COTTON RESPONSE TO FOLIAR APPLIED UREA AND TRIAZONE NITROGEN IN SOUTH TEXAS

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Abstract

Upland cotton (*Gossypium hirsutum*) requires adequate nitrogen for optimum yields. One method of supplementing soil applied nitrogen is through foliar application. Foliar applications of urea nitrogen have been tried for many years across the cotton belt, but response has been highly variable. No published information has been available regarding nitrogen status indicators for irrigated cotton grown in the Rio Grande Valley of Texas. This study investigated various indicators of cotton N status and response to foliar applied N. Foliar N fertilizers investigated were urea and triazone, a relatively new product originally marketed by Triazone Division Arcadian Corporation for which little information is available for cotton. Studies were conducted for three years at Weslaco, Texas in a factorial treatment arrangement with four levels of soil applied N and three foliar treatments, none, triazone, and urea. In two of the three years, foliar applied urea resulted in a significant increase in seedcotton yield in the absence of soil applied N. There were no other significant differences due to foliar treatment. Foliar applied triazone N was ineffective at increasing seedcotton yields. The trend in all years indicated that foliar applied urea increased yield when plants were N deficient, with the yield increment diminishing as plants approached N sufficiency. Petiole nitrate-N agreed well with established models, but indicated that current models may be slightly low during the prebloom and early bloom period for irrigated cotton in the Rio Grande Valley. Total leaf N indicated that 3.5% N represented a deficient level at any time during the bloom period, and that optimum levels may be closer to 4.0% N. Nodes above white flower (NAWF), height to node ratio, and portable chlorophyll meter readings (SPAD) appeared to have very limited usefulness as N status indicators for this region.

Introduction

Upland cotton requires adequate, but not excessive, N for optimum yield and maturity. Foliar N fertilization is a well known method of supplementing soil N. Much research has shown that cotton will respond to foliar N when plants are N deficient. However, accurately and consistently determining at what point plants will respond to foliar N is difficult. Petiole nitrate-N has been widely used as an N status indicator for many years (Joham, 1951), although optimum levels vary between years and regions (Lutrick, et. al., 1986; Maples, et. al., 1977; Phillips, et. al., 1987). Total leaf N values are usually more stable between years and environments, but are not as sensitive to N status as petiole nitrate-N (Cope, 1984). Due in part to this difficulty in accurately assessing cotton N status, acceptance of foliar N fertilization varies widely among regions and among farmers. No published information is available regarding critical N levels for irrigated cotton in the Rio Grande Valley of Texas. With the semi-tropical, semi-arid environment of the area, it is possible that critical N levels may be different than for other more temperate, humid areas for which criteria have been established.

The effects of N on cotton growth and development are well known. Recent studies have indicated that measurement of plant parameters known to be affected by plant N status may be useful in making N management decisions (Parker, et. al., 1993; Silvertooth, et. al.,1995). Two such parameters are the size of the vegetative shoot, known as 'nodes above white flower', and the height to node ratio. Since plant N status is also known to affect leaf chlorophyll levels, recent studies have also correlated plant N status with chlorophyll levels as measured with a hand-held chlorophyll meter manufactured by Minolta Corp (Edmisten, et. al., 1992). Such plant parameters appear to be correlated with N status in research plots, but their suitability has been investigated in relatively few regions..

Urea has long been the material of choice for foliar N fertilization due primarily to its low osmotic potential. Triazone, a relatively new N containing compound, is also now available as a source of foliar N (Clapp, 1989.). Triazone, also known as S-tetrahydrotriazone, is a heterocyclic N compound with three nitrogens and three carbons in a six membered ring. Studies have shown that potential ammonia volatilization from triazone is very low (Kissel and Cabrera, 1988). However, there is little published information regarding the efficacy of foliar applied triazone.

The objectives of this study were to investigate various indicators of cotton N status and their relation with response to foliar applied urea and triazone N on irrigated cotton under South Texas conditions.

