STARTER AND DEEP BANDED P ON SUGARBEETS IN ALKALINE SOIL

Bryan Hopkins and Jason Ellsworth

ABSTRACT

Phosphorus (P) is an essential element for sugarbeet (*Beta vulgaris*) nutrition. Soils in the Western United States tend to be calcareous and have an alkaline pH, both of which reduce P solubility. Sugarbeets have difficulty exploiting the soluble P in 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 limited the adaptation of these techniques in Idaho. Little research has been done in the western US to determine optimal P starter fertilizer rates or forms. This project evaluated the effectiveness of two starter fertilizers, ammonium polyphosphate (APP) and phosphoric acid (PA), at two depths (0 and 2 inches below the seed) in various combinations of with and without deep banded (6 inches) or broadcast APP. Banded applications of APP resulted in a 2 ton per acre increase in sugarbeet yield, regardless of rate or placement depth. Multiplying sugar concentration by yield revealed similar results, but the increase was only significant for the deep banded treatments. Although the results of this study are promising, this data represents only the first year of a three year project.

INTRODUCTION

Studies in the North-Central US show significant increases in yield and revenue with the use of 3-5 gallons/acre of ammonium polyphosphate (APP) starter bands (12-20 lbs P_2O_5) used on sugarbeets (Lamb, 1986; Moraghan and Etchevers, 1980; Sims and Smith, 2001). These researchers found increased yields/revenue when a starter band was placed: 1) in direct seed contact, 2) two inches below the seed, and 3) two inches below and two inches 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 sugarbeets 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 that no advantage was gained by placing the starter band two inches below and to the side of the seed. Other research also supports the fact that optimum placement of phosphorous (P) for sugarbeets seems to be directly below the seed (Anderson and Peterson, 1978).

Although sugarbeet growers in the North-Central US 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 optimum starter P fertilizer

Presented at the Idaho Sugarbeet Conference on January 10, 2003.

placement and rates have been conducted in this region. Many growers in these areas 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 fertilizer using materials with a relatively 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 conducted in alkaline soils. Soils in the western states tend to have relatively high pH, carbonates, and salts, as well as low organic matter and clay content and, as a result, have increased likelihood of P deficiency, ammonia toxicity, salt injury, and surface crusting, as compared to the locations where the previously cited research was conducted. One objective of this study is to determine the effectiveness of starter band applications of P to sugarbeet in alkaline, calcareous soil.

In addition to a starter fertilizer effect, deep banding of P is becoming a more common practice in cropping systems with P nutrition problems not effectively solved with broadcast P applications. Phosphorus availability and diffusion rates increase when P is applied in a band application (Anderson and Peterson, 1978; Lamb, 1986; Moraghan and Etchevers, 1980; Sims and Smith, 2001). This may be especially important for sugarbeets because their root growth is primarily downward rather than horizontal to diagonal as observed in most other plant species (Anderson and Peterson, 1978). This is especially true during the first few weeks of the growing season (Anderson and Peterson, 1978). Considering sugarbeet root morphology and architecture, one objective of this study is to determine if deep-banded P enhances sugarbeet P nutrition and, if so, how does this affect final yield and sugar content?

MATERIALS & METHODS

The study was conducted in south central Idaho near Minidoka on an irrigated sugarbeet crop with an alkaline (pH 8.2-8.4), calcareous (10-16% free $CaCO_3$) soil with high soil test P (25-38 ppm bicarbonate extractable P). The properties of the soil used in this study are typical of those commonly observed in sugarbeet-producing regions of Idaho.

The treatments were arranged in a randomized complete block design with six replications. Treatments included combinations of P placement and fertilizer source to provide orthogonal comparisons of various combinations of the following: no P, broadcast P, APP starter bands, phosphoric acid (PA) starter bands, and deep APP bands. Twelve treatments were selected (Table 1).

Zero, low, and high rates of P were applied (0, 20, and 200 lb P_2O_5/ac, respectively). The low rate is consistent with amounts found in previous research to give adequate starter P response on low to medium P testing soils. The rate for the high P treatments were intended to be based on University of Idaho fertilizer recommendations for sugarbeets, however, the initial soil test for the plot area was provided by a commercial laboratory that significantly underestimated the P availability in the soil. Further analysis by other laboratories showed that the soil test levels were 2-3 times higher than originally measured. As a result, the rate of P applied for the high rate plots were based on a soil test of 13 ppm bicarbonate P, rather than the actual level of >25 ppm.

