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Using Soil Texture to Guide Variable-Rate Nitrogen Fertilization.

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Introduction

Variable-rate fertilization is becoming a common practice in the US. Many producers are applying phosphorus and potassium at site-specific rates that take into account local factors that affect nutrient availability, crop growth and yield potential. Phosphorus and potassium are relatively immobile in the soil and soil testing can be effectively used to map the plant available concentration in the soil. Fertilizer spread maps are created from interpolations of these samples. Nitrogen, however, is very mobile in the soil. Sampling is only meaningful until the next rain or irrigation. Nitrogen is highly affected by soil moisture and rainfall. It is more difficult to create fertilizer spread maps based on soil N test values.

Nitrogen availability for crop growth is related to many soil factors. These factors include organic matter, soil texture, topography, aspect, residues and previous crop. Of these, soil texture has a large effect on N availability because it effects water holding capacity. Nitrogen movement in the soil is highly related to water movement. Coarse textured soils have higher infiltration rates and lower water holding capacity. Fine textured soils have lower infiltration rates but high water holding capacity. The combination of irrigation management and soil texture greatly affects the N availability to a crop. In a site-specific management study by Machado et al. (2002), it was pointed out that although the spatial variability of crop yields depends on the interaction between many physical and biological factors, the effects of soil physical properties on crop yield is predictable and therefore useful in variable rate technology.

Nitrogen is an important factor in the growth of most crops, especially in sugar beets where it directly affects yield, sugar content and quality. With many crops the cost of applying too much nitrogen is the cost of the excess fertilizer and application as well as the environmental impact that is not a direct cost to the grower. However, applying too much nitrogen to sugar beets will reduce sugar content and quality, which is a direct cost to the grower. (Humburg and Stange, 1999).

This paper will present the results of a variable rate N study and the importance of texture in determining the N rate and yield and yield quality.

Materials and methods

Two sugarbeet fields were chosen in south central Idaho for this study. Each site was chosen to represent the variability in the area. The fields were managed according to the grower's typical practices with the exception of the nitrogen fertilizer treatments.

Each site received N treatments, as urea of 0.5X, 1.0X and 1.5X of the UI recommended rate of N based on the soil test value. Treatments were applied prior to row closure in 24 row strips the length of the field. Each treatment was replicated 3 times at each site. For each site fifteen 40 foot by 72 row test areas that spanned the three treatments in each replication were chosen across the site based on areas of contrasting soil color and topography. A study involving site-specific management of N fertilizer showed that using soil test areas that represent different areas of a field was helpful in

forming the basis for extrapolating spatial patterns that could be used in variable rate fertililization (Blackmer and White., 1996, 1998).

Soil samples were collected just after emergence in one foot increments to two feet. Samples were analyzed using standard soil analyses practices for major soil nutrients and physical properties including nitrate-N and soil texture. Each test area was divided into three 40 ft. x 24 row subplots to represent the N treatments. After row closure, soil N and petiole N measurements from each of the fifteen test areas were taken at approximately three week intervals. Samples were extracted and analyzed using standard soil and tissue analysis practices.

Eighty feet of row was harvested from each subplot within a test area using a small plot harvester. Yields for each section were calculated from harvest weights and samples from each plot were analyzed for yield quality. Soil samples were also taken shortly after harvest to two feet in two foot increment depths from each subplot and analyzed for nitrate-N.

Results and discussion

Both locations had five or more test areas of a single soil textures. The Minidoka site had 5 and 6 test areas that were clay loam and silt loam, respectively. While the Oakley site had 6 and 7 test areas that were clay and loam, respectively.

Figure 1 shows the yield, percent sugar and total sugar for each site. Yields at Oakley were not significantly different. In terms of economics, the 0.5X rate was the most economical. If the yield response to each increment of applied fertilizer was calculated, it wouldn't have been enough to justify additional N over the 0.5X rate. Percent sugar among the three treatments at Oakley was not significant, either, and, therefore, neither was total sugar yield.

