# FIELD VALIDATION OF VARIABLE RATE NITROGEN APPLICATIONS IN CALIFORNIA

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## Introduction

Precision agriculture practices are becoming more accessible to California growers through the expanded use of equipment guidance and delivery systems that are synchronized with GPS technologies. This technology has led to application practices that have specific utility to the Far West. The largest use of this technology is currently in the application of soil amendments for salinity management and reclamation. This is largely the result of new equipment that provides more efficient field scale evaluations of soil salinity and other physical characteristics. Advances made in the development of a more accurate yield monitor and the availability of other crop status indicators from remote sensing has also expanded the utility of this technology for California.

The uses of precision applications have shown the potential for reducing input cost for other cultural practices necessary in California cotton production (Taylor et al.). The major objectives of this study were to field test this technology for precision N applications. Therefore, a field trial was established to validate the use of variable rate nitrogen (N) applications on lint yields and reducing production input cost. The trial was also designed to field test recently developed N guidelines for San Joaquin Valley cotton production. An additional objective was to create variations in field N levels for remote sensing of canopy N status during the 2001 Ag 2020 production season.

## Methods

The field trial was located in a 152-acre field on Sheely Farms, Lemoore, CA. The soil was a Lethent silty clay. The field (8-2) had been monitored during the 2000 production season as part of the AG 2020 remote sensing project being conducted on Sheely Farms. The previous crop (2000) was pima cotton and tomatoes during the 1999 season. As a result, maps from the 2000 season were available to develop management zones for field 8-2. The zone map was created from combining a normal difference vigor index (NDVI) map and the 2000 field yield map (Agri-Plan). The combination of these maps showed distinct productivity zones (Figure 1) in field 8-2. Representative sites from each zone were selected and soil samples collected for analysis (Table 1). The variable N rates were determined from the residual N in the surface 2 feet of soil. Liquid urea (UN-32) was sidedress applied on June 6 and 7, 2001 prior to the first furrow irrigation. Application rates were calculated to meet an application total of 140 lbs N per acre (50 % of residue plus applied, Table 1). This was the amount being uniformly applied as the standard treatment. A standard tool bar was used to inject the fertilizer. A Raven Application Management System and Raven (440) Controller were used to apply and monitor the liquid fertilizer. The guidance system (GPS) for position coordination with specific variable applications was provided by BEELINE Technologies.

The trial was established as a replicated complete block design with 5 main treatments (N rates) and 4 replications. Plots widths were 16 rows and ran the entire length of the field. Each calculated zone rate (red, green and blue) was applied uniformly as treatments (1, 2 and 3, respectively). This allowed comparison between rates and also individual rate comparisons to the uniform standard (No. 4) and the actual variable rate treatment (No. 5). Treatment No. 5 was the only treatment actually applied according to the zone map and GPS location. Estimates of fertilizer savings were based on the total fertilizer that would have been applied using the application map (Figure 1) to a uniform application across the entire 152 acres. Standard analysis of variance was performed on final lint yields. The variety planted was Phytogen 72. Petiole samples were collected at first bloom (FB, 6/26/2001), first bloom plus 3 weeks (FB+3, 7/19/2001) and at cutout (8/7/2001). Petiole analysis was performed by the U.C. DANR Analytical Laboratory, Davis, CA. Harvest was with a John Deere 4-row spindle machine equipped with an Agri-Plan yield monitor. The center 8 rows of each 16-row plot were harvested. This allowed for a 4-row buffer on each side of the harvest area. Plot weights were recorded with the yield monitor and full plot

weights verified with a boll buggy scale. Sub-samples were collected at harvest for gin turnouts. The samples were ginned at the UC Shafter Research and Extension Center gin. Final lint yields were based on the correction of seed cotton plot yields with actual gin turnouts. Post-season soil samples were collected and are being analyzed (data not presented).

## Results and Discussion

The major differences in the defined zones of Field 8-2 were due to salinity levels (Table 1). The soil Ece values ranged from highs of 9 in the Red zone to values of 2-3 for the Blue zone. The NDVI map corresponded to similar differences in the 2000 crop vigor for these areas of the field. Even though cotton is considered a more salt tolerant crop, soil Ece values of 8 and above are reported to cause reductions of potential yield of 10 to 15 percent (Agriculture Handbook No. 60). Uniform fertilization across these affected areas over time contributed to the high residue N found in the soil profile associated with the higher salinity.

The field recommendation was to receive 140 lbs. N per acre uniformly across the 152 acres. This recommendation is consistent with current UC guidelines (Hake et al, and Weir et al, 1996). The established zone N rates were compared to the standard uniform application and the treatment (No. 5) receiving varying N applications according to the zone maps.

Standard N practices for San Joaquin Valley cotton begins with a sidedress application prior to the first irrigation. This is often supplemented with mid-season water-run applications and/or a foliar application after cutout. The supplemental additions are based on mid-season crop assessments of petiole N values, actual boll loads and seasonal outlooks. Fields with high yield potential usually justifies the additional N. For years or fields with less yield potential (short season, late planting or heavy pest pressure etc.) the general recommendations are to not apply additional N. Field 8-2 received additional water run N fertilizer. Supplemental N was applied uniformly across all treatments in three mid-season irrigations. The water-run applications of ammonia added approximately 111 additional pounds N to the sidedress treatments. The total N applied varied from 153 to 251 lbs. per acre within the established treatments. The main treatment differences were the N rates established with the sidedress application.