Materials and Methods

Cotton (c.v. D&PL 50) was planted 3-3-93, 3-3-94, and 3-13-95 on research farms of the Texas Agricultural Experiment Station at Weslaco, Texas. Plots were located on the main station on a Hidalgo sandy loam soil in 1993. In 1994 and 1995, plots were located on the annex station farm on a Harlingen clay soil. Prior to planting in 1993, composite soil samples from each replication were taken

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three feet deep in one foot increments and analyzed for residual nitrate-N. In the fall of 1993, corn was grown on the annex site and above ground plant material was removed to deplete the site of residual soil N.

The experimental design was a randomized complete block with factorial treatment arrangement. The two factors were level of soil applied N and type of foliar N fertilizer. Plots were six forty-inch wide rows by 25 feet long. Four levels of soil applied N were 0, 40, 80, and 120 lb./acre. Soil N was applied as urea knifed below the surface on each side of the row. Soil applied N was sidedressed at pin-head square in 1993, and plots were irrigated immediately after application as some root damage was noted. Soil applied N was applied preplant in 1994 and 1995.

Foliar treatments were applied to the center four rows of each plot. Foliar treatments consisted of either an unsprayed check, or four applications of either urea or a triazone-urea formulation beginning at or shortly after first bloom and continuing at weekly intervals. Triazone N was applied as N-SURE® manufactured by Triazone Division Arcadian Corporation. Of the 28% total N in N-SURE®, approximately 67% is in the form of triazone N with 28% as unreacted urea and the remainder as unidentified organic N (Clapp and Parham, 1991). Foliar N applications in 1993 were made at 10 pounds of N per acre per application. Due to a slight foliar burn from triazone, foliar N applications were reduced to 5 pounds of N per acre per application in 1994 and 1995. Total spray volume was 20 gallons per acre.
Petiole samples were collected from the most recently mature leaf in all years beginning near first bloom and continuing at weekly intervals until cutout. Petiole samples were analyzed for nitrate-N by nitrate electrode procedures (Baker and Thompson, 1992). Leaf blade samples were collected simultaneously with petiole samples in 1994 and 1995. Blades were separated from petioles immediately upon sampling. If leaf sampling followed a foliar N application with no rainfall since application, leaf samples were washed for 15 seconds in each of two deionized water baths. Leaf blades were analyzed for total Kjeldahl N by acid digestion (Baker and Thompson, 1992) and auto analyzer procedures (Isaac and Johnson, 1992).

The number of nodes above white flower was counted for ten plants per plot beginning at first bloom and continuing weekly to cutout in 1994 and 1995. Six plants per plot were tagged at first bloom in 1995 and were measured weekly for height and total nodes until cutout. Chlorophyll meter readings were also taken weekly in 1995 using the Minolta® SPAD meter. An average of ten readings was taken on the most recently matured leaves from first bloom until cutout. In all years, seedcotton yield was determined by hand picking the center 20 feet of the two center rows in each plot.

Results

Soil samples taken prior to planting on the main station farm in 1993 averaged 104 pounds of nitrate-N per acre in the upper three feet. Plots on the main station farm in 1993 were unable to be sprayed by airplane, and boll weevil infestations were severe by mid bloom. Late season fruit set was severely limited by the weevil damage that year. In 1993 and 1994 after the third consecutive application of triazone, plants receiving low rates of soil applied N exhibited a slight foliar burn. Plants receiving low preplant N in 1995 exhibited a very slight foliar burn from triazone.

