# USE OF YIELD MONITOR TO EVALUATE SITE SPECIFIC MANAGEMENT IN RECLAMATION OF A SALT AFFECTED COTTON FIELD

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## Abstract

The tendency of saline and sodic conditions to occur in patches makes soil reclamation and ideal practice on which to apply site-specific management (SSM). Site-specific management, also called precision agriculture, is the management of an agricultural crop at a spatial scale smaller than that of the individual field (Plant et al., 2000). The principle behind SSM is that in many fields the crop's environment varies substantially from one part of the field to another. By adjusting management practices and input levels according to what is appropriate for local conditions the farmer can in principle save money, improve yield, and reduce unwanted environmental effects. The primary object of this study is to evaluate the effect of variable rate application of soil amendments on a cotton field having saline-sodic soil conditions. To aid in this evaluation, yield monitors mounted on commercial pickers were used to rapidly measure and geo-reference yield observations.

## Introduction

A major problem with fully irrigated agricultural production systems is the gradual accumulation of soil salinity. Although some salinity is inherently present in the soil, the primary cause of salinization is the importation of salts in irrigation water. In arid and semi-arid areas where rainfall is insufficient to leach salts from the soil, this salt will gradually accumulate (Richards, 1954). Approximately 4.5 million acres of irrigated cropland in California, primarily on the west side of the San Joaquin Valley, are affected by saline soils or irrigation water (Letey, 2000).

Managing soil salinity involves several aspects, of which two of the most important are disposing of saline drainage water and reclaiming fields whose productivity is limited by salinity. This second problem of land reclamation is the component addressed in this study. Crop response to the osmotic and toxic effects of soil salinity varies by species. Tolerance also depends on the time of the season. Cotton is relatively sensitive to salinity at emergence due to effects on the soil structure, but is less sensitive once the plant is established (Hake et al, 1996).

The most appropriate reclamation procedure depends on the nature of the ionic chemistry affecting the soil. Salt affected soils are traditionally divided into three broad categories depending on the extent to which they are saline or sodic (also called alkali) (Richards, 1954). These categories are based upon the electrical conductivity of the saturation paste extract, denoted $EC_e$, exchangeable sodium percentage (ESP), and pH (Richards, 1954). Establishing adequate drainage and providing adequate low sodium water to leach the salts from the system may reclaim saline soils, but saline-sodic and sodic soils need the application of appropriate amendments to aid in reclamation (Richards, 1954).

The desired effect of the amendments is a cation exchange of calcium for sodium so that low sodium water can be used to leach the exchanged sodium. Therefore the amendments must supply calcium, either directly or indirectly. The most effective and economic means of doing this depends on the soil chemistry. If the soil is low in carbonate, then the calcium must be supplied directly. The most common amendment in this condition is gypsum, although in some cases (generally those of low pH), lime may also be used. If the soil has sufficient calcium carbonate, then this may be used as a source of the calcium. In this case, sulfuric acid may be applied. It reacts with calcium carbonate to form gypsum, which then supplies exchangeable calcium. Alternatively, sulfur may be applied. This forms sulfuric acid in the soil through microbial actions, and the sulfuric acid in turn reacts to form gypsum. Because of the need to remove salts through leaching, the salinity properties of the soil and the nature of the reclamation are highly affected by the field drainage and water table.

The tendency of saline and sodic conditions to occur in patches makes soil reclamation an ideal practice for which to apply site-specific management (SSM). Site-specific management, also called precision agriculture, is the management of an agricultural crop at a spatial scale smaller than that of the individual field (Plant et al., 2000). Yield monitors can aid in implementing SSM by providing a measure of the effectiveness of the varying cropping inputs according to the spatial patterns seen in the crop product yield. The principle behind SSM is that in many fields the crop's environment varies substantially from one part of the field to another. By adjusting management practices and input levels according to what is appropriate for local conditions the farmer can in principle save money, improve yield, and reduce unwanted environmental effects.

