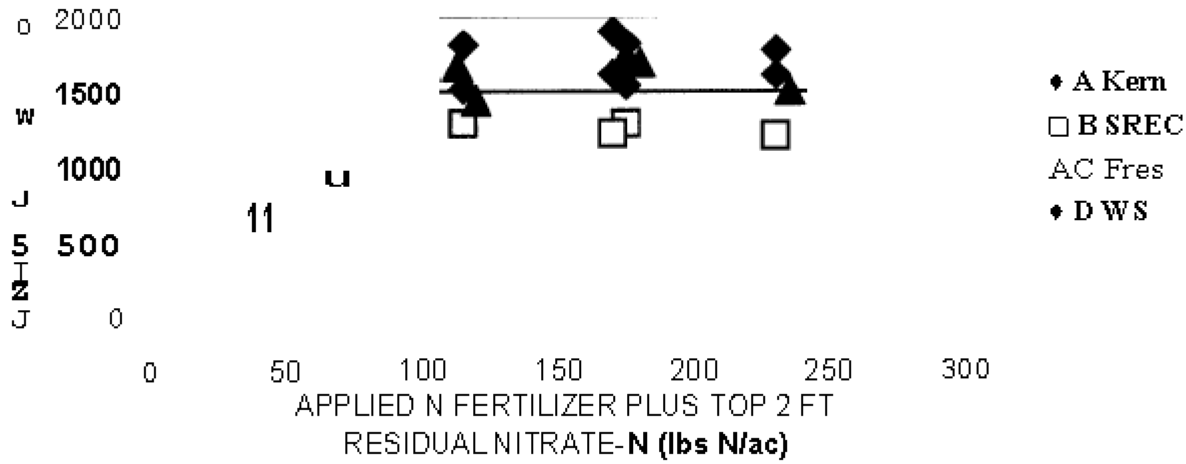


Figure 7. Lint yields **at 2001 test sites as a function** of the sum of applied N fertilizer **plus residual soil nitrate** -N in the upper two feet of the **soil profile.**

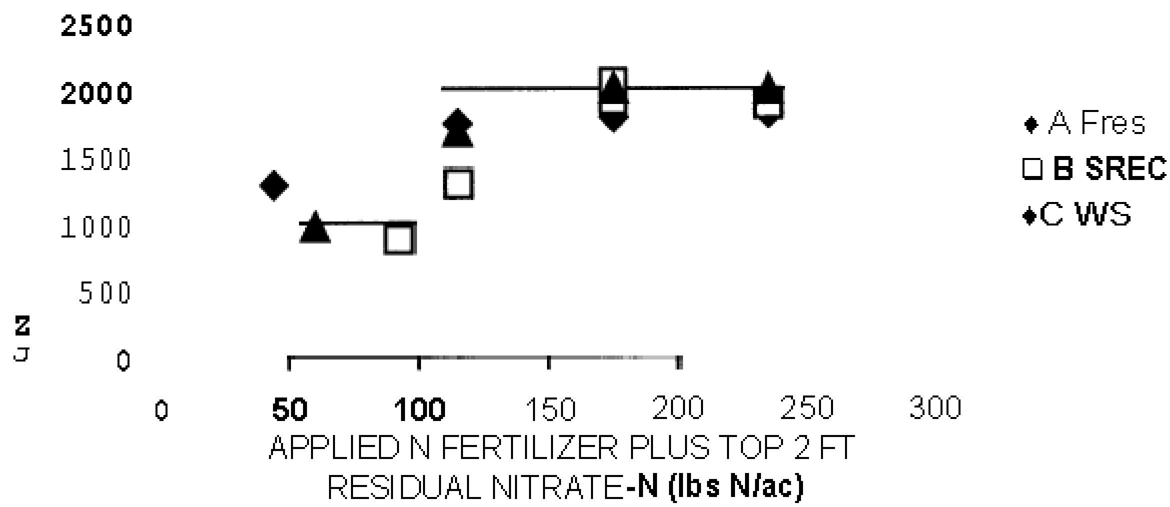


Figure 8. Lint yields at 2002 test **sites as a function** of the sum of applied N fertilizer **plus residual soil nitrate** -N in the upper two feet of the **soil profile.**

