BANDING 10-34-0 ON SUGAR BEETS

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ABSTRACT

Field experiments were conducted over 10 site-years in the Red River Valley of Minnesota on various soil types that tested low in available P. The objectives were to evaluate sugar beet yield response to liquid 10-34-0 and dry 11-52-0 fertilizer banded in-furrow with the seed at planting and to compare those responses to that of phosphorus (P) fertilizer rates broadcast and incorporated prior to planting. Treatments had no effect on net sucrose concentration in the root so effects on recoverable sucrose were almost entirely due to significant treatment effects on root yield. Banding fertilizer in-furrow increased sugar beet root yields over the control in all site-years. Maximum yield response occurred with 28 L ha^{-1} 10-34-0 with no further yield response to 37 and 47 L ha^{-1} 10-34-0. Banding dry 11-52-0 at rates to supply the equivalent amount of P as 28 L and 37 L of 10-34-0 also increased root yields over the control, but was never as effective as 28 L 10-34-0 ha^{-1}. When comparing the interaction effects of 28 L 10-34-0 banded in-furrow with broadcast and incorporated P fertilizer there were three basic root yield responses: 1) little response to P fertilizer regardless of source or method of application; 2) little response to broadcast P fertilizer, but a larger response to 28 L banded 10-34-0; and 3) large response to both source and method of fertilizer application. Regardless of the root yield response to broadcast P fertilizer, the response to 28 L banded 10-34-0 always matched or exceeded that response in all site-years. In addition, the response to 28 L banded 10-34-0 could not be improved with additional rates of banded 10-34-0 or additional P fertilizer broadcast and incorporated prior to planting.

INTRODUCTION

Phosphorus (P) deficiencies in sugar beet can occur in soils with low P availability. Generally symptoms are darker green, cupped, and erect leaves and very slow early season growth, Low soil temperatures at planting, as is frequently the situation in Minnesota and North Dakota, can enhance P deficiency symptoms on soils with low P availability. These conditions may also cause stunted sugar beet growth on soils that have sufficient P availability. However, these symptoms frequently disappear by mid-season and vigorous vegetative growth returns to a state such that it is not easy to determine that a problem ever existed (Sims and Smith, 2001). The recovery of the sugar beet plant has been associated with increasing soil temperatures as the season progresses (Sipitanos and Ulrich, 1971). The vast majority of the sugar beet root biomass is accumulated after the period of time when the vegetative growth appears to have recovered. This suggests there should be little yield loss associated with those plants that experienced the P deficiency early in the growing season, but have recovered. However, Sims and Smith (2001) showed that significant yield losses were possible in those areas where deficiencies occurred early in the season if sufficient P fertilizer was not applied.

Banding P fertilizer has been recognized as an effective strategy in sugar beet production since the 1950's. Schmehl et al. (1955) found no sugar beet yield differences when P fertilizer was banded directly below the seed row, below and to the side of the seed row, or broadcast and incorporated. Grunes et al. (1958), however, did report significant sugar beet yield increases with banded P fertilizer compared to broadcast and incorporated P. The fibrous root system in sugar beet, where the majority of P absorption will take place, develops relatively slowly compared to other common agricultural crops (Brown and Bisco, 1985). These authors found that horizontal fibrous root development in sugar beet was about 5 cm from the tap root 40-50 days after planting. Two months after planting the sugar beet fibrous root growth is more prolific and develops deeper in the soil profile and further away, horizontally, from the tap root. This indicates that the effectiveness of banded P fertilizer may be very dependent on the precise placement of the band relative to the seed and tap root pathway. Anderson and Peterson (1978) found the sugar beet plant acquired P sooner after planting if the P fertilizer band was placed 5 cm directly below the seed row instead of 5 cm to the side or 5 cm below and 5 cm to the side of the seed row. This was a greenhouse experiment that was not taken to a typical root harvest so it is not possible to determine the effect on root yield that may or may not have occurred due to delayed access to P fertilizer. Soil conditions in the sugar beet growing areas of Minnesota and North Dakota are such that placing the P band 5 cm below the seed row at planting may damage the seed bed resulting in reduced seedling emergence and causing more problems than what it corrects. Therefore, banding the fertilizer directly with the seed at planting is an attractive strategy for growers in this region.