## Materials and Methods

Research was conducted in a commercial cotton field located near Lemoore in the San Joaquin Valley, California (Sheely Farms). The field was a standard quarter section, measuring approximately 2600 ft. on a side (160 acres). Preliminary research was carried out in 2000 to establish the pattern of soil salinity and to determine a prescription for variable rate amendment application. 195 preliminary georegistered EM-38 horizontal and vertical survey readings were collected in 2000 from the field in a regular grid. The ESAP-95 program (Lesch et al., 2000) was used to process the EM–38 survey data and generate sampling plans for soil core extraction. The algorithm in this program selects a limited set of calibration sites with desirable spatial and statistical characteristics by combining survey site location information with response surface design techniques (Lesch et al., 1995, Lesch et al., 2000,). Twelve (12) optimal sampling locations were identified for this field using this program. Soil samples were then collected from each site at 0-1, 1-2, 2-3 foot intervals (Taylor and Lesch, 2000). A commercial laboratory then analyzed the soil samples for $EC_e$ $Ca^{++}$ , $Mg^{++}$, $Na^+$ SAR, and B from a saturation paste extract. The EM38 and soil data were used to determine the salinity status of the entire field. The ESAP-95 program was used to produce a prescription map. This prescription map was used in identify the locations within the field where to apply the amendments used in this experiment. The amendment quantities for the experimental area within the field were calculated based on achieving an SAR value of 5 (Horney et al, 2001).

The experimental area was selected based on the observed variable SAR and $EC_e$ values. These two parameters had greater values located at the north end of the field, with a decreasing trend and then increasing again towards the south (Fig 3.). The experiment design for this field was laid out as a randomized complete block with four blocks and five treatments. Each plot consisted of 8 rows of 38" beds. The treatments consisted of the following:

1. A uniform 6 tons /acre application rate of gypsum (50%).
2. Variable gypsum (50%) application rate. Each variable gypsum rate plot was separated into four zones. The applied rates range from 12 to 18 tons / acre (50% gypsum) in each zone,
3. A uniform application rate of 1000 lbs/acre of sulfuric acid was applied,
4. A variable rate application of sulfuric acid with four zones of application 2000 lbs in one zone and 3000 lbs in another. The ESAP-95 (RSSD) program (Lesch et al., 2000), was used to determine the zones for each variable plot.
5. A control with no amendment applied.

Multiple samples from the supplied gypsum used were analysis to determine the content of the actual $CaS0_4$-2 $H_2O$ applied.

A modified irrigation schedule and uniform water source were used during this experiment in an attempt to maximize the establishment rate of the cotton. The idea behind this was that it would give a better evaluation of the cotton's yield response to the soil amendments. Westlands district water was used for all irrigation; no tail water from other fields was used in the 2001-growing season. Some of tail water from a field directly to the north had been blended with well water or Westlands district water during the 2000- growing season. The irrigation schedule included sprinkler irrigation for the initial two irrigation dates, with the remaining irrigation dates being furrow irrigated. This modified irrigation schedule was based partly on the observation that initial sprinkler irrigation aids in stand establishment (Rhoades et al., 1997, Hake et al, 1996, and Horney et al., 2001). Water samples were collected from each irrigation and analyzed to determine its agricultural suitability. The agricultural suitability was evaluated based on method described by Blaine Hanson and Stephen Grattan (1993).

Soil samples were collected within the study after the amendments had been applied. The sampling scheme was based on a systematic grid pattern (Fig 5). Yields for the entire field were collected and determined by yield monitors mounted on a commercial picker for the years of 2000 and 2001. Not all the pickers in 2000 were equipped with a yield monitor, thus some of the 2000 data for this field is missing, including approx. 25% of the study area. Because of this, a yield comparison for the two years was not evaluated in this study. Each yield monitor was calibrated by harvesting 6-(38") rows. The yield monitor values were then compared to a buggy weight. A correction coefficient was then entered into the monitor software to correct for the difference between the two. After the initial calibration the yield monitor was not adjusted during the remainder of the harvesting. The 2001 yield data within the experimental area was collected from the middle four rows of each plot.

Statistical computations of effects due to the various soil amendment treatments were made using the PROC GLM procedure of SAS Version 8.0 software. Significance was determined using Dunnett's and Tukey's tests.