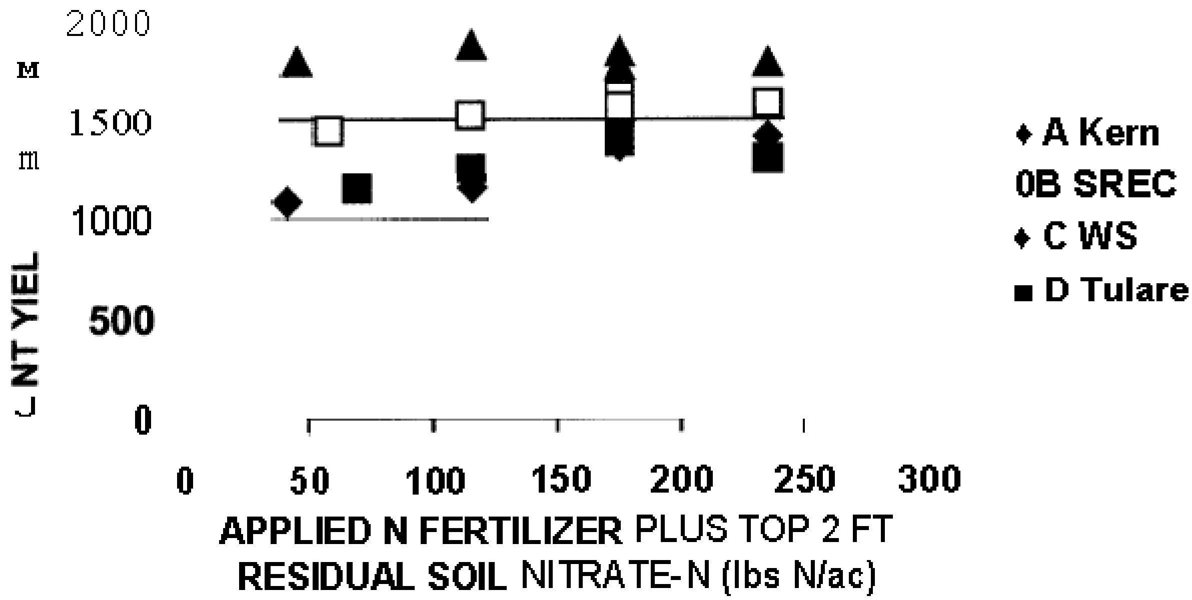


Figure 9. Lint yields at 2003 test sites as a function of the sum of applied N fertilizer plus residual soil nitrate-N in the upper two feet of the soil profile.