Minidoka had significant differences among the treatments for yield (Fig. 1). There was a five ton difference between the 0.5X rate over the 1.0X rate but no significant difference between the 0.5X and 1.5X rates. There was a significantly higher percent sugar in the 0.5X rate over both the 1.0X and 1.5X rate. Total sugar for the 0.5X rate was 0.8 and 1.5 tons/acre higher than the 1.5x and 1.0x rates, respectively.

Yields for each of the test areas were separated by soil texture (Fig. 2). The Oakley yields for each treatment were not significant, but overall, the loam yielded higher than the clay textured soil. At Minidoka there was a 3.5 ton increase in yield for the 0.5x treatment over the 1.0 and 1.5x treatments in the clay loam soil. These differences were evident in higher percent sugar and total sugar yield as well (data not shown). There were no differences among treatments for the silt loam soil. Additionally the yield in the clay loam soil averaged better than the silt loam soil.

Mid-season soil samples for the Oakley site showed increasing soil test levels from the low to high treatments for the clay soil as expected. Although the loam soil appears to trend downward with increasing N rate the values are not significantly different.

At Minidoka, both soil textures had increasing soil test values as N rate increased (Fig. 3). The differences between textures among the treatments were not significant indicating that there was no difference in soil test N between textures.

With respect to petioles (Fig. 4), in Oakley there were no differences among the textures just the expected increase in petiole nitrate as the N rates increased. In Minidoka,

however, there was a significant difference in petiole nitrate levels for each texture. The clay loam soil had 20% higher values than did the silt loam soil. Since there was no difference among the soil test values for the two textures then the differences in petiole N may be related to irrigation management and the water holding capacity of the clay loam soil.

Conclusions

There were was a large response to soil texture at Minidoka. The sugarbeets followed a grain crop thus there was less residual N and a greater response to fertilizer. The differences is soil texture were related more to the water holding capacity of the soil than the N content since the soil test values for the two textures were similar. The crop in Oakley followed potatoes which often has high concentrations of residual N. The adequate soil N and good irrigation management overshadowed any differences due to texture.

Although this is one year of data and some of it is anecdotal, soil texture is an important consideration when determining variable rate N recommendations for crops and in particular, sugarbeets. Sugarbeets can have large reductions in sugar content with high rates of N in the field late in the season. Since sugarbeets can root as deep as 6 feet it is important to know the N soil test values at these depths. Nitrate is very mobile in the soil and soils with low water holding capacity and high infiltration rates will have a higher probability of having N at lower soil depths. If irrigations and N practices are not managed in a wise manner, producers could suffer from losses in sugar at harvest.
Soil texture is a one time soil test, meaning it isn't going to change from year to year as N does. Using a bare soil image or published soil survey is a place to start in mapping out soil textures for fields. This information can be incorporated with other information to build variable rate N recommendations that are agronomically, economically and environmentally sound.

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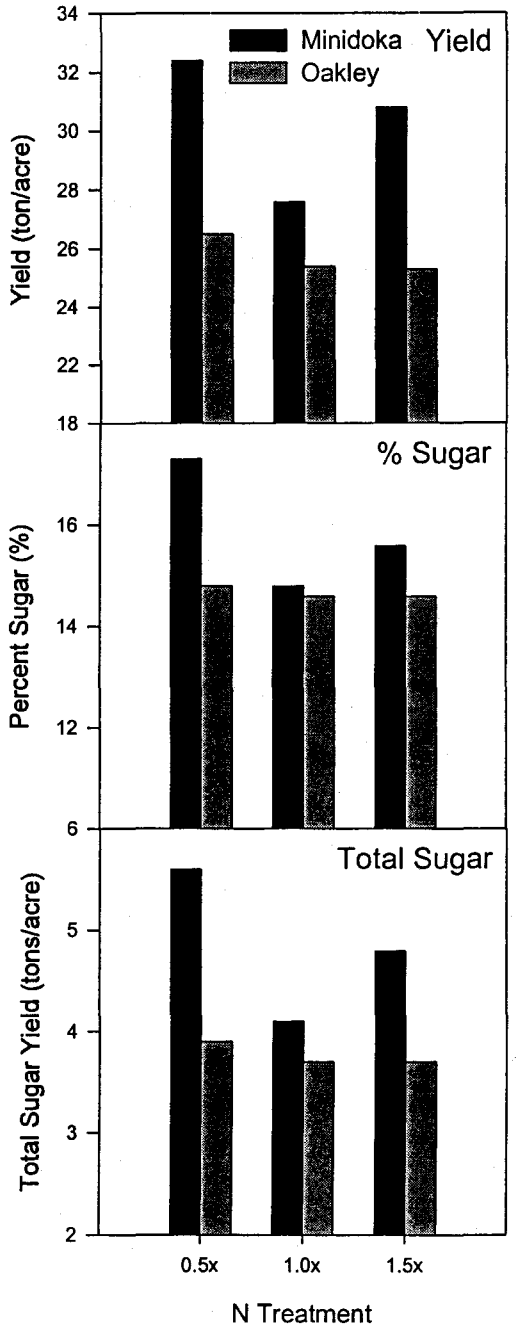