Yield

Yield results are shown in Fig. 1 along with regression trends on mean yields for each foliar treatment. Although the exact relationship between treatments varied somewhat between years, the trend was similar in all years. In the absence of foliar N, yields tended to increase up to the point of sufficient soil applied N, after which there was no further increase. Based on the regression curves, optimum soil applied N was 120, 80, and 40 pounds per acre in 1993, 1994, and 1995, respectively. Foliar applied urea tended to increase seedcotton yields at the lower rates of soil applied N and gave no yield increase at sufficient soil applied N. Foliar applied triazone did not affect yields. No significant differences due to foliar treatment were noted in 1993. In 1994, yields exhibited a classic response to soil applied N and to foliar applied urea (Fig. 1B). At the zero rate of soil applied N, pairwise contrasts indicated that foliar applied urea significantly increased seedcotton yield by 431 pounds per acre (+28.7%) as compared to no foliar treatment ($p = 0.0022$), and by 467 pounds per acre (+31.9%) as compared to triazone ($p = 0.0015$). The yield increase due to foliar urea exhibited a gradual decline as soil N approached sufficiency. In 1995 there was only a limited response to soil applied N, most likely due to high soil N mineralization and a more indeterminate fruit set as a result of beet armyworm pressure. At the zero rate of soil applied N, pairwise contrasts indicated that foliar applied urea significantly increased seedcotton yield by 334 pounds per acre (+15.7%) as compared to no foliar treatment ($p = 0.0169$), and by 283 pounds per acre (+13.0%) as compared to triazone ($p = 0.0323$). The 1995 results are complicated somewhat by the tendency of foliar urea to increase yields at all rates of soil applied N, even though the increase was significant only at the zero rate of soil applied N. Throughout the study, the 40 lb rate of soil applied N together with foliar applied urea resulted in yields that were either the highest or essentially equal to the highest yielding treatment. In 1994 and 1995, when harvest was sequential, the 40 lb soil N plus foliar urea combination also resulted in the greatest amount of early cotton harvested (data not shown).

Petiole Nitrate-N

Results of petiole nitrate analyses are shown in Fig. 2. These means are from plots receiving no foliar N. There was a trend toward increasing petiole nitrate-N in plots receiving foliar triazone, although there were few significant differences due to foliar treatments within soil N and sample date combinations. In all cases, petiole nitrate-N concentrations declined as plants matured. Petiole nitrate-N in 1993 tended to be somewhat variable and fairly high due to high residual soil nitrate-N. Due to the prior depletion of soil N and the heavy early season boll set in 1994, petiole nitrate-N was initially lower and declined rapidly. Little separation of the petiole nitrate-N levels for the three treatments receiving soil applied N was observed in 1995. In all cases, petiole nitrate-N levels for all treatments tended to be similar prior to bloom and again as plants approached cutout, with the greatest degree of separation due to soil N treatments occurring between 5 and 25 days after first bloom.

Total Leaf N

Results of total leaf N analysis for 1994 and 1995 are shown in Fig. 3. Foliar N treatment had no consistent effect on total leaf N levels, so values were averaged across foliar treatments. Total leaf N in 1994 responded to soil N treatment with means well separated on 10, 17, and 24 days after first bloom. On days 3, 38, and 45, values were not as well separated. Based on 1994 results, 3.5% total leaf N would represent a deficient level, with 4.0% or greater being optimum during the mid-bloom period. Total leaf N values in 1995 were similar throughout the season. Levels responded to soil N treatments only on day 24 and later. Even then, 1995 total leaf N levels were not as distinctive with treatment as 1994 levels. Based on the slight yield response in 1995 to increasing soil N from zero to 40 lb/acre, the deficient level for total leaf N appeared to be 3.5%. Total leaf N concentration seemed to be affected by irrigation in 1995. Subsequent to both the first and second irrigations (4 days prior and 11 days after first bloom), total leaf N levels declined for the next sampling period and then increased for the following sampling period.

Physical Plant Parameters

The number of nodes above white flower (NAWF) for 1994 and 1995 is shown in Fig. 4. Foliar N treatment had no effect on NAWF, so values were averaged across foliar treatments. In both years, NAWF tended to be only weakly related to soil applied N and tended to be a late indicator of N deficiency. Patterns of decline in NAWF varied slightly in that the heavy early boll set of 1994 caused a more rapid decline in NAWF, whereas the more indeterminate boll set of 1995 resulted in a more gradual decline in NAWF. Height to node ratios in 1995 were very similar through the bloom period (data not shown). The range of ratio means for individual soil N by sample date combinations was from 1.46 to 1.66 inches.

