BANDED P PLACEMENT FOR SUGARBEETS IN CALCAREOUS SOIL

Bryan G. Hopkins and Jason W. Ellsworth

ABSTRACT

Phosphorus (P) is an essential element for sugar beet (Beta vulgaris) nutrition. Soils in the Western US tend to be calcareous and alkaline, resulting in low P solubility. Sugar beets have difficulty exploiting soluble P in surface soil due to its tap root system. Research in the North-Central US supports P applied in a band in contact with the seed or below the seed for best results. However, grower concerns about germination problems and seedling vigor have prevented adaptation of these techniques in Idaho. This project evaluated the effectiveness of two starter fertilizers (ammonium polyphosphate, APP and urea ammonium nitrate, UAN) at three depths at two Idaho locations. The UAN treatments were included in an effort to isolate the N only response from the combined effect of N and P in the APP treatments. The banded application of APP at the 6 in below the soil surface depth resulted in increased sugar production due to a combined increase in sugar percentage and total yield at one location. In contrast with the results from the previous year, the banded APP at the surface did not result in increased sugar % or yield and, in fact, significantly reduced sugar yield at one location. No other treatments resulted in increases or decreases in sugar production. Although some discrepancies exist between locations this year and with the results from a similar study in 2002, the band at the 6 in depth resulted in the highest total sugar production for two of the three site years of data.

INTRODUCTION

Studies in the North-Central US show yield increases with the use of 12-20 lbs.-P\textsubscript{2}O\textsubscript{5}/acre of ammonium polyphosphate (APP: 10-34-0) starter in sugar beets (Lamb, 1986; Moraghan and Etchevers, 1980; Sims and Smith, 2001). These researchers found increased yields when a starter band was placed: 1) in direct seed contact, 2) two in below the seed, and 3) two in below and two in to the side of the seed. The magnitude of the response, however, was delayed and reduced as the distance between the seed and the starter fertilizer band increased. Sims and Smith (2001) concluded that direct seed contact was the best option due to the rapid, vigorous response and because much of the soil in which the sugar beets are being grown in that region is high in clay and susceptible to implement-soil interface compaction, thus creating a poor seed bed. Unlike many other crops, this study found little advantage by placing the starter band two in to the side of the seed. Other research also supports the fact that optimum placement of phosphorous (P) for sugar beets seems to be directly below the seed (Anderson and Peterson, 1978).
Although sugarbeet growers in other regions have research based starter fertilizer recommendations, the soil and management conditions are very different in the Western US. Recent research has elucidated optimum P rates in sugarbeets (Stark, personal communication, 2002), but no scientific studies evaluating starter P fertilizer techniques have been reported in this region. Many western growers do not apply starter fertilizer with sugarbeets, due to previously observed problems with germination and emergence (Gallian, personnel communication, 2002). However, these observations were primarily made at high rates of starter and with fertilizer with high potential for salt, ammonia, and biuret injury to seeds and seedlings in alkaline soils. No scientific evaluations of low rates of starter fertilizer or other types of starters in these conditions have been reported in alkaline soils. Western soils tend to have relatively high pH, carbonates, and salts and low organic matter and clay content and, as a result, have increased likelihood of P deficiency, ammonia toxicity, salt injury, and surface crusting.

Although researchers have shown declining impact as P bands increase in distance from the seed, Idaho soils tend to be very high in surface P and very low in subsurface P. This scenario works well for shallow rooted crops, such as potato, but may be problematic for sugarbeets because of their dominate tap root system (Anderson and Peterson, 1978). It is probable that sugarbeet seedlings have adequate P at germination in soils with very high P levels, but there is concern that P availability is insufficient as the sugarbeet tap root explores relatively less of the surface soil and more of the subsurface soil during the first weeks of growth. Phosphorus availability and diffusion rates increase when P is applied in a band application (Anderson and Peterson, 1978; Lamb, 1986; Moraghan and Etchevers, 1989; Sims and Smith, 2001). Banded P may enhance subsurface P uptake if placed relatively deep and in the path of the sugarbeet tap root. The objective of this project is to determine if deep-banded P enhances sugarbeet P nutrition and, if so, how does this impact final yield and sugar content?