In Minnesota, Smith (1983) reported that 10-34-0 (ammonium polyphosphate) banded in-furrow with the sugar beet seed at planting enhanced early season growth in 5 out of 6 years, but only increased yields in 2 out of the 6 years indicating a possible economic return from the banded fertilizer about 30% of the time. These trials, however, were conducted where soil P availability was already sufficient with either a high soil test P level or P fertilizer had already been broadcasted. Some sugar beet producers in Minnesota have expressed satisfaction with banding 28 L ha^{-1} 10-34-0 fertilizer in-furrow with the sugar beet seed and applying no broadcast P fertilizer even though their soils tested low in P. University recommendations suggest P fertilizer rates can be reduced by half, compared to broadcasted rates, when banded with or near the seed row. For a low P testing soil, 4-7 mg kg^{-1} $NaHCO_3$ test, the Universities of Minnesota/North Dakota recommend 67 kg P_2O_5 ha^{-1} as broadcast or 33 kg P_2O_5 ha^{-1} banded. Twenty eight L 10-34-0 ha^{-1} supplies 13.5 kg P_2O_5 ha^{-1}, which is considerably less than recommended band rates. Peterson et al. (1981) reported that the efficiency of banded P relative to broadcast P increased as soil test P levels decreased in winter wheat production. Is this a similar situation in sugar beet production?

The objective of this experiment was to evaluate sugar beet production when P fertilizer is banded with the seed at planting or broadcast and incorporated prior to planting on low P testing soils. More specifically the objectives are: 1) compare various rates of liquid 10-34-0 and dry 11-52-0 banded with the seed at planting; 2) determine the effects of various rates of broadcast P fertilizer on sugar beet production; and 3) determine the interaction of banding 10-34-0 in-furrow with the seed and broadcasting and incorporating P fertilizer prior to planting.

METHODS AND MATERIALS

Experiments have been conducted over 10 site-years in the Red River Valley within a 110 km radius of Crookston, Minnesota. Three site-years have been on Glendon sandy loam soils (Coarse-silty, mixed, superactive, frigid Aeric Calciaquolls), two years on Colvin-Perella and Colvin-Fargo complex clay soil (Colvin: Fine-silty, mixed, superactive, frigid Typic Calciaquolls; Perella: Fine-silty, mixed, superactive, frigid Typic Endoaquolls; Fargo: Fine, smectitic, frigid Typic Epiaquerts); and five years on a Wheatville loam soil (Coarse-silty over clayey, mixed over smectitic, superactive, frigid Aeric Calciaquolls). All soils tested very low to low in soil test P levels (3-6 mg kg^{-1} $NaHCO_3$ test). The experimental design was a randomized complete block with four replications and the same 11 treatments in all site-years. Treatments were as follows: broadcast P at rates of 0-67 kg P_2O_5 ha^{-1} in 16.8 kg increments (one site had up to 101 kg P_2O_5 ha^{-1}) and no fertilizer banded; 28, 37, 47 L 10-34-0 ha^{-1} with no broadcast P fertilizer; and 28 L 10-34-0 ha^{-1} with broadcast rates of 0-50.4 kg P_2O_5 ha^{-1} in 16.8 kg increments. In three of the site-years, dry 11-52-0 fertilizer was banded at P rates similar to that in 28 and 37 L 10-34-0. All banded fertilizer was applied in-furrow in direct contact with the sugar beet seed at planting and all broadcast fertilizer was applied and incorporated prior to sugar beet planting. The broadcast fertilizer source was 0-44-0.

Urea fertilizer was broadcast applied over the entire experimental area at recommended N rates based on a 1.2 m deep soil NO_3-N test. Appropriate herbicides, insecticides, and fungicides were applied as required and determined necessary through visual field scouting. All plots were 6 rows wide (55.9 cm row spacing) and 10.7 m long. Sugar beet seed was over seeded and hand thinned when the first two true leaves emerged. In late September of each year, the center two rows of each plot were machine harvested. The beet roots were weighed and ten beets were randomly selected, bagged, and sent to the American Crystal Sugar Company Quality Laboratory in East Grand Forks, Minnesota to be analyzed for tare weight, sucrose concentration, and loss to molasses.

The experiment was divided into three separate experiments for statistical purposes: 1) sugar beet response to banded fertilizer sources and rates; 2) sugar beet response to broadcast P rates; and 3) variation in sugar beet response to broadcast P rates if 28 L 10-34-0 ha^{-1} is banded in-furrow. Statistical tables will not be shown due to space restrictions. Only those treatment effects that were significant at the PR>0.05 will be discussed, but in many cases the significant levels were higher, PR>0.001.

RESULTS

Sugar beet seedlings were counted in the middle four rows of each plot and compared to the control (no P fertilizer was applied) to determine the effects of the various treatments on seedling emergence. In most site-years 47 L banded 10-34-0 caused some emergence reductions that ranged from 20-30%; no other treatments caused reduced seedling emergence. When the seedlings were hand thinned, the reduction caused by the 47 L of 10-34-0 was negated and did not play a role in the final sugar beet yield.