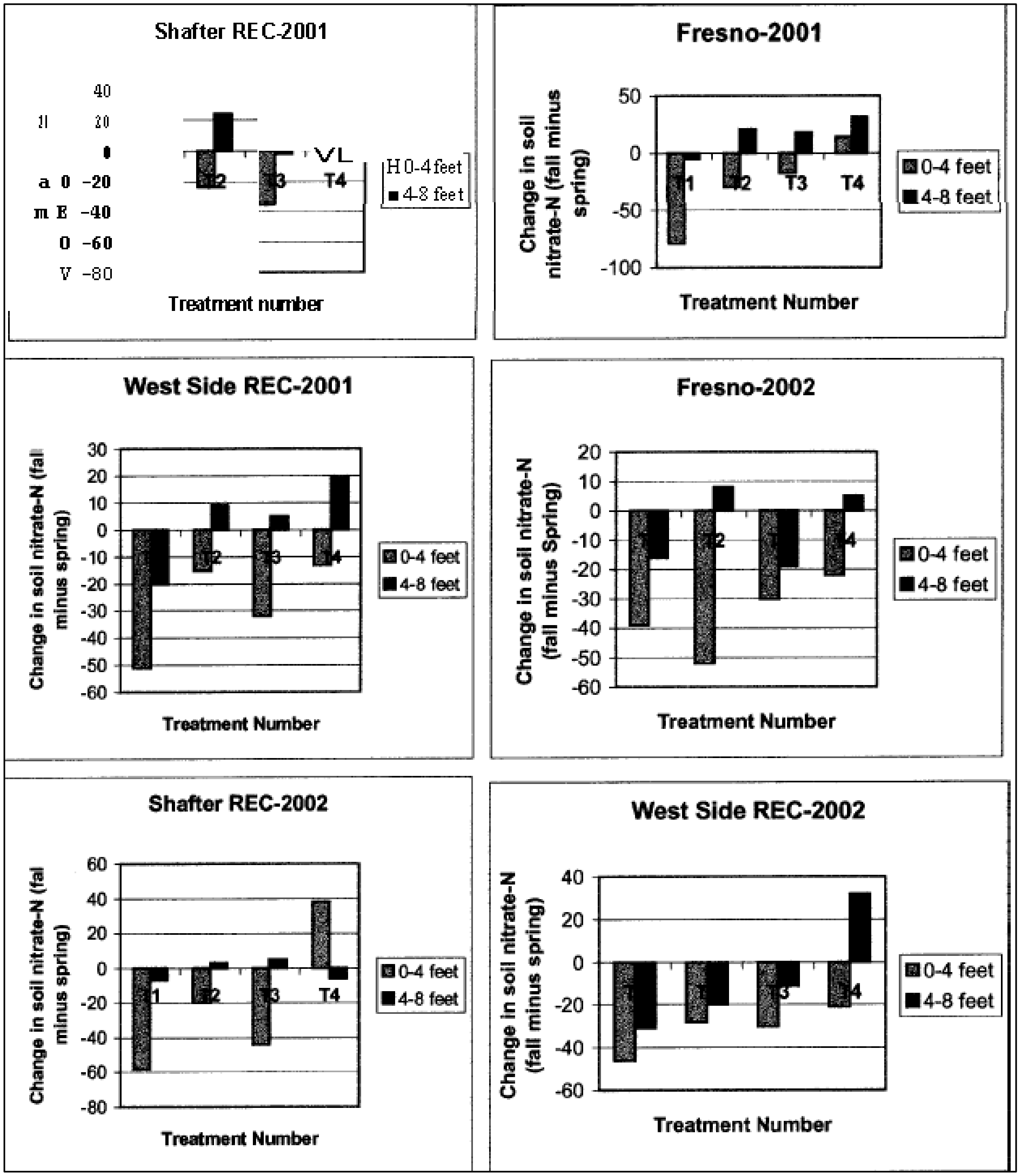


Figure 10. Change in average soil nitrate-N as a function of trial site, treatment number and depth in soil profile (0 to 4 foot versus 4 to 8 foot zone) between spring (post-planting) and fall (post-harvest) soil sampling done on the planting bed shoulder area in sampled fields in 2001 and 2002 at sites shown. Since data is calculated as fall minus spring-time samplings, a negative number (-) indicates net reduction in soil nitrate N between spring and fall, while a plus indicates a net increase in soil nitrate-N in the soil depth range.