In the first year of this project, banded applications of APP resulted in increased sugarbeet yield, regardless of rate or placement depth. Broadcast and banded phosphoric acid (PA) applications did not increase sugarbeet yield. Percent sugar content was not significantly different for any treatment. However, when combined with yield to calculate sugar production, the deep banded (6 in) APP treatments generally resulted in increased sugar production. Surface and 2 in starter bands of APP also resulted in increased sugar yield, but the differences were not statistically significant. Surprisingly, the PA treatments did not result in an increase in sugar yield, which leaves the reasoning for the response of the APP in doubt. Was the response to APP simply due to N or the combination of N and P? Or, did the PA bands result in reduced P availability as the season progressed. Thus, the study treatments were changed for this study to better answer the question of whether or not banded APP enhances P uptake and increases yield.

**MATERIALS & METHODS**

Two field experiments were conducted in 2003 near Twin Falls and Blackfoot, Idaho on irrigated sugarbeets growing in alkaline (pH 8.0-8.4), calcareous (5-12% CaCO₃) soils.
with high soil test P (20-35 ppm bicarbonate P). The treatments included four placements of two fertilizer sources. The placement methods included: broadcast fertilizer and banded fertilizer at 0, 3, and 6 in below the surface (directly above/below the seed) applied as either APP or urea ammonium nitrate (UAN: 32-0-0) with 6 lb-N + 20 lb-P₂O₅ or 6 lb-N + 0 lb-P₂O₅/ac, respectively. The UAN source was included as an N only check to serve the purpose of isolating the response of N and P in the APP treatments. Humic acid was applied with all fertilizer solutions at 0.5 gal/ac to match Idaho grower practices. No additional fertilizer P was applied. Additional broadcast N fertilizer was applied based on need according to soil and petiole analyses.

The plots were arranged in a RCBD experimental design with six replications and were established as six – 40 foot rows on 22 in centers. Broadcast applications were applied and tilled into the soil at final ground preparation. The subsurface bands were applied after hilling and prior to planting. The surface band was applied immediately after planting by spraying the fertilizer material directly over the seed zone in a one to two in band.

Fertilizer application and planting occurred on April 8-9 at the field near Blackfoot and on May 5-6 in Twin Falls. Normal cultural management practices were followed in raising the crop. The air and soil temperatures were characterized by unusually warm late winter/early spring temperatures, followed by cool air temperatures during most of May, and then unusually warm temperatures throughout the remainder of the season.

Plant samples were taken to ascertain differences in plant growth, dry matter accumulation, and nutrient partitioning. Above and below ground whole plant samples were taken during the season at 77 (Blackfoot) and 87 (Twin Falls) d after planting. Plant samples are being analyzed for N and P concentration, but the analysis is not yet complete and thus the data not shown. Harvest occurred on October 3 or 151 d after planting for the Twin Falls field and October 13 or 188 d after planting for the field near Blackfoot. The sugar beets were weighed to determine total yield and analyzed for conductivity and sugar and nitrate concentration. Adjustments were made for tare (contaminates such as soil) after cleaning and reweighing. Sugar yield was determined by multiplying sugar concentration by yield. Statistical analysis was performed using ANOVA and means were separated by LSD with an alpha level of 0.05.

RESULTS AND DISCUSSION

The results from the Twin Falls location showed no significant differences in total yield, conductivity, sugar percentage, nitrate concentration, and total sugar production (Table 1). It is likely that a combination of the late planting date, unusually warm soils in 2003, and early harvest date resulted in increased P solubility/reduced P need.

The results from the field near Blackfoot also showed no significant differences in conductivity, sugar percentage, and nitrate concentrations (Table 2). However, the total yield and the net total sugar production (Fig. 1) proved to have significant differences. The APP applied 6 in below the soil surface was the only treatment significantly greater
than the check. In contrast to the results from the Twin Falls site and the previous year results, the surface applied APP (0 in) resulted in a significant decline in sugar production. No other treatments resulted in increases or decreases in yield.

In 2002, a similar study was conducted with 0, 20, and 220 lb-P₂O₅/a broadcast and banded phosphoric acid (PA) and/or APP (Hopkins and Ellsworth, 2003). Placement depths of the bands were similar to those in this study. Unlike the results from this year, the results of the 2002 study showed significant increases in yield for APP at all three placement depths. Total sugar also increased for all three APP depths, but only the 6 in depth was significant. Surprisingly, none of the PA treatments showed increases in total or sugar yield, leaving the reason for the APP increases in doubt. Was the reason for the APP increase due to N or P or both? Did the PA suppress yield due to acid induced P solubility reduction? In order to answer these questions and avoid further confusion, the study protocol this year was changed to the format described above. The inclusion of the UAN treatments effectively separates the N contribution of the starter.

