The Effect of Method and Rate of Phosphate Application On Yield and Quality of Sugar Beets[1]

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The frequent need for phosphate fertilizer for sugar beet production in Colorado is recognized, and the annual rate of application has been about 100 lb P_2O_5 (44 lb P) per acre (1)[3]. Efficient methods of application of phosphate fertilizer are required to insure high yields and high quality of roots. The objective of this study was to determine the influence of method of application of phosphate fertilizer on yield and quality of sugar beets. Two rates of phosphate were applied to determine if a method $\times$ rate interaction would appear.

Experimental Procedure

The experiment was conducted on a calcareous Larimer fine sandy loam which contained 37 lb of available P_2O_5 (16 lb P) per acre by the $NaHCO_3$ test (4). The site had been in irrigated grass pasture for 17 to 18 years, then planted to alfalfa for one year with a barley nurse crop before the sugar beet experiment. There was no record of previous fertilizer application. Concentrated superphosphate was applied at two rates, 50 and 200 lb P_2O_5 (22 and 88 lb P) per acre by; 1) broadcasting the fertilizer on the surface and plowing under with the legume and grain stubble, 2) a broadcast application after plowing mixed 3 to 4 inches into the surface by disking, 3) a split application with one half the fertilizer plowed under and the remainder disked into the surface, 4) banding the phosphate 1½ to 2 inches below the seed and 5) plowing under 150 lb and banding 50 lb P_2O_5 below the seed. The treatments were replicated four times. Nitrogen at the rate of 150 lb N per acre was broadcast uniformly over the experimental area and mixed 3 to 4 inches into the surface with the disking operation.

The crop was planted April 15, 1958. Stands were good on all treatments and growing conditions were generally good throughout the season. Petioles were taken at three sampling dates and analyzed for acetic acid-soluble phosphorus (2). The beets were harvested October 22. Root weights and sucrose

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[3] Numbers in parentheses refer to literature cited.

content were determined. The data were analyzed statistically. A "significant" effect, as used in the text, indicates that the odds are 19 to 1, or greater, that the observed result was caused by the imposed treatment rather than by chance.

Results and Discussion

Beet and sugar yields and percentage sucrose are presented in Table 1. The method of application of phosphate had little influence on final yield of roots, sucrose content or sucrose production; nor was there a significant interaction for rate × method-of-application. The yield of beets was increased nearly 4 tons per acre by the application of 50 lb P_2O_5. Applying an additional 150 lb P_2O_5 increased the yield another 1½ tons above that of the 50-lb rate. Sucrose percentage did not appear to be influenced by either method or rate of phosphate application. Quality of beets, using sucrose percentage as the index, was maintained with the application of 150 lb N applied uniformly to the area. Yield of sugar was a reflection of beet yield.

Table 1.—The effect of method and rate of application of phosphate fertilizer on yield of beets, percent sucrose and sugar production.

Method of application of phosphate	50 lb P_2O_5 per acre			200 lb P_2O_5 per acre		
	Roots tons/A	Sucrose %	Sucrose tons/A	Roots tons/A	Sucrose %	Sucrose tons/A
Plow under	17.3	20.0	3.46	18.5	20.4	3.77
Disk	17.4	19.8	3.44	19.5	19.6	3.82
Split (plow & disk)	16.8	20.1	3.38	19.4	19.6	3.80
Band below seed	17.7	19.9	3.52	18.4	19.5	3.59
Plow 150 lb, band 50 lb	----	----	----	18.3	20.0	3.66
Avg.[1]	17.3	20.0	3.45	19.0**	19.8	3.73*
Significance—method of appl.	N.S.	N.S.	N.S.	N.S.	N.S.	* N.S.

*Greater than 50 lb P_2O_5 rate at 0.05 level of significance.
**Greater than 50 lb P_2O_5 rate at 0.01 level of significance.
[1] No phosphorus treatment: 13.5 tons roots, 20.2% sucrose, 2.73 tons sucrose.