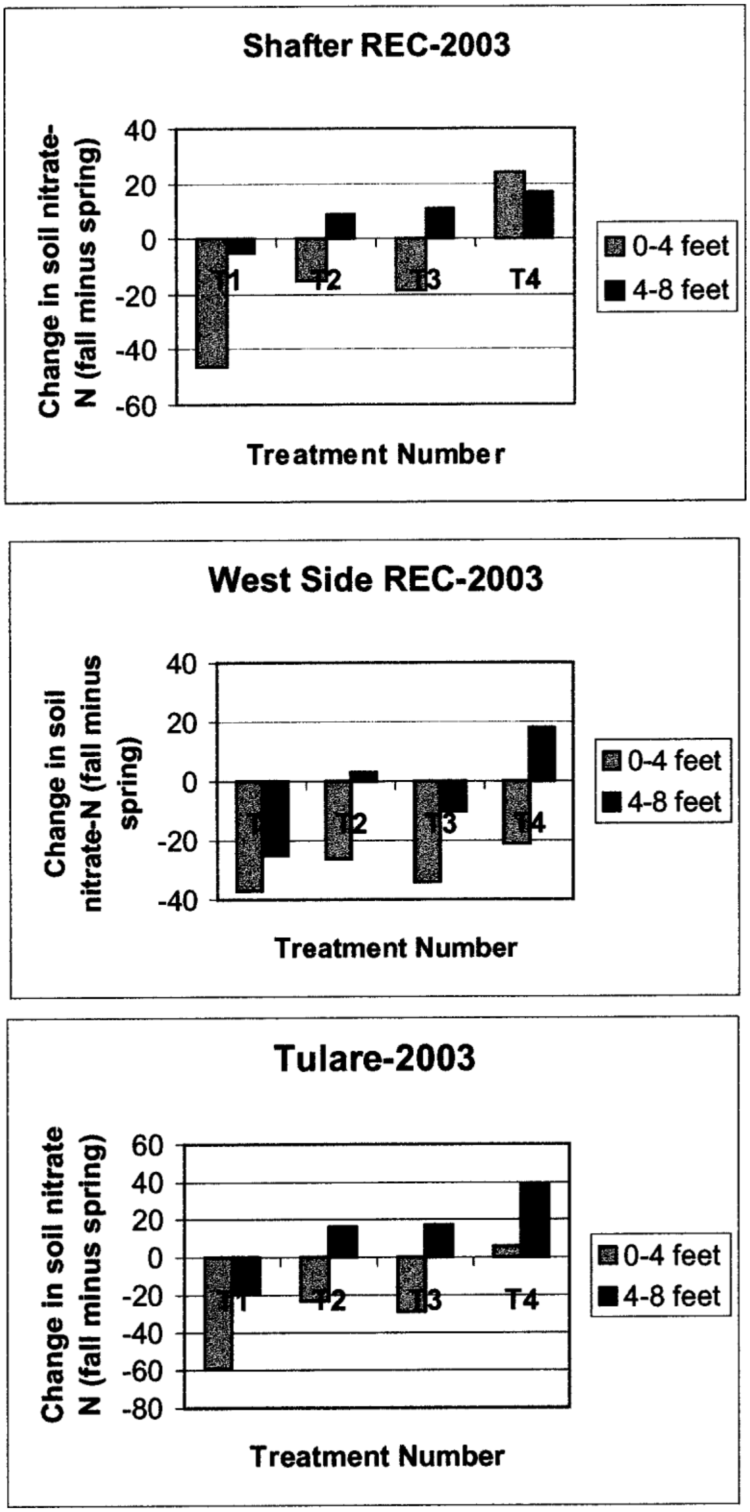
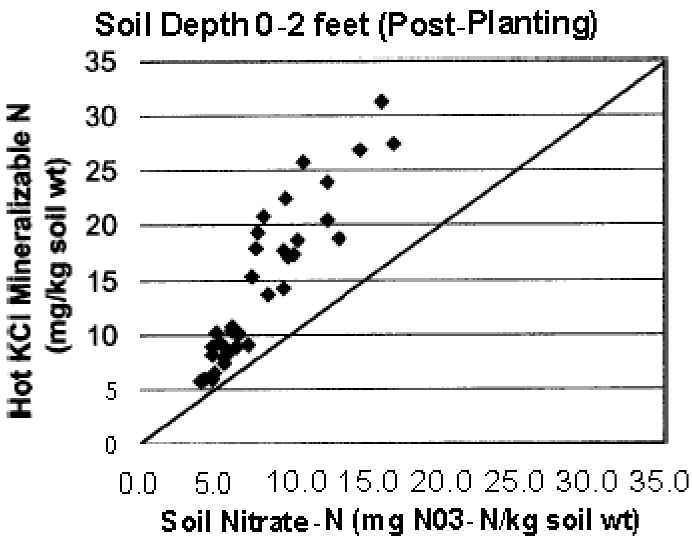


Figure 11. Change in average soil nitrate-N as a function of trial site, treatment number and depth in soil profile (0 to 4 foot versus 4 to 8 foot zone) between spring (post-planting) and fall (post-harvest) soil sampling done on the planting bed shoulder area in sampled fields in 2003 at sites shown . Since data is calculated as fall minus spring-time samplings, a negative number (-) indicates net reduction in soil nitrate N between spring and fall , while a plus indicates a net increase in soil nitrate -N in the soil depth range.