Figure 1. Yield, % Sugar and Total Sugar yield for the two locations.

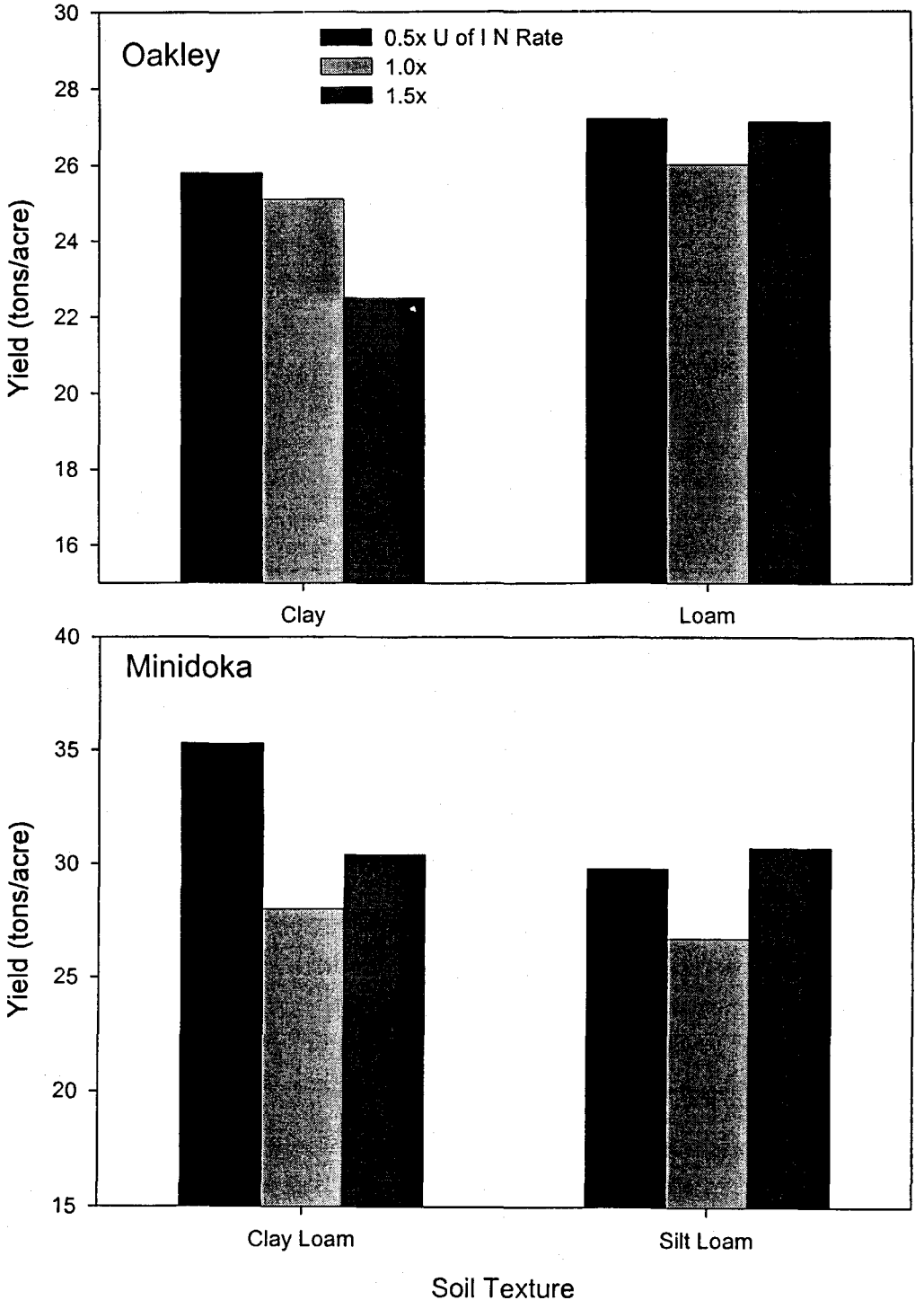

Figure 2. Yield for Minidoka and Oakley for