## Results

Fig 1 shows the bulk soil salinity pattern as determined by the EM-38 sampling, and Fig. 2 shows the resulting soil core extraction pattern determined by the ESAP-95 program. Table 1 shows the results of soil core analysis. These analysis results and the EM-38 data were then used in the ESAP-95 program to estimate the soil $EC_e$ level as shown in Fig. 3. The resulting ESAP-95 program recommended gypsum application rate is shown in Fig. 4; the recommended $H_2SO_4$ application rate has the same pattern but different rates. Fig. 5 shows the resulting layout of the replicated amendment experiment.

Analysis of gypsum samples indicated a mean gypsum content of 60.8 percent dry weight with a standard deviation of 2.4 percent. Fig. 6 shows the locations of soil sample sites within the experimental area. Table 2 gives the results of soil analysis of cores extracted from these locations.

Plant establishment was determined at the sample sites shown in Fig. 2, three of which fell within the experimental plot of Fig. 5. Stand ranged from 58,500 to 65,900 plants per acre at these sites. Irrigation water analysis indicated an improvement in water quality in 2001 over that of 2000. For example, mean adjusted SAR was 6.4 in 2000 and 3.3 in 2001.

Table 3 contains a comparison of total plot yield as measured by the yield monitor and the boll buggy for each experimental plot. Yield monitor weight of plots 1 through 14 are all within 10% of boll buggy weight, whereas yield monitor weight for plots 15 through 20 are an average of 129% of boll buggy weight. These plots were the first to be harvested, and we believe that this discrepancy results from incorrect calibration.

In statistical analysis of plot yield, Dunnett's test was used for comparisons of all treatments against a control. The Tukey test was used for a pair-wise comparison of the means. Because we did not see any interaction the main effects were analyzed (Table 4). Both test showed no significant difference among the treatments, but a trend of increasing yield with the variable rate application of the sulfuric acid (treatment 4) and the variable rate of gypsum as compared with treatment 5 (control).

In reviewing the yield monitor data we discovered that some of the plots included areas outside the trial area and some plots had multiple data entries at the same location within the plot. We standardized the yield monitor data in an attempt to reduce the significance difference seen in block four. The multiple data reading were determined to be associated with the monitor sensor having to be cleaned during the harvesting. The multiple entries showed a velocity of less than 1 MPH and a total weight of less than 5. Data values meeting either of these criteria were eliminated.

Because of increase in seed weight yield as measured by the yield monitor over the last 6 plots observation a Tukey analysis was performed on this data set to determine if this increase was significant. The Tukey analysis did show a significant difference with block four (Table 5), and although reduced, the same trend of increasing yield is seen with the variable rate application of sulfuric acid and the variable rate application of gypsum.

The averaging of the entire plots might be masking potential beneficial affects seen from the variable rate treatments. The yield/acre average for each treatment zone after adjusting blocks 4 by the buggy weight factor of 1.29 to take into account the presumed calibration error gave the results shown in Table 6. In this table the yields are separated by zone of variable rate application as shown in Fig. 5.

## Discussion

Although the treatments were not statistically significant, the primary yield trend in the experiment was due to the use of the variable rate application of sulfuric acid, treatment 4 in Table 6. There was however, a significant difference between the two northern zones (#1 and #2) as compared to the two southern zones (#3 and #4) Table #12. This is somewhat encouraging because zone #1 in this study was the most affected by salinity problems, according to the EM38 and soil surveys performed in 2000 and 2001(Figs. 1 and 3). The trend observe with the variable rate application of sulfuric acid may be in part do to the rapid reaction with the soil and residue gypsum from a previous application. In addition, the effects of gypsum may not be evident in the first year following application due the particle size, purity of the gypsum, and water quality.

Because block four was the first block to be harvested after the calibration, the cause for the yield monitor to read an average 29% higher for this block cannot be explained, but was presumably due to a calibration error. However, the yield monitor does a good job in estimating the yields as compared to the buggy weight for general commercial use. The value of the yield monitor data was evident in this study, allowing a further evaluation of each plot spatially, as seen with a significant difference in the first two zones as compared to the last two. One potential explanation for this difference by zone is that the irrigation water, which is applied on the north end of the field, moves soluble salts across the field and re-distributes them into the southern portion of the field. This brings up the issue of drainage and how it affects the distribution of salts within the field. Without good drainage full reclamation of salt affected soil will be very difficult, if not impossible

**Acknowledgments**

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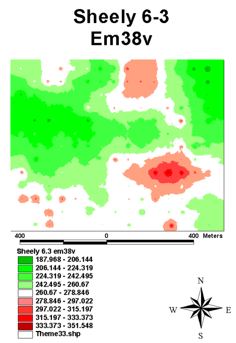


Figure 1. Bulk soil salinity pattern as determined by vertical EM-38 measurements.