Although the results from the two locations this year and the 2002 study were different, it is interesting to note that the APP band 6 in below the soil surface performed better than all other treatments for both the field near Blackfoot this year and for the field from the previous year.

Although the nutrient analysis for the 2003 study is not yet available, the 2002 study shows substantial increases of N and P in the stems/leaves and of P in the roots when sampled early in the season (data not shown). These tissue concentration differences disappeared late in the season for the stems/leaves, but not so for the root P concentrations. The banded P treatments consistently exhibited higher root P concentrations than the broadcast or unfertilized check. The tissue nutrient concentration results from the 2002 study, combined with the evidence from the results of this study, lead one to believe that all or much of the yield response observed with the deep banded APP treatment is due to enhanced P uptake and utilization. No response was observed when N was added by itself, again indicating that the response mainly from P.

During the early half of the season, sugarbeet roots are oriented dominantly downward, as compared to a more diagonal orientation for most other plant species. The architecture of sugarbeet roots results in more exploration of the subsoil and less of the surface soil. Subsurface P concentrations tend to be very low, especially in alkaline, calcareous soils common in the western states. This combination of sugarbeet roots not effectively exploring the surface soil and low subsoil P levels results in a potential problem for P availability early in the season, even in high P testing soils. Deep banding APP seems to effectively correct this problem.

**CONCLUSIONS**

The result of this study, combined with evidence from other studies, indicates that deep banded (6 in below the soil surface) APP fertilizer placed directly below the seed enhances P availability and results in increased sugar production. This increase in sugar
production due to deep banding was observed in alkaline, calcareous soils with high
residual soil test P. Shallower placement (3 in) or surface banding also resulted in
increased yields in a previous study, but the effect was neither as great nor as consistent
as the deep banded treatment when evaluating the findings of both studies. In fact, in one
instance it appeared that the surface applied APP resulted in significantly decreased
yields, probably due to salt injury to the seeds/seedlings. Starter UAN bands did not
enhance sugar production. Although additional studies are planned, the results of this
study, in combination with the work from the previous year, show that deep banding P on
sugarbeets enhances P uptake and, as a result, sugar production.

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studies in 2003.
Table 1. Sugarbeet P placement study data for the Twin Falls, Idaho location in 2003. Ammonium polyphosphate (APP) or urea ammonium nitrate (UAN) were applied as broadcast or banded at 0, 3, or 6 in below the soil surface. (lsd – ns = Not Significantly Different)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sugar %</th>
<th>NO₃ ppm</th>
<th>Conductivity</th>
<th>Yield, ton/a</th>
<th>Sugar, lb/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast UAN</td>
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<td>193</td>
<td>0.76</td>
<td>31.6</td>
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<tr>
<td>Broadcast APP</td>
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<td>33.9</td>
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<td>0&quot; UAN</td>
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<td>303</td>
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<td>0&quot; APP</td>
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<tr>
<td>3&quot; UAN</td>
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<td>6&quot; UAN</td>
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<td>6&quot; APP</td>
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<td>LSD</td>
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Table 2. Sugarbeet P placement study data for the field near Blackfoot, Idaho in 2003. Ammonium polyphosphate (APP) or urea ammonium nitrate (UAN) were applied as broadcast or banded at 0, 3, or 6 in below the soil surface. (lsd – ns = Not Significantly Different)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sugar %</th>
<th>NO₃ ppm</th>
<th>Conductivity</th>
<th>Yield, ton/a</th>
<th>Sugar, lb/a</th>
</tr>
</thead>
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<tr>
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Fig. 1. Total sugar yield results from the field near Blackfoot, Idaho of a banded N & P fertilizer placement study. Fertilizer was applied either as ammonium polyphosphate (APP) or urea ammonium nitrate (UAN). Fertilizer was applied either as a broadcast/incorporated or as starter bands at 0, 3, or 6 in below the soil surface. The APP applied 6 in below the soil surface was the only treatment significantly greater than the check (Brest UAN). The surface applied APP (0 in) resulted in a significant decline in sugar production, although this effect was not observed at the other location this year nor the site tested in the previous year. Treatment bars with the same letters above them are not significantly different from one another (α=0.05).