Nitrogen was balanced across all plots with a broadcast application of ammonium nitrate (34-0-0). The amount of nitrogen applied to balance the treatments was subtracted from the total amount recommended and applied based on soil test and yield goal.

Normal cultural management practices were followed in raising the crop. The individual plots were established as six 40 foot rows on 22 in centers. The broadcast applications were applied and tilled into the soil at final ground preparation. The subsurface bands were applied after hilling and prior to planting. These bands were placed directly below the seed zone at 2 and/or 6 inches below the soil surface. The surface band was applied immediately after planting by spraying the fertilizer material directly over the seed zone. All treatments were applied the day of planting.

Fertilizer application and planting occurred on April 24, 2002. High winds and freezing temperatures over the first two weeks resulted in a need to replant, which occurred on May 13, 2002. Unfortunately, the replant operation broke the heavy surface crust and negated the evaluation of the effects of PA on crusting.

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 twice during the season at 45 and 74 d after planting. Plant samples are being analyzed for N and P concentration, although the data is not completed for inclusion in this report at this time (partial data for the P shows differences in uptake, but the data set is not yet complete). Harvest occurred on October 17 or 157 d after planting. Statistical analysis was performed using ANOVA and means were separated by LSD with an alpha level of 0.05.

RESULTS AND DISCUSSION

In general, banded P fertilization increased overall yield (Fig. 1) when applied as APP, regardless of rate or placement. Starter band applications of APP applied either on the soil surface (treatment 3) or 2 in below the seed (treatment 5) increased yield compared to the check, although treatment 3 was only significant when α=0.10. All of the deep banded P (6 inches below surface) treatments increased yield, although treatment 11 with PA was only significant when α=0.10. Treatments with banded PA alone or broadcast APP alone did not increase yield. No further yield advantage was observed in the treatments with the APP starter bands combined with the deep band.

Combining treatments for orthogonal comparisons reveals similar trends as those discussed above (Fig. 2). Broadcast and PA only treatments were not significantly different from the check plots. Adding APP in a starter band, either at the soil surface or 2 in below, resulted in nearly a 2 ton per acre yield advantage. Similarly, adding APP at the high rate 6 in below the soil surface resulted in a significant yield increase whether or not it was combined with the various starter bands.

It seems apparent that the sugarbeet crop in this study benefited from banded application of APP regardless of rate or depth. Why did the APP bands show a yield response when the PA bands did not? The first possibility is that the banded ammonium and/or a combination of banded ammonium with P are responsible for yield increase. Research at the University of Wyoming showed that banded N applications to sugarbeet resulted in significant yield increases (Blaylock, personal communication, 2002). Another possibility is that the precipitation products formed from the application of the PA actually reduced P availability over the course of the season. There is evidence that the P precipitates that form after PA is applied to an alkaline soil have enhanced solubility in the short term due to the favorably low pH. But, as the overall soil pH dilutes the acidic soil band the calcium phosphates that form are actually less soluble than those that are present if a neutral pH form of P is applied (Stark, personnel communication, 2002). Further work is being conducted to elucidate whether the lack of response for the PA bands is primarily due to the absence of banded ammonium or the formation of insoluble P precipitates.

Additionally, it is a common phenomenon in sugarbeet research to observe decreases in sugar concentration that effectively negates any yield increase effect. The yield increases observed in this study did not result in sugar percentage decline. As a result, sugar yield showed similar trends as the overall yield, although the starter band only treatments were not statistically different from the untreated check (Table 2). In general, the treatments with P banded 6 in below the surface resulted in increased sugar yield, although the 6 in band combined with a 2 in PA band (trt 11) was not significantly different from the check plots. Economical interpretation of these results would be dependent upon whether growers' sugarbeet contracts favored overall yield or sugar yield.

CONCLUSIONS

Banded applications of APP resulted in increased sugarbeet yield, regardless of rate or placement depth. PA band and APP broadcast applications did not increase sugarbeet yield. Percent sugar content was not significantly different; 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. Broadcast APP and PA starter bands did not increase sugar yields.

It should not be assumed that the responses observed were completely due to P nutrition. The PA treatments that contained banded P without N did not result in increased yields. There are three possible explanations for these results. First, the response to the banded N + P treatments (APP) was due primarily to enhanced P nutrition and the reason for the lack of response to PA was due to P availability problems induced by the low pH. Second, the responses observed were due entirely to a banded N response. Or, third, the responses observed were due to a synergistic effect of both banded N & P. Although this study represents only one site year of data, the trends are compelling and warrant further investigation. Efforts will be made in future studies to differentiate between the effects of banded N and banded P.