Chlorophyll Meter Readings (SPAD)

SPAD results for 1995 are shown in Fig. 5. Foliar N treatment had no effect on SPAD readings, and values were therefore averaged across foliar treatments. SPAD readings showed little separation due to soil N treatment until 31 and 38 days after first bloom. Irrigation appeared to have a large effect on SPAD readings, as the drop in SPAD readings from the first to the second sampling was preceded by irrigation. At the second sampling date, plants had visibly responded to the irrigation with a flush of pale, new growth in the terminal, and SPAD readings were correspondingly lower.

Critical Petiole Nitrate-N Levels for Foliar N Fertilization

Analysis of critical petiole nitrate-N levels for foliar N fertilization is considered for urea application only, as foliar application of triazone did not affect yields. In this analysis, definition of critical petiole nitrate-N levels for purposes of foliar N fertilization was based on an economic response as indicated by the yield regressions for the individual years. Regressions were depicted in Fig. 1, and values for the regression parameters are given in Table 1. Net prices of cotton after harvesting and ginning, were estimated at 47, 68, and 64 cents per pound of lint for 1993, 1994, and 1995 marketing years (Anderson, 1995). Turnout was estimated to be 38% for the handpicked cotton in this study. The cost for urea was approximated at $250 per ton, or 27 cents per pound of N. The cost of application was based on typical custom rates of $3.50 per acre. Based on the above assumptions and regression equations, an economic response to foliar applied urea would have occurred in 1993 at the zero rate of soil applied N, in 1994 at the zero and 40 lb/acre rates of soil applied N, and in 1995 at all rates of soil applied N. Fig. 6 shows as solid dots all petiole nitrate-N levels corresponding to year by soil N combinations which, based on the yield regressions, not only responded to foliar urea, but also represented less than optimum soil N for the year. Open circles represent year by soil N combinations which either did not indicate a response to urea or represented optimum or greater soil N. A clear boundary was observed to day 24 between sufficient and deficient levels. Based on this study, irrigated cotton in the Rio Grande Valley with petiole nitrate-N levels falling in the area represented by the solid dots would be likely to respond favorably to foliar application of urea. This critical level for foliar N is represented in Fig. 7 by the regression equation: Critical Pet.NO3N (ppm/1000) = $14.61 - 0.611(\text{day}) + 0.007(\text{day})^2$, between five days prior to bloom and 45 days after bloom. This equation should not be extrapolated beyond the range of this data.

Conclusions

Foliar applied urea increased seedcotton yields when plants were deficient in N, but foliar applied triazone was ineffective at increasing seedcotton yields. Foliar urea resulted in a yield increase which was dependent on the degree of N deficiency of the plants. As plants approached sufficient N, the yield increase diminished. Critical petiole nitrate-N levels agreed fairly well with established models, with the exception that levels in this study were higher during the prebloom and early bloom period. For irrigated cotton in the Rio Grande Valley, petiole nitrate-N levels at first bloom, and 10, 20, and 30 days later should be 15000 , 9000 , 5000 ,and 2500 ppm or greater, respectively. Plants below this level would likely respond to foliar application of urea. Total leaf N should be above 3.5% throughout the bloom period. Nodes above white flower and height to node ratio appeared to be more useful as indicators of overall plant vigor than for indicating N status. Chlorophyll meter readings did not appear to be a reliable indicator of cotton N status.

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Table 1. Parameters for regression of yield on soil applied N for individual year by foliar combinations.