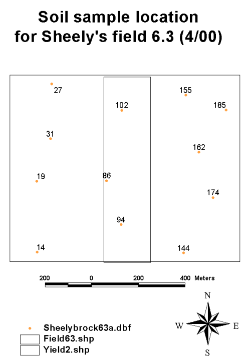


Figure 2. Sampling pattern used to extract preliminary soil core samples.

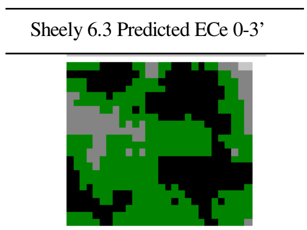


Figure 3. Predicted saturated soil paste extract EC ($EC_e$) of the test field.

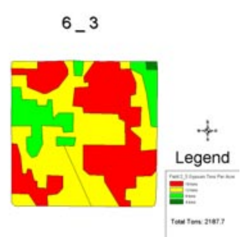


Figure 4. Gypsum rate prescription based on the map of Fig. 3.

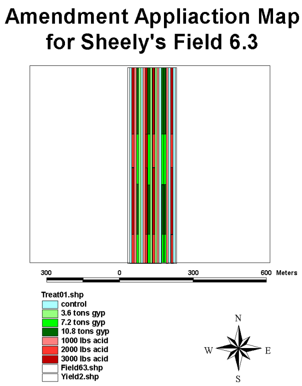


Figure 5. Diagram of the experimental plot.

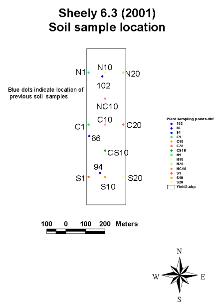


Figure 6. Diagram showing soil sample locations within the experimental area.

Table 1 Analysis results from soil samples.