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ACKNOWLEDGEMENTS

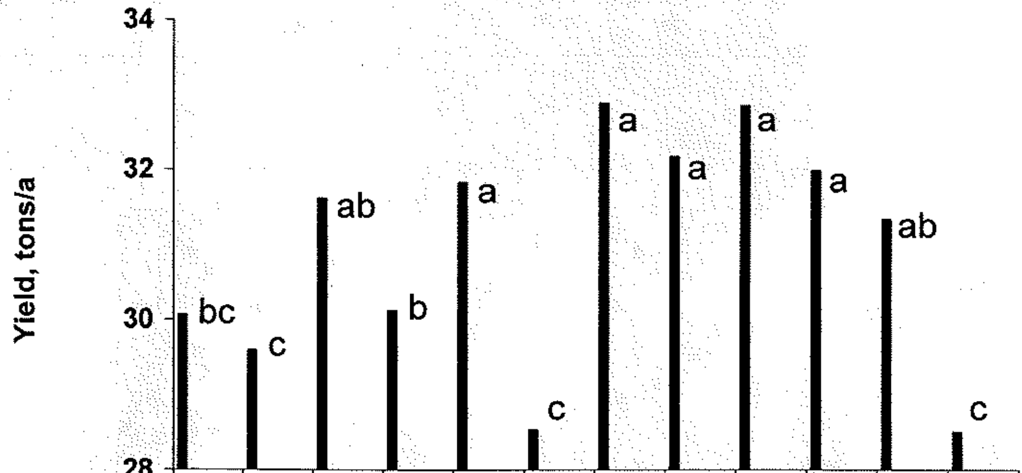
Sincere appreciation is expressed to the Fluid Fertilizer Foundation for providing the funding for this project. Appreciation is also expressed to Simplot and MDS Harris Laboratories for providing supplemental support for this project. Gratitude is also expressed to Terry Miller of Miller Research for providing the land and equipment and Drs. Jeff Stark and John Gallian (University of Idaho), Dr. Alan Blaylock (Agrium), and Dr. Terry Tindall (Simplot) for their technical expertise for this project.

Table 1. Sugarbeet P placement study fertilizer treatments (Minidoka, ID 2002). APP = ammonium polyphosphate; PA = phosphoric acid.

		Total P	Broadcast APP	Surface Band		2” Band		6” Band APP	Band N APP
				APP	PA	APP	PA		
1	Check	0							
2	Low Broadcast	20	20						
3	Low Surface Band APP	20		20					6
4	Low Surface Band PA	20			20				
5	Low 2” Band APP	20				20			6
6	Low 2” Band PA	20					20		
7	High Broadcast + 6” Band	220	20					200	65
8	High Surface Band APP + 6 “ Ba	220		20				200	65
9	High Surface Band PA + 6” Band	220			20			200	65
10	High 2” Band APP + 6” Band	220				20		200	65
11	High 2” Band PA + 6” Band	220					20	200	65
12	High Broadcast	220	220						

Table 2. Sugar concentrations and tonnage for the sugarbeet P placement study. Although sugar percentages were not significantly different, combining this data with total yield reveals differences in total sugar yield. In general, the treatments with P banded 6 inches below the surface resulted in increased sugar yield. Means followed by the same letter are not significantly different from one another (alpha 0.05).

#	Treatment	Sugar, %	Sugar, tons/a	
1	check	18.1	5.43	cd
2	low broadcast	17.2	5.10	de
3	low surface band APP	17.7	5.61	bc
4	low surface band PA	17.8	5.35	cde
5	low 2" band APP	17.6	5.60	bc
6	low 2" band PA	18.3	5.21	de
7	high broadcast + 6" band	17.6	5.78	ab
8	high surface (APP) + 6" band	18.0	5.79	ab
9	high surface (PA) + 6" band	18.4	6.03	a
10	high 2" (APP) + 6" band	18.5	5.91	ab
11	high 2" (PA) + 6" band	17.8	5.59	bc
12	high broadcast	17.9	5.09	e
	LSD	NS	0.33	



	1	2	3	4	5	6	7	8	9	10	11	12
Yield, tons/a	30.1	29.6	31.6	30.1	31.8	28.5	32.9	32.2	32.9	32.0	31.3	28.5
Total P, lbs P2O5/a	0	20	20	20	20	20	220	220	220	220	220	220
Broadcast, lbs P2O5/a		20					20					220
Surface APP, lbs P2O5/a			20					20				
Surface PA, lbs P2O5/a				20					20			
2" APP Band, lbs P2O5/a					20					20		
2"PA Band, lbs P2O5/a						20					20	
6" Band, lbs P2O5/a							200	200	200	200	200	