The treatments had highly significant effects on sugar beet root yield, but no significant effect on sucrose concentration or root impurities and thus no effect on net sucrose concentration. Therefore, the highly significant effects of the treatments on recoverable sucrose (root yield X net sucrose concentration) were due to the effects on root yields. The paper will only discuss the sugar beet root yield response to the treatments.

Banded Fertilizer Sources and Rates

Banding fertilizer increased sugar beet root yields over the control in all site-years. But, the magnitude of yield increase varied. In all site-years the maximum increase in root yield compared to the control was achieved with 28 L 10-34-0 banded in-furrow (Fig 1 left and right). Additional rates of 10-34-0 did not further improve yields.

Banding 11-52-0 was not as affective as banding 10-34-0 in any of the site-years where 11-52-0 was included (Fig 1 right). Sugar beet root yields were increased over the control, but 11-52-0 at the 13.5 kg P_2O_5 ha^{-1} rate never resulted in root yields as great as 28 L 10-34-0. Banding 11-52-0 at 18.0 kg P_2O_5 ha^{-1} (similar to that of 37 L 10-34-0) resulted in root yields similar to 28 L 10-34-0 in one of three site years.

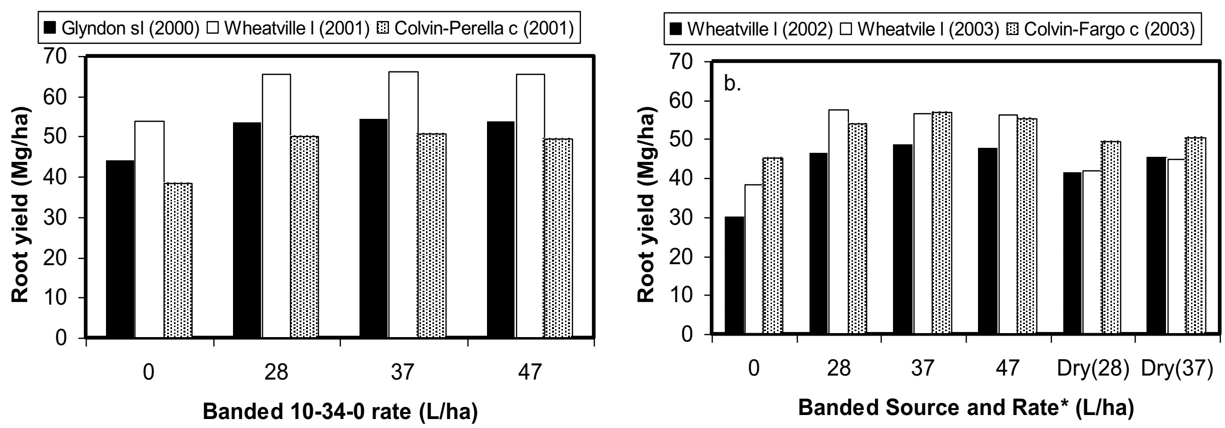

Figure 1. Typical sugar beet root yield response to three rates of 10-34-0 banded in furrow at Planting (left) and three rates of 10-34-0 and two rates of 11-52-0 banded in furrow at planting (right). Three specific site years are shown in each graph; but other site years had similar responses.

*Dry (28) and Dry (37) represent of 11-52-0 used to get same amount of P in the band as 28L and 37L of 10-34-0, 13.5 and 18.0 kg P_20_5 $ha^{-1,}$ respectively.

28 L 10-34-0 Banded by Broadcast Interactions

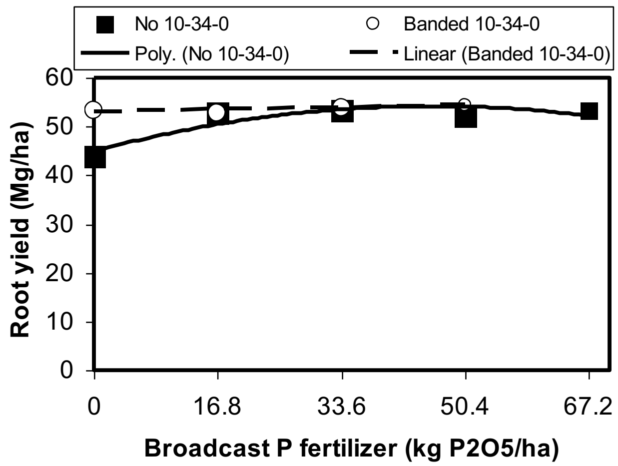

Figure 2. Sugar beet root yield response to broadcast P fertilizer rates with and without 28 L 10-34-0 banded in-furrow at planting for Glyndon sandy loam in 2000.