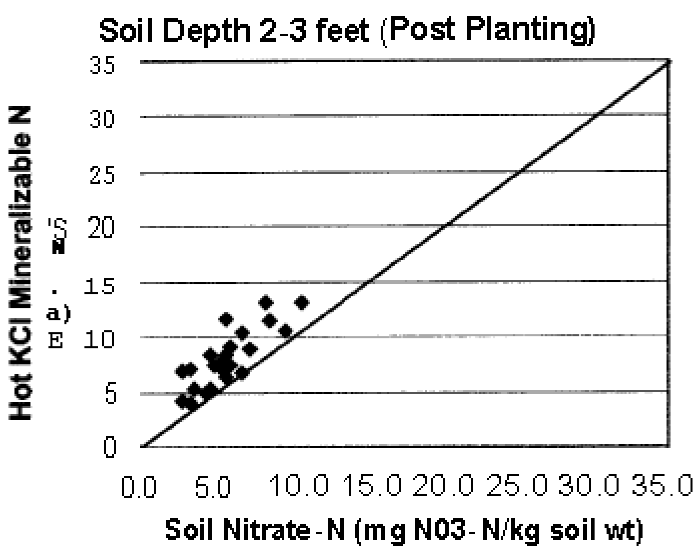


Figure 12. Hot KCI method mineralizable N (three to four field replicate averages at 9 field sites) in the (a) top two feet of soil profile, or (b) third foot of the profile during the post-planting period regressed against soil nitrate-N measurements made at the same time. The 1:1 line is drawn to facilitate observations of the difference in values between the two methods. Three field replicates were measured at all sites in the third foot samples, while four field replicates were sampled at all sites in the first two foot samples.

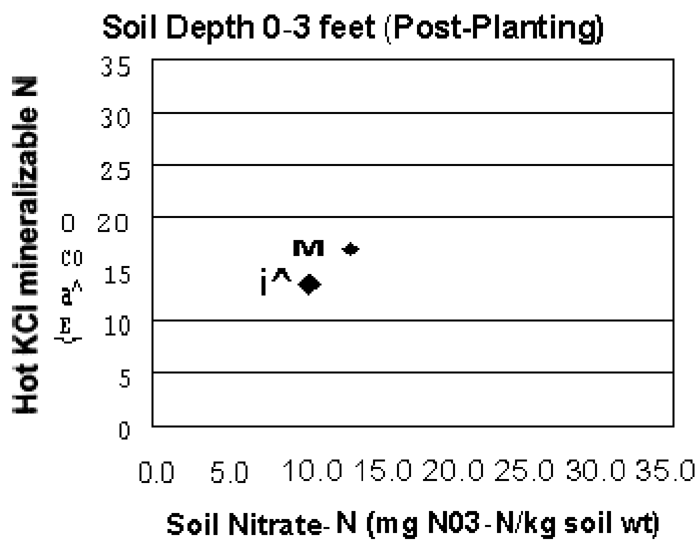


Figure 13. Hot KCl method mineralizable N (three to four field replicate averages at 9 field sites) with all samples within the top three feet during the post planting period regressed against soil nitrate-N measurements made at the same time. The 1:1 line is drawn to facilitate observations of the difference in values between the two methods. Three field replicates were measured at all sites in the third foot samples, while four field replicates were sampled at all sites in the first two foot samples.

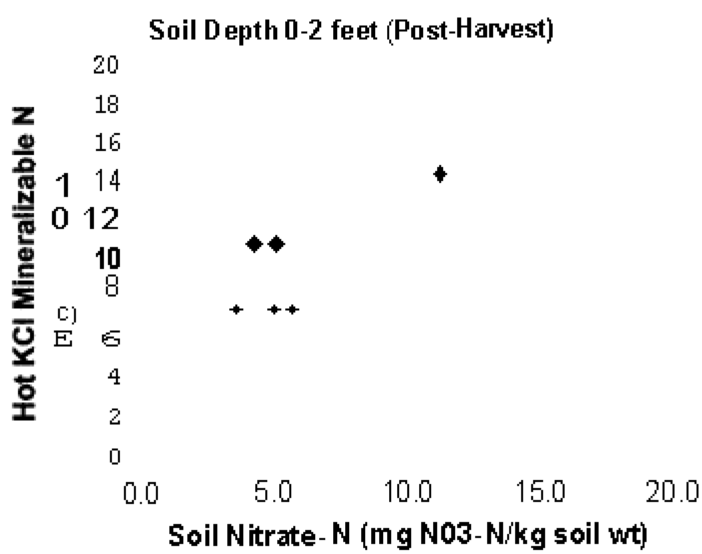


Figure 14. Hot KCl method mineralizable N (three field replicate averages at 9 field sites) with all samples within the top two feet during the post-harvest period regressed against soil nitrate-N measurements made at the same time. The 1:1 line is drawn to facilitate observations of the difference in values between the two methods.