Fig. 1. Sugarbeet yield data for P placement study (Minidoka, ID 2002). Starter band applications of ammonium polyphosphate (APP) applied either on the soil surface (trt. 3) or 2 in below the seed (trt. 5) increased yield as compared to the check plots, although trt. 3 was only significant at the alpha 0.10 level. All of the treatments with deep banded P (6 in below surface) increased yield, although trt. 11 with phosphoric acid (PA) was only significant when α=0.10. Treatments with banded PA alone or broadcast APP alone did not increase yield. Banded treatments were all placed directly above or below the seed. Treatment bars with the same letters to the side are not significantly different from one another (α=0.05).

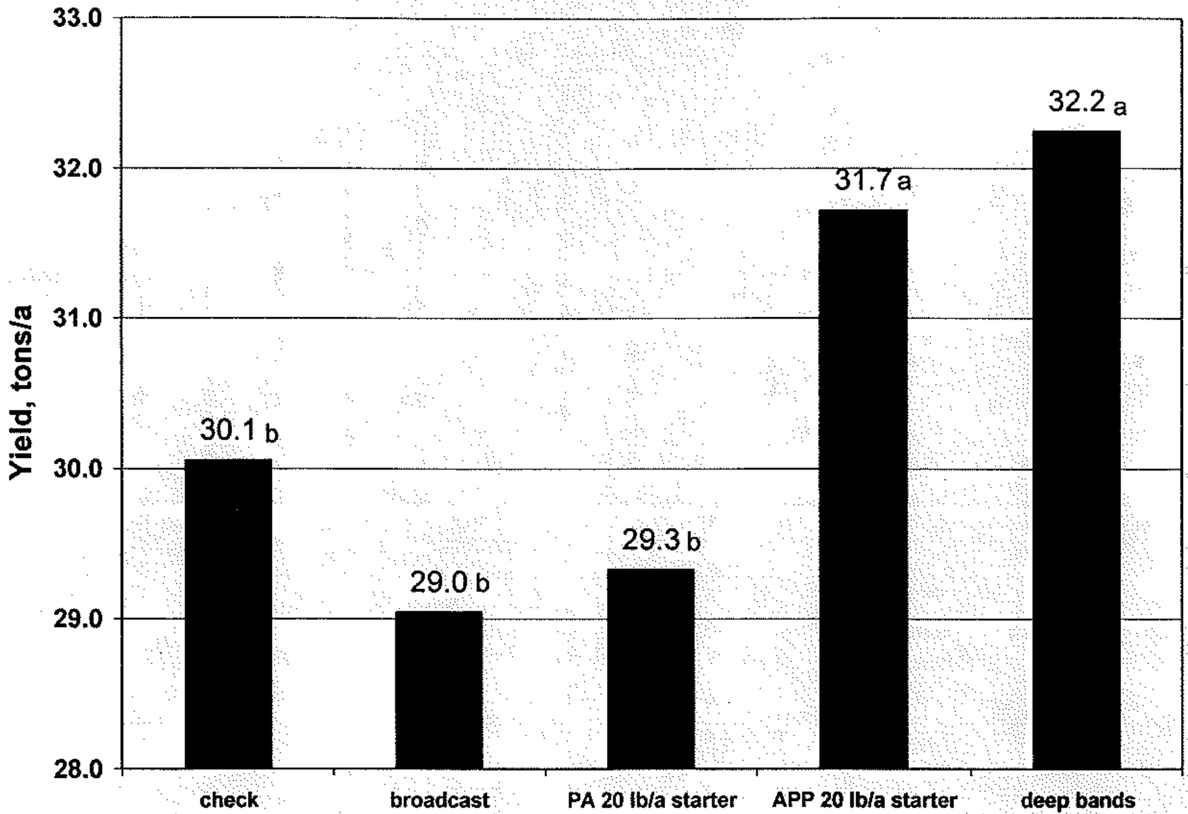


Fig. 2. Combined treatment comparisons for sugarbeet P placement study (Minidoka, ID 2002). Combined across rates, broadcast treatments did increase yield as compared to the check plots. Similarly, treatments consisting of phosphoric acid (PA) starter bands only, combined across depths, did not increase yields. However, treatments consisting of ammonium polyphosphate (APP) starter bands only did increase yield similar to that observed with those treatments that included a 6 in deep below the seed deep P band. Means followed by the same letter are not significantly different from one another (α=0.05).