Year	Foliar	Intercept	Soil N	$(Soil\ N)^2$	r^2
1993	None	1877	10.32	-0.04	.9442
1993	Triazone	1983	3.93	-0.01	.9979
1993	Urea	2123	5.91	-0.03	.5527
1994	None	1514	16.91	-0.10	.9898
1994	Triazone	1466	16.83	-0.10	.9999
1994	Urea	1939	8.51	-0.06	.9799
1995	None	2139	5.58	-0.04	.7504
1995	Triazone	2159	3.43	-0.02	.7612
1995	Urea	2470	1.03	-0.01	.2480

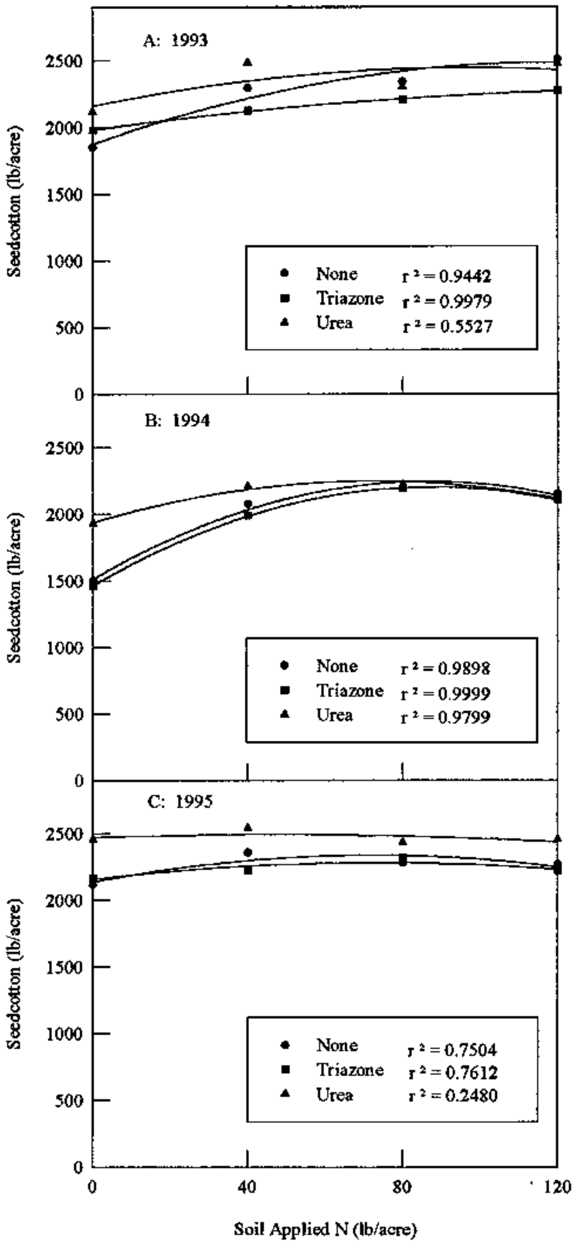

Fig. 1 Effect of soil applied N on seedcotton yield.