each treatment by soil texture.

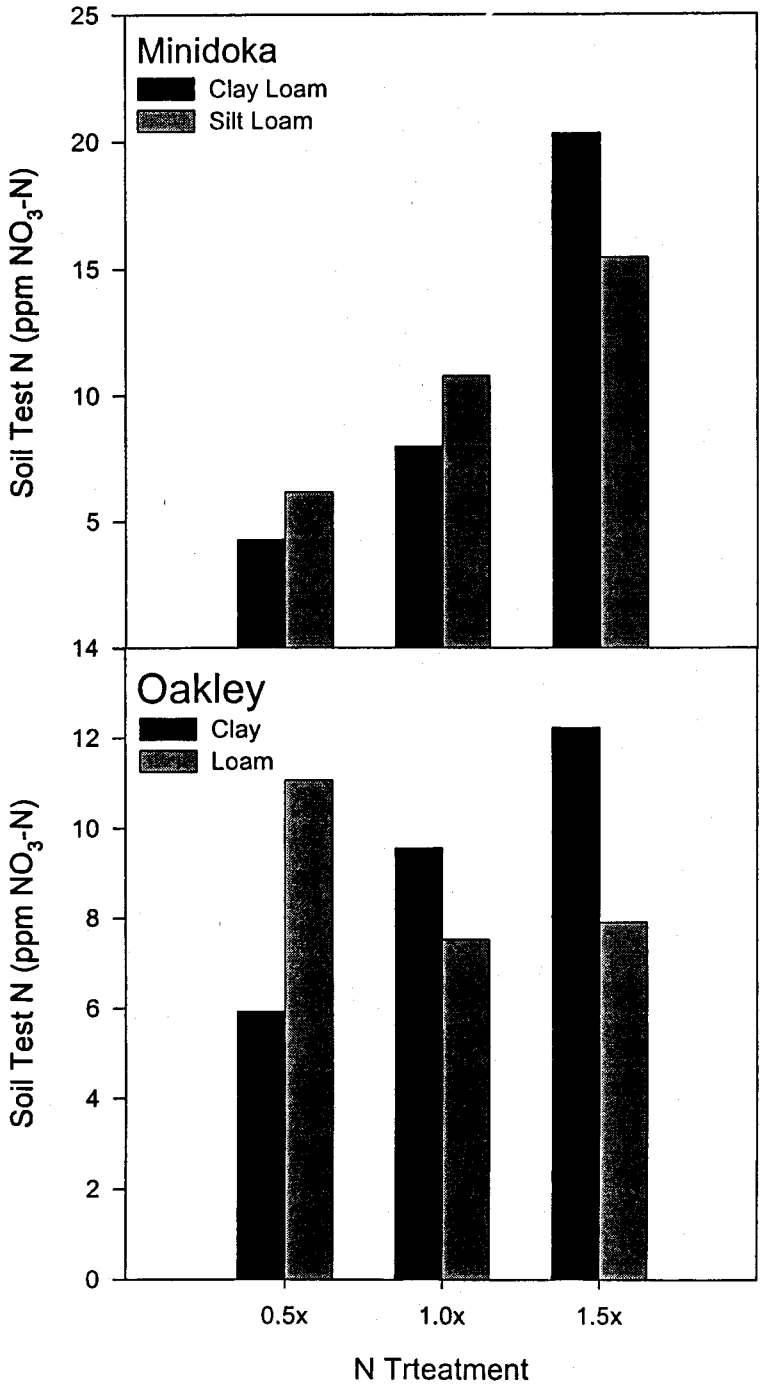

Figure 3. Nitrate-N values for each treatment by soil texture for each location.