Sheely field 6.3 year 2000

| Site # | Depth | Sp | ECe | Ca | Mg | Na | SAR | B |
|---|---|---|---|---|---|---|---|---|
| | | | | | meq/l | | | ppm |
| 14 | 0-1 | 44 | 4.64 | 10.4 | 9.8 | 29.1 | 7.7 | 1.71 |
| | 1-2 | 42 | 4.50 | 14.4 | 8.0 | 23.1 | 6.9 | 1.53 |
| | 2-3 | 43 | 3.90 | 8.0 | 6.7 | 26.5 | 9.8 | 1.36 |
| 19 | 0-1 | 49 | 2.81 | 13.6 | 4.4 | 13.8 | 4.6 | 1.18 |
| | 1-2 | 37 | 2.64 | 6.7 | 3.3 | 15.1 | 6.8 | 1.07 |
| | 2-3 | 33 | 3.23 | 6.3 | 3.6 | 20.1 | 9.0 | 1.18 |
| 27 | 0-1 | 45 | 5.40 | 7.6 | 5.3 | 37.4 | 14.7 | 2.02 |
| | 1-2 | 42 | 5.07 | 14.8 | 11.7 | 37.7 | 13.1 | 2.02 |
| | 2-3 | 38 | 7.35 | 9.5 | 9.6 | 53.2 | 17.7 | 2.39 |
| 31 | 0-1 | 41 | 2.85 | 9.2 | 4.9 | 16.1 | 6.1 | 1.14 |
| | 1-2 | 40 | 2.45 | 7.4 | 3.2 | 13.7 | 6.0 | 1.20 |
| | 2-3 | 33 | 3.24 | 7.4 | 4.1 | 24.7 | 10.3 | 1.38 |
| 86 | 0-1 | 49 | 2.97 | 13.4 | 3.9 | 17.3 | 5.9 | 1.24 |
| | 1-2 | 49 | 3.22 | 8.2 | 3.4 | 23.9 | 9.9 | 1.59 |
| | 2-3 | 44 | 3.31 | 10.2 | 4.7 | 24.1 | 8.8 | 2.20 |
| 94 | 0-1 | 49 | 4.76 | 21.5 | 10.9 | 23.8 | 5.9 | 1.43 |
| | 1-2 | 40 | 5.11 | 16.5 | 8.1 | 45.5 | 13.0 | 1.63 |
| | 2-3 | 37 | 5.22 | 17.6 | 8.9 | 30.5 | 8.4 | 1.67 |
| 102 | 0-1 | 47 | 4.32 | 14.3 | 7.1 | 25.2 | 7.7 | 2.76 |
| | 1-2 | 30 | 4.21 | 7.8 | 6.0 | 27.8 | 10.6 | 2.79 |
| | 2-3 | 40 | 7.72 | 25.4 | 18.1 | 53.7 | 15.7 | 4.21 |
| 144 | 0-1 | 40 | 3.94 | 8.2 | 4.1 | 23.0 | 9.3 | 1.91 |
| | 1-2 | 34 | 5.25 | 7.9 | 4.5 | 36.6 | 14.7 | 3.30 |
| | 2-3 | 34 | 4.82 | 5.3 | 3.4 | 40.2 | 19.3 | 3.69 |
| 155 | 0-1 | 53 | 10.6 | 27.6 | 29.3 | 108 | 20.3 | 5.15 |
| | 1-2 | 60 | 11.8 | 15.7 | 17.3 | 132 | 32.4 | 6.97 |
| | 2-3 | 63 | 9.06 | 7.1 | 4.4 | 68.6 | 28.6 | 6.07 |
| 162 | 0-1 | 54 | 3.36 | 9.1 | 3.0 | 15.6 | 6.3 | 1.75 |
| | 1-2 | 52 | 5.36 | 15.2 | 6.4 | 50.7 | 15.4 | 1.00 |
| | 2-3 | 50 | 5.40 | 5.5 | 3.3 | 48.1 | 22.9 | 2.79 |
| 174 | 0-1 | 55 | 4.52 | 13.7 | 5.3 | 31.0 | 10.1 | 2.91 |
| | 1-2 | 50 | 1.89 | 1.6 | 1.0 | 19.3 | 16.9 | 3.29 |
| | 2-3 | 47 | 5.19 | 3.1 | 6.6 | 50.4 | 22.8 | 4.31 |
| 185 | 0-1 | 45 | 2.07 | 3.2 | 1.7 | 12.2 | 7.8 | 1.12 |
| | 1-2 | 46 | 2.30 | 4.1 | 3.7 | 14.9 | 7.5 | 1.26 |
| | 2-3 | 44 | 3.42 | 5.6 | 4.0 | 24.3 | 11.1 | 2.49 |

Table 2: Soil sample results from soil cores extracted at locations shown in Fig. 6.