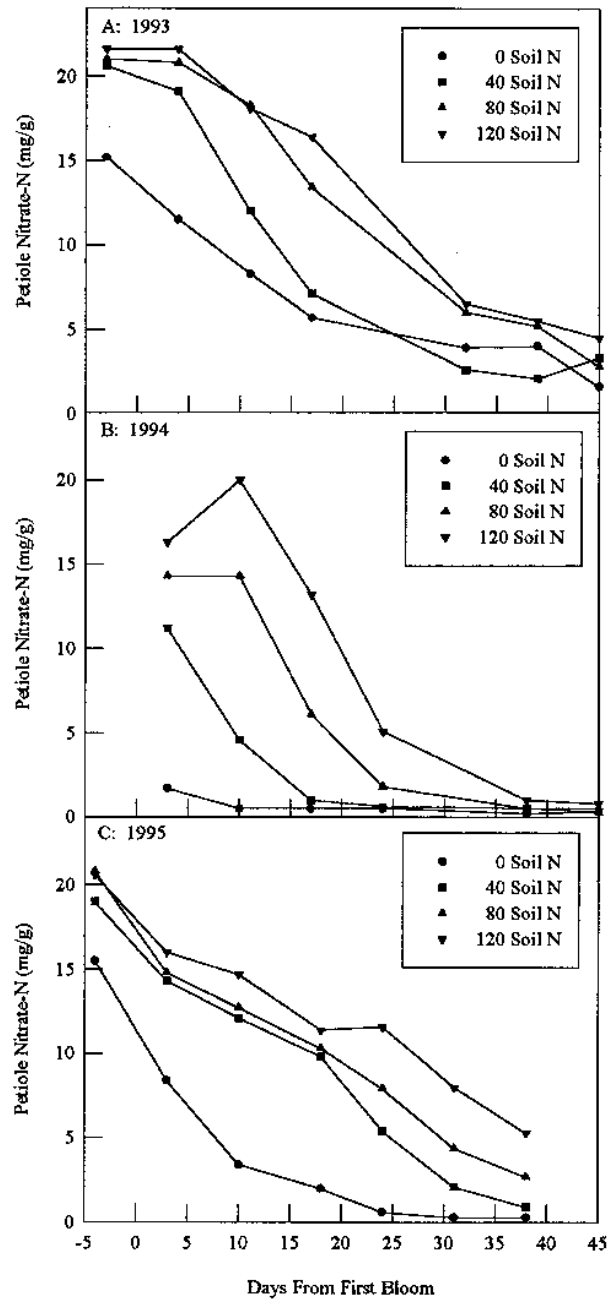

Fig. 2 Petiole nitrate-N as affected by days after first bloom.

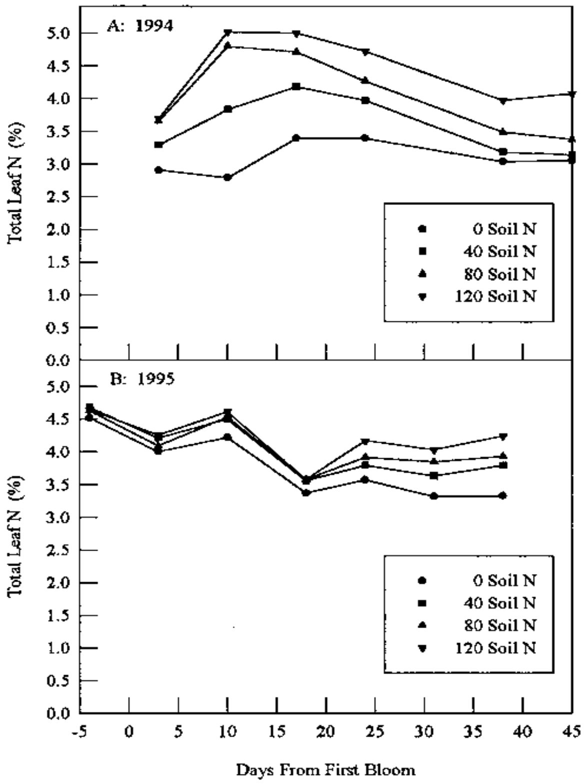

Fig. 3 Total leaf N as affected by days after first bloom.

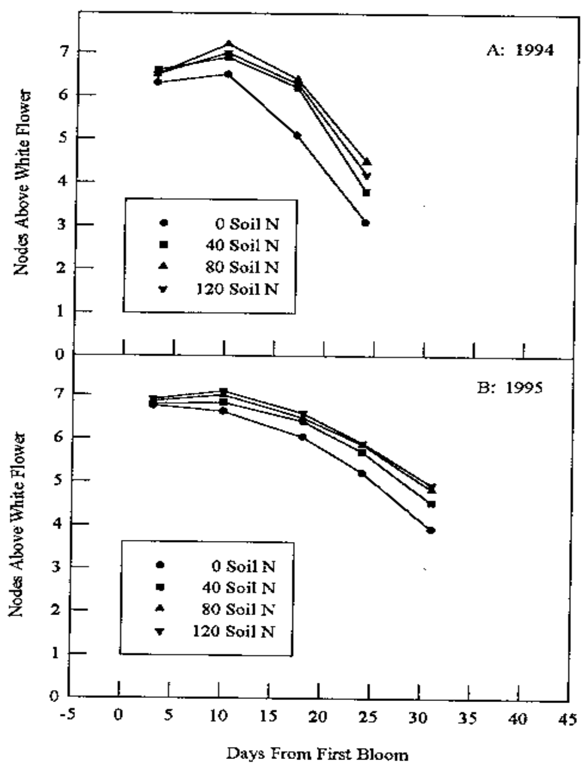

Fig. 4 Nodes above white flower as affected by days after first bloom.

