

# The Interaction of Rates of Phosphate Application With Fertilizer Placement and Fertilizer Applied at Planting Time on the Chemical Composition of Sugar Beet Tissue, Yield, Percent Sucrose, and Apparent Purity of Sugar Beet Roots<sup>1</sup>

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An experiment was initiated in 1959<sup>3</sup> with the following objectives: 1) determining the minimum amount of phosphate fertilizer to be applied at planting time in relation to the total application without significantly decreasing the early growth or final yield of roots, and 2) the amount of preplant phosphate required to best complement the planting-time fertilizer. An additional objective was included in 1961 in which the method of placement of the planting-time fertilizer and its interaction with the amount of preplant phosphate was investigated.

## Materials and Methods

This experiment was established at the Monitor Sugar Company farm located near Bay City, Michigan, on a calcareous Kawkawlin-Wisner loam soil complex with pH of 7.5. For the sugar beet crop, four rates of P<sub>2</sub>O<sub>5</sub> were broadcast ahead of planting: 0, 200, 400, and 800 pounds per acre. A basic application of 200 pounds of KCl was plowed under. Treatments were replicated three times in the east-west direction of the field. Superimposed on these areas were three rates of fertilizer: 0, 150, and 300 pounds of 6-24-12 per acre. The 6-24-12 fertilizer contained 2% manganese and 1/2% boron. The fertilizers were applied in two ways: 1) in a band 1 1/2 inches to the side and 3 inches below the seed, and 2) 3 inches directly below the seed. The rows were planted across the plots where P<sub>2</sub>O<sub>5</sub> was broadcast. The planting-time fertilizer application was replicated three times. Sixty pounds of N per acre as anhydrous ammonia was applied as a sidedressing to all plots.

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<sup>3</sup>Davis, J. F., Grant Nichol and Don Thurlow. 1961. The effect of phosphorus fertilization and time of application on chemical composition of foliage on yield, sucrose content, and percent purity of sugar beet roots. *J. Am. Soc. Sugar Beet Technol.* 11(5): 406-412.

Plot size was four 28-inch rows by 66 feet. Monogerm beet seed variety SL122  $\times$  SP5460 was planted April 13. Stand counts were taken May 11. Plant samples of 100 plants per plot were taken June 2, 1961, oven-dried at 65 degrees Centigrade, weighed and analyzed for phosphorus, potassium, and calcium. Petiole samples were taken at three different dates, July 11, August 3 and September 11. A portion of each sample was extracted with a 10% sodium acetate in 3% acetic acid solution (1 to 20 ratio of green tissue to solution) and the percent of phosphorus determined. The remainder of the tissue was dried and analyzed for total calcium, phosphorus and potassium using a perchloric acid digestion procedure. The beets were harvested October 10, and the number, yield, percent sucrose, and percent apparent purity were determined.

### Results and Discussion

The number of plants for the various treatments per 50 feet of row was as follows: 193 plants where 300 pounds of 6-24-12 fertilizer was applied 3 inches below the seed as compared to 184 plants where 300 pounds was applied 1½ inches to the side and 3 inches below the seed. For the 150 pound rate, the number of plants was 190 and 182, respectively. Disregarding placement the average number of plants where 0, 150, and 300 pounds of 6-24-12 were applied was 185, 186 and 189 plants per 50 feet of row.

The effect of fertilizer treatment and the weight and chemical composition of the plant samples taken June 6 are recorded in Table 1.

Fertilizer applied at planting time increased the early growth of the plant, the percent phosphorus in the tissue, and the uptake of phosphorus. Phosphate plowed down, in general, caused similar effects. As preplant phosphate was increased, the effect of fertilizer applied at planting time on the percentage of phosphorus in the tissue was decreased.

There was a marked effect of the placement of the 6-24-12 planting-time fertilizer on the early growth and nutrient uptake by the beets. Fertilizer applied 3 inches below the seed increased the weight of beets and the uptake of each of the nutrients. However, there was a trend for the percentage of P and Ca in the tissue to decrease, although not always significantly so<sup>4</sup>, where the fertilizer was applied directly below the seed as compared to fertilizer applied 1½ inches to the side of and 3 inches below the seed.

<sup>4</sup> Where the term "significant," applying to differences, is mentioned, the 5% level is indicated.