| Sheely field 6.3 study area year 2001 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site # | Depth | Sp | pH | ECe | Na | Ca | Mg | SAR | B |
| | | % | | dS/m | meq/l | | | | ppm |
| 1-S | 0-1' | 70 | 7.42 | 3.17 | 23.22 | 11.61 | 5.44 | 7.95 | 0.96 |
| 1-S | 1-2' | 61 | 7.49 | 2.82 | 24.33 | 7.37 | 4.27 | 10.09 | 1.36 |
| 10-S | 0-1' | 60 | 7.30 | 3.80 | 27.59 | 15.01 | 7.33 | 8.25 | 0.81 |
| 10-S | 1-2' | 64 | 7.48 | 3.62 | 26.93 | 12.46 | 6.43 | 8.76 | 1.48 |
| 20-S | 0-1' | 61 | 7.53 | 3.02 | 22.76 | 10.76 | 4.84 | 8.15 | 0.9 |
| 20-S | 1-2' | 60 | 7.54 | 3.19 | 27.55 | 9.06 | 5.44 | 10.23 | 1.15 |
| 1-CS | 0-1' | 64 | 7.20 | 4.44 | 28.44 | 16.43 | 7.67 | 8.19 | 0.99 |
| 1-CS | 1-2' | 58 | 7.39 | 5.12 | 36.94 | 17.85 | 8.78 | 10.13 | 1.3 |
| 10-CS | 0-1' | 58 | 7.57 | 3.32 | 25.88 | 10.48 | 5.18 | 9.25 | 1.55 |
| 10-CS | 1-2' | 63 | 7.64 | 3.11 | 28.01 | 7.08 | 3.79 | 12.01 | 2.01 |
| 20-CS | 0-1' | 63 | 7.56 | 3.86 | 27.32 | 14.45 | 6.14 | 8.52 | 1.42 |
| 20-CS | 1-2' | 64 | 7.65 | 3.65 | 29.49 | 9.91 | 5.12 | 10.75 | 1.48 |
| 1-NC | 0-1' | 60 | 7.55 | 3.37 | 20.33 | 12.18 | 4.45 | 7.05 | 0.66 |
| 1-NC | 1-2' | 63 | 7.42 | 3.46 | 22.97 | 11.63 | 4.96 | 7.97 | 0.46 |
| 10-NC | 0-1' | 63 | 7.52 | 3.05 | 18.43 | 12.18 | 4.77 | 6.33 | 0.67 |
| 10-NC | 1-2' | 62 | 7.45 | 3.34 | 20.75 | 10.79 | 4.96 | 7.39 | 0.56 |
| 20-NC | 0-1' | 59 | 7.53 | 2.50 | 15.83 | 9.13 | 3.87 | 6.21 | 0.33 |
| 20-NC | 1-2' | 63 | 7.68 | 2.86 | 20.93 | 9.14 | 4.77 | 7.94 | 1.17 |
| 1-N | 0-1' | 57 | 7.62 | 5.13 | 35.28 | 14.67 | 7.28 | 10.65 | 1.53 |
| 1-N | 1-2' | 45 | 7.54 | 4.71 | 33.48 | 11.35 | 6.46 | 11.22 | 1.45 |
| 10-N | 0-1' | 59 | 7.72 | 5.04 | 33.10 | 14.39 | 7.73 | 9.95 | 1.94 |
| 10-N | 1-2' | 67 | 7.82 | 4.45 | 34.40 | 8.86 | 6.21 | 12.53 | 1.84 |
| 20-N | 0-1' | 56 | 7.69 | 4.89 | 33.91 | 13.01 | 6.46 | 10.87 | 1.86 |
| 20-N | 1-2' | 61 | 7.94 | 4.04 | 33.34 | 6.37 | 4.03 | 14.63 | 1.53 |
| 86-B | 0-1' | 62 | 7.65 | 3.09 | 22.13 | 11.61 | 4.47 | 7.80 | 0.72 |
| 86-B | 1-2' | 62 | 7.73 | 3.44 | 27.09 | 9.07 | 4.13 | 10.55 | 0.98 |
| 94-B | 0-1' | 65 | 7.64 | 3.83 | 27.82 | 13.88 | 6.40 | 8.73 | 0.62 |
| 94-B | 1-2' | 66 | 7.49 | 4.00 | 28.64 | 13.03 | 6.96 | 9.06 | 1.08 |
| 102-B | 0-1' | 57 | 7.67 | 3.83 | 30.28 | 11.05 | 5.80 | 10.43 | 2.07 |
| 102-B | 1-2' | 57 | 7.73 | 4.11 | 36.32 | 8.50 | 6.23 | 13.39 | 2.16 |

Table 3: Comparison of yield monitor and boll buggy yield measurements.

| Plot# | #/seed wt Monitor | #/seed wt Buggy | % Buggy |
|---|---|---|---|
| 1 | 3105 | 2956 | 105.0 |
| 2 | 3460 | 3592 | 96.3 |
| 3 | 3272 | 3550 | 92.2 |
| 4 | 3741 | 3514 | 106.5 |
| 5 | 3644 | 3492 | 104.4 |
| 6 | 3260 | 3249 | 100.3 |
| 7 | 3525 | 3330 | 105.9 |
| 8 | 3800 | 3586 | 106.0 |
| 9 | 3545 | 3353 | 105.7 |
| 10 | 3007 | 3206 | 93.8 |
| 11 | 3856 | 3553 | 108.5 |
| 12 | 3096 | 3314 | 93.4 |
| 13 | 3064 | 3334 | 91.9 |
| 14 | 3396 | 3317 | 102.4 |
| 15 | 4331 | 3277 | 132.2 |
| 16 | 3967 | 3176 | 124.9 |
| 17 | 4798 | 3601 | 133.2 |
| 18 | 4448 | 3390 | 131.2 |
| 19 | 4652 | 3496 | 133.1 |
| 20 | 4364 | 3554 | 122.8 |
| mean | 3716.55 | 3392 | |
| stdev | 552.53 | 171.62 | |
| Median | 3594.5 | 3371.5 | |