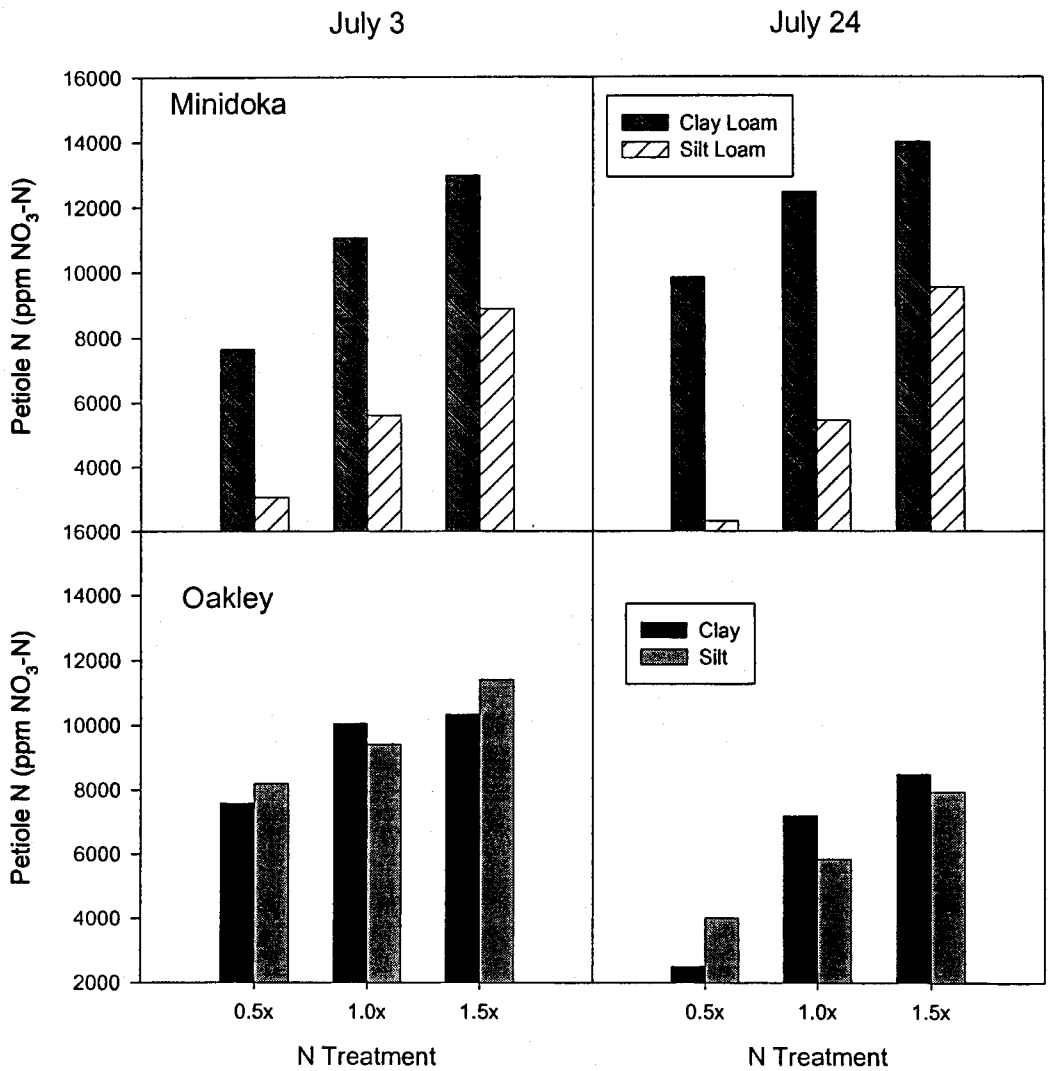

Figure 4. Petiole Nitrate levels for two sampling times during the season. Values are for each treatment within a soil texture.

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