The petiole analysis by sample date is presented in Table 2. The results show variation is petiole N level between the treatments on the first bloom sampling. The apparent trend of the first sampling was reversed by the second sampling on July 19. The trend in petiole N values of the first sampling reflects the higher residual soil N levels of the lower sidedress applied rates. By the second sampling, the higher sidedress treatment (No. 4) had the highest petiole N value. All treatment means were above the minimum petiole value established by the current UC guidelines (Bassett and MacKenzie 1983). At cutout, August 7, all treatments except the highest N rate (No. 4) was below the minimum value recommended. The lower petiole values at cutout were not associated with differences in final lint yields.

Final lint yields are presented in Table 3. The average of all 5 treatments was 1725 lbs. lint per acre. Although total applied N ranged from the true variable applied rate up to 250 lbs. N per acre, there was no significant difference in final lint yields between the N treatments. Due to the high residual soil N at this site, there should have been an additional treatment of a true check without any added fertilizer. It was thought that the lowest N rate (42 lbs./a) would serve as a check but this treatment was offset from the additional water-run applied N.

Estimates of fertilizer savings are based on what would have been applied across the entire acreage with a uniform application to what would have been applied according to the zone application map and established zone rates (Table 4). This information is available from the zone map where each zone has a calculated acreage (Figure 1). Using a unit price of $93.00 per ton of UN-32 and calculating the price per acre according to the target application rates, the price comparison shows a saving in sidedress fertilizer cost of 52 percent.

## Conclusions

The application of variable rate application technology using a zone management approach reduced sidedress applied fertilizer nitrogen by 52 percent. Prebloom and mid-season petiole nitrate values were sufficient and provided information on mid-season adjustments for supplemental nitrogen management decisions. At this site, variable rate technology using zone management fertilizer applications produced as well as standard uniform practices.

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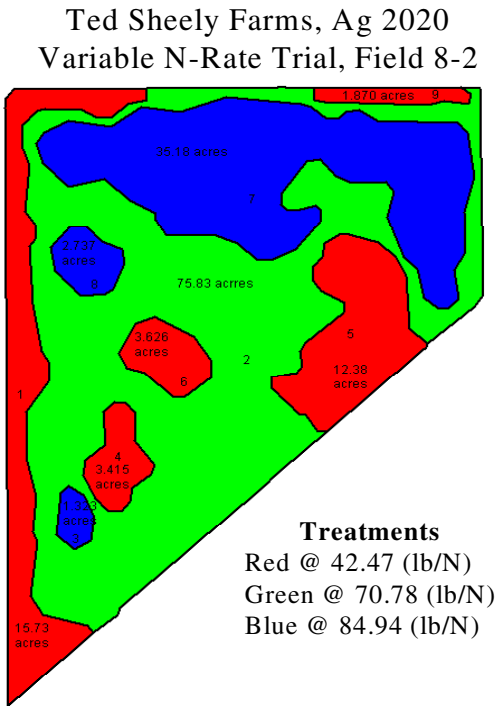


Figure 1. Zone map of Field 8-2, Sheely Farms, Lemoore, CA, 2001.

Table 1. Soil analysis of Field Management Zones for Field 8-2, and recommended N rates based on residual soil N. Variable N-Rate Trial, 2001.

| Treatments: Zones | Ece (dS/m) | Residual N* (lbs/a) | Sidedress N Applied (lbs/a) |
|---|---|---|---|
| 1) Red | 7-9 | 109 | 42 |
| 2) Green | 3-4 | 83 | 70 |
| 3) Blue | 2-3 | 70 | 85 |

*50% of $NO_3$-N reported in top 2 feet.

Table 2. Petiole analysis for $NO_3$-N (ppm) Variable N-Rate Trial 2001.

| Treatments | Sidedress N applied (lbs/a) | Sample Dates 6-26-01 | 7-19-01 | 8-7-01 |
|---|---|---|---|---|
| 1) Red | 42 | 12887 a | 8111 bc | 2267 c |
| 2) Green | 70 | 12405 a | 7742 c | 2620 bc |
| 3) Blue | 85 | 11362 ab | 9075 bc | 2997 ab |
| 4) Uniform | 140 | 9633 b | 10671 a | 3462 a |
| 5) Variable | by zone | 11298 ab | 9411 ab | 2577 bc |
| ANOVA | | | | |
| p. | | 0.022 | 0.0058 | 0.0137 |
| CV %) | | 10.51 | 10.25 | 14.82 |
| LSD (0.05) | | 1865 | 1422 | 636 |

Values are means of four replications. P is for statistical probability. Means separations performed with a Fisher protected LSD. Means followed by same letter are not significantly different at the 0.05 level.

Table 3. Lint Yields for Variable N-Rates, Sheely Farms, Lemoore, CA 2001. Cotton variety: Phytogen 72 (SJV Approved Acala )

| Treatments | Sidedress N Applied (lbs/a) | Total N Applied* | Lint Yield (lbs/a) |
|---|---|---|---|
| 1) Red | 42 | 153 | 1741 |
| 2) Green | 70 | 181 | 1722 |
| 3) Blue | 85 | 196 | 1704 |
| 4) Uniform application | 140 | 251 | 1703 |
| 5) Variable rates from field zone map | + | 111 | 1754 |
| **ANOVA** | | | NS |
| CV (%) | | | 3.74 |

NS: Not significant (p. 0.05).

Include the variable rate sidedress application plus the 111 pounds applied as water-run N (anhydrous ammonia).

Table 4. Fertilizer cost comparison for variable zone application to a uniform application. Calculations based on unit cost of $93 per ton of UN-32.

| Treatment | Fertilizer Cost for 152 Acres Total Cost |
|---|---|
| Uniform Application @ (140 lbs. N/a) | $ 6509 |
| Variable Rates and Zone applications | $ 3106 |
| Savings of: 52 % | |