The effect of the phosphate treatment on acid-soluble phosphorus in the petioles is shown in Table 2. Application of phosphate fertilizer increased petiole phosphorus over the no-phosphorus treatment in every case except for the first sampling where 50-lb P_2O_5 had been disked into the soil. Early in the season (June 17) petiole phosphorus was significantly higher for the band-applied phosphate than for the other methods of application at the 50-lb rate of fertilization. With the 200-lb rate there was little difference between band, plow-down and split (plow-disk) applications but petiole phosphorus was significantly

Table 2.—The effect of method and rate of application of phosphate fertilizer on acetic acid soluble phosphorus in beet petioles at different stages of growth.

Method of application	50 lb P_2O_5[1]			200 lb P_2O_5		
	Sampling date			Sampling date		
	June 17	July 22	Aug. 13	June 17	July 22	Aug. 13
	ppm P					
Plow under	2100	1750	1200	2600	2450	1500
Disk	1550**	1300**	950	1850**	2050**	1300
Split (plow-disk)	1950	1700	1000	2500	2050	1650
Band below seed	2400**	1600	1200	2450	1900**	1250
Plow 150 lb band 50 lb	.....	.....	.....	2650	2300	1400

**Significantly different at the 0.01 level from plow-under method of application at the same rate of phosphate and the same sampling date.

[1] Acid soluble phosphate in the no-phosphorus treatment was 1600, 1050, and 600 ppm P for the June, July and August samplings, respectively.

lower for the disk application. For the July sampling, band, disk and split (plow-disk) methods of application were less effective, as indicated by petiole phosphorus, than the plow method of application. The sampling on August 13 showed little influence of method of application on petiole phosphorus. Petiole phosphorus for the combination of plow-under and banded phosphate was about the same as 200 lb P_2O_5 plowed under.

The interaction rate $\times$ method-of-application was significant for petiole phosphorus for the first and second sampling dates. This was caused by a relatively greater effectiveness of the plow-down method of application, as shown by petiole phosphorus, at the 200 lb rate than at the 50 lb P_2O_5 rate.

At all sampling dates and particularly for the plow and disk methods of application, increasing the rate of phosphate significantly increased the acid-soluble phosphorus content of the petiole. An early stimulation in top growth from phosphate fertilizer was observed, but the early visual effects were caused largely by phosphate rate rather than method of application.

The results of the experiment show that phosphorus fertilizer increased both root and sugar yields of beets grown in this phosphate-deficient soil. Early and midseason petiole measurements of acid-soluble phosphorus, however, were not a reliable index of the influence of method of fertilizer application on yield or quality of the crop at harvest. On the other hand, the late season sampling appeared to be more closely associated with yield. The seasonal change in compostion of the petiole would tend to support the thesis that the bulk of the absorptive root tissue of the sugar beet does not remain in the vicinity of a concentrated band of fertilizer but for a short time early in the

season. Other work in Colorado (5,8) has shown the influence of a band or concentrated placement of fertilizer is dependent upon the relative positions of fertilizer and seed and will change as the season progresses. The small effect of method of application of phosphate on crop yields suggest that the sugar beet plant has great ability to adapt to the environment.

Results of research in Montana (3), Colorado (8) and Wyoming (6) have shown that plowing down an application of phosphate fertilizer was generally as good or better, as indicated by crop yields, than band or surface applications. Incorporation of phosphate by disking the light-textured soil of this experiment was possibly more effective than with a heavier-textured soil. Since the soil was light in texture at the surface, more frequent early irrigations were required. This would have promoted more root growth in the top soil and could have caused relatively better results from the disked applications than often observed. At the same time, the band application should have benefited from the irrigation management.

The application of phosphate had no significant effect on the sucrose content of the root. Other results in Colorado (8) and in Nebraska (7) would suggest that applications of phosphate may increase the sucrose content of the root when applied to soils very low in available phosphate but would have little influence when applied to soils intermediate to high in available soil phosphorus.

Summary

A field experiment was conducted to study the yield and quality of sugar beets as affected by method and rate of application of phosphate fertilizer on a phosphate-deficient, calcareous soil.

1. The phosphate applications increased yield of beets and sugar production.
2. There were no significant differences in yield or sucrose content among methods of phosphate application for either 50 or 200-lb P_2O_5 rates; nor was there a method $\times$ rate interaction.
3. The early growth response to band-applied phosphate as shown by visual observations and chemical composition of the petioles did not continue through the season or result in enhanced yields for this treatment.
4. Yield responses to phosphorus fertilizer were more closely associated with late rather than with early season petiole analyses.

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