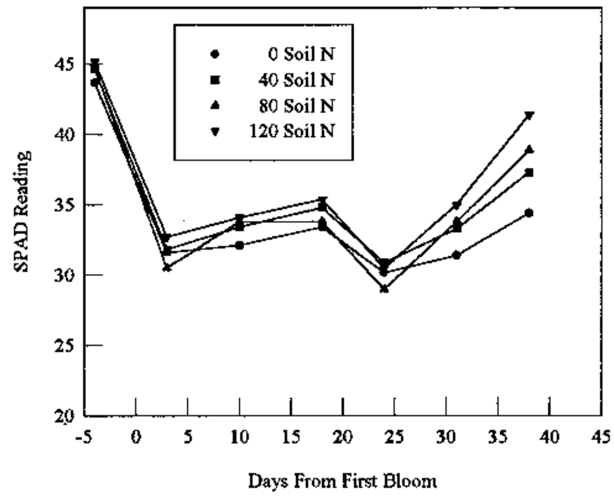

Fig. 5 Chlorophyll meter reading as affected by days after first bloom.

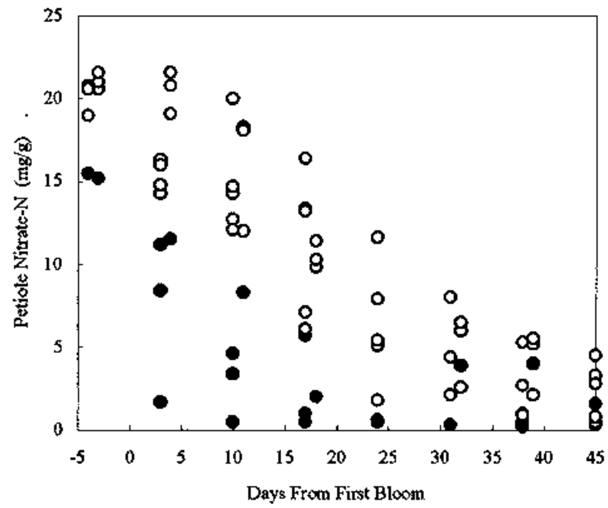

Fig. 6 Three Year Petiole Nitrate-N Summary. Solid = less than optimum soil N plus economic response to foliar urea. Open = optimum or greater soil N or no economic response to foliar urea.

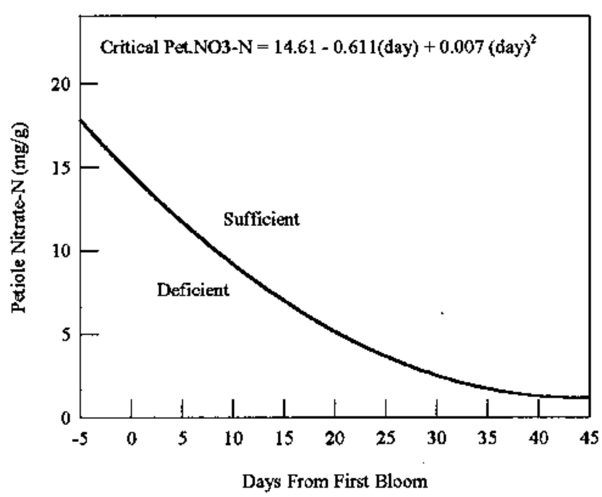

Fig. 7. Critical petiole nitrate-N levels for economic yield response as affected by days after first bloom.