Table 4: Analysis of variance of boll buggy weights.

Dunnett's comparisons significant at the 0.05 level are indicated by ***.

Difference Simultaneous

treat Between 95% Confidence

Comparison Means Limits

| | | | |
|---|---|---|---|
| 4 - 5 | 362.3 | -646.5 | 1371.0 |
| 2 - 5 | 330.0 | -678.7 | 1338.7 |
| 3 - 5 | 134.8 | -874.0 | 1143.5 |
| 1 – 5 | - 170.3 | - 1179.0 | 838.5 |

Tukey means with the same letter are not significantly different.

| Tukey Grouping | Mean | N | block | Tukey Grouping | Mean | N | treat |
|---|---|---|---|---|---|---|---|
| A | 3443.4 | 5 | 4 | A | 3556.8 | 4 | 4 |
| A | | | | A | | | |
| A | 3420.8 | 5 | 1 | A | 3453.8 | 4 | 3 |
| A | | | | A | | | |
| A | 3359.0 | 5 | 3 | A | 3350.5 | 4 | 1 |
| A | | | | A | | | |
| A | 3344.8 | 5 | 2 | A | 3330.0 | 4 | 2 |
| | | | | A | | | |
| | | | | A | 3269.0 | 4 | 5 |

Table 5: Analysis of variance of yield monitor data using Tukey's test.

Tukey means with the same letter are not significantly different.

| Tukey Grouping | Mean | N | treat | Tukey Grouping | Mean | N | block |
|---|---|---|---|---|---|---|---|
| A | 3942.0 | 4 | 4 | A | 4445.8 | 5 | 4 |
| A | | | | | | | |
| A | 3896.0 | 4 | 2 | B | 3548.6 | 5 | 3 |
| A | | | | B | | | |
| A | 3664.8 | 4 | 3 | B | 3444.4 | 5 | 1 |
| A | | | | B | | | |
| A | 3548.8 | 4 | 1 | B | 3427.4 | 5 | 2 |
| A | | | | | | | |
| A | 3531.3 | 4 | 5 | | | | |

Table 6: Analysis of variance of yield monitor data after correction for presumed calibration error.

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| block | 3 | 595865.238 | 198621.746 | 0.68 | 0.5661 |
| treat | 4 | 2343877.950 | 585969.487 | 2.01 | 0.1045 |
| zone | 3 | 6513359.238 | 2171119.746 | 7.46 | 0.0003 |
| treat*zone | 12 | 1441751.450 | 120145.954 | 0.41 | 0.9524 |

Means with the same letter are not significantly different.

| Tukey Grouping | Mean | N | treat |
|---|---|---|---|
| A | 4898.1 | 16 | 4 |
| A | | | |
| A | 4574.3 | 16 | 2 |
| A | | | |
| A | 4526.9 | 16 | 3 |
| A | | | |
| A | 4454.1 | 16 | 1 |
| A | | | |
| A | 4416.3 | 16 | 5 |

| Tukey Grouping | Mean | N | block |
|---|---|---|---|
| A | 4660.4 | 20 | 2 |
| A | | | |
| A | 4658.1 | 20 | 1 |
| A | | | |
| A | 4506.8 | 20 | 3 |
| A | | | |
| A | 4470.4 | 20 | 4 |

| Tukey Grouping | Mean | N | zone |
|---|---|---|---|
| A | 4903.4 | 20 | 2 |
| A | | | |
| A | 4807.8 | 20 | 1 |
| B | 4335.6 | 20 | 4 |
| B | | | |
| B | 4248.9 | 20 | 3 |