Over the 10 site-years of this experiment sugar beet root yield response fell into three categories: 1) a small response to both banded and broadcast fertilizer; 2) a small response to broadcast fertilizer, but a large response to banded fertilizer; and 3) a large response to both broadcast and banded fertilizer. In the first category, there was usually an increase in root yield with the first increment of broadcast fertilizer (16.8 kg P_2O_5 ha^{-1}) and a similar response with banded 28 L 10-34-0 (Fig 2). However, since maximum yield was achieved with 16.8 kg P_2O_5 ha^{-1} broadcast and 13.5 kg P_2O_5 ha^{-1} banded, it was not possible to determine which method of application was more effective or if the crop simply needed 13-17 kg P_2O_5. In the second category, sugar beet root yields increased with increasing broadcast P fertilizer rates, but the increase over the control was relatively small compared to the yield increase with banded 10-34-0 (Fig 3). In the last category, sugar beet root yields increased over the range of broadcast P fertilizer rates and maximum yields were substantially large compared to those in category 2. However, in category 3, the maximum root yield achieved with high rates of broadcast were also achieved with 28 L banded 10-34-0 (Fig 4). Regardless of the category of sugar beet root yield response to the treatments, yield response to 28 L 10-34-0 banded in-furrow always, without exception, equaled or exceeded root yield response to broadcast P rates. In addition, the level of root yield response achieved with 28 L 10-34-0 banded in-furrow could not be improved with additional P fertilizer broadcast and incorporated prior to planting.

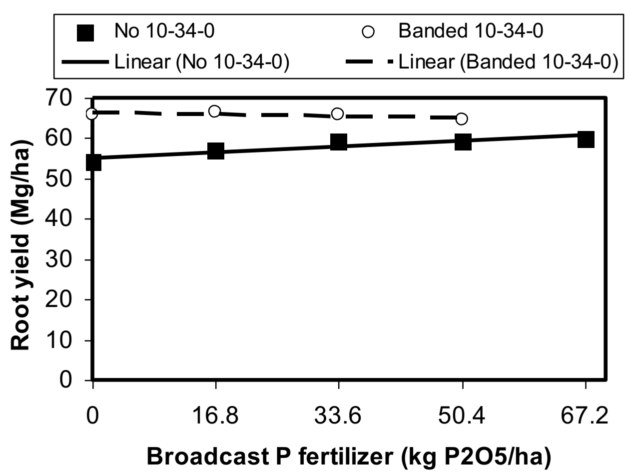

Figure 3. Sugar beet root yield response to broadcast P fertilizer rates with and without 28 L 10-34-0 banded in-furrow at planting for Wheatville loam in 2001

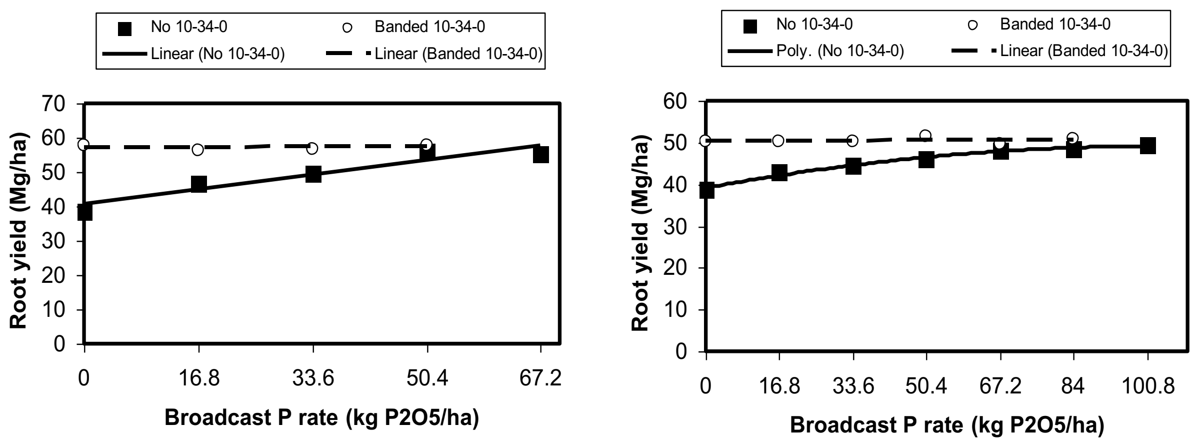

Figure 4. Sugar beet root yield response to broadcast P fertilizer rates with and without 28 L 10-34-0 banded in-furrow at planting for Wheatville loam in 2003 (left) and Colvin-Perella clay in 2001 (right).

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