Table 1.—The effect of time and method of application of fertilizer on the weight and chemical composition of sugar beet plants at blocking time (6-2-61). (Monitor Sugar Co., 1961)

P <sub>2</sub> O <sub>5</sub> plowed under	6-24-12 planting time	Placement <sup>1</sup> of fertilizer	Grams per <sup>2</sup> 100 plants	Nutrient on dry weight basis			Total uptake in grams		
				% P	% Ca	% K	P	Ca	K
0	0	.....	10.2 l	.377 g	2.42 a	5.14 de	.038	.247	0.52
		Side	16.8 kl	.535 ef	2.13 b	5.55 cde	.090	.358	0.93
		Under	39.6 def	.527 f	1.99 bcd	5.07 de	.209	.788	2.18
	300	Side	20.4 ijk	.537 ef	2.14 ab	6.24 ab	.110	.436	1.3
		Under	52.5 bc	.575 cdef	1.83 d	6.75 ab	.302	.961	3.5
		.....	17.2 kl	.552 def	2.12 bc	4.97 de	.095	.365	0.86
200	150	Side	28.8 ghij	.618 abc	2.06 bcd	5.65 cde	.178	.593	1.63
		Under	44.2 cde	.579 cdef	1.99 bcd	5.60 cde	.256	.880	2.48
		.....	29.5 ghi	.632 abc	2.13 b	5.95 bcd	.186	.628	1.76
	300	Side	61.7 ab	.588 bcde	1.88 bcd	7.13 a	.363	1.160	3.40
		Under	20.2 jk	.624 abc	2.09 bcd	4.64 c	.126	.422	0.94
		.....	31.3 fgh	.615 abc	2.04 bcd	5.27 cde	.192	.648	1.66
400	150	Side	45.8 cd	.603 abcd	2.00 bcd	5.05 de	.276	.916	2.31
		Under	34.4 fgh	.657 a	1.93 bcd	5.93 bcd	.226	.664	2.04
		.....	57.5 ab	.617 abc	1.99 bcd	6.92 ab	.355	1.144	3.98
	300	Side	25.4 high	.633 abc	1.97 bcd	4.59 c	.161	.500	1.17
		Under	35.9 efg	.642 ab	2.04 bcd	4.98 de	.230	.732	1.79
		.....	56.0 b	.603 abcd	2.00 bcd	5.47 cde	.338	1.120	3.06
800	150	Side	40.7 def	.622 abc	1.95 bcd	5.44 cde	.253	.794	2.21
		Under	66.7 a	.595 bcd	1.84 cd	6.97 ab	.396	1.224	4.64
		.....							

<sup>1</sup>Side — 1½" to side of and 3" below seed.

Under — 3" below seed.

<sup>2</sup>All data with the same literal postscripts are not significantly different from each other at the 5% level.

Table 2.—The effect of time and method of application of fertilizers on the phosphorus composition of sugar beet petioles at three sampling dates. (Monitor Sugar Co., 1961)

P <sub>2</sub> O <sub>5</sub> plowed under	6-24-12 planting time	Placement <sup>1</sup> of fertilizer	7-11-61 <sup>2</sup>		8-3-61		9-11-61	
			P in green tissue	Total P	P in green tissue	Total P	P in green tissue	Total P
0	0	-----	.111 d	.182 c	.051 i	.143 ef	.102 d	.198 cd
	150	Side	.097 d	.145 d	.063 hi	.162 def	.121 d	.187 d
		Under	.111 d	.170 cd	.059 hi	.152 ef	.114 d	.188 d
	300	Side	.112 d	.165 cd	.040 i	.123 f	.125 d	.212 cd
Under		.114 d	.168 cd	.056 i	.162 def	.107 d	.213 cd	
200	0	-----	.222 abc	.292 ab	.096 fg	.204 cde	.250 abc	.307 a
	150	Side	.225 abc	.285 ab	.116 bcdefg	.205 cde	.198 c	.247 bc
		Under	.212 abc	.276 b	.090 gh	.224 bcd	.229 abc	.298 ab
	300	Side	.238 abc	.272 b	.103 efg	.232 bc	.213 bc	.295 ab
Under		.200 c	.269 b	.113 cdefg	.233 bc	.213 bc	.285 ab	
400	0	-----	.245 ab	.315 a	.122 abcdefg	.260 abc	.284 a	.315 a
	150	Side	.236 abc	.303 ab	.105 efg	.238 bc	.236 abc	.270 ab
		Under	.228 abc	.291 ab	.127 abcdef	.256 abc	.264 ab	.323 a
	300	Side	.220 abc	.283 ab	.109 defg	.249 abc	.263 ab	.298 ab
Under		.209 abc	.272 b	.125 abcdef	.270 abc	.231 abc	.288 ab	
800	0	-----	.250 a	.313 a	.147 abc	.292 ab	.255 abc	.307 a
	150	Side	.244 abc	.303 ab	.155 a	.312 a	.235 abc	.290 ab
		Under	.226 abc	.300 ab	.136 abcde	.265 abc	.253 abc	.306 a
	300	Side	.205 bc	.287 ab	.141 abed	.287 ab	.251 abc	.307 a
Under		.234 abc	.298 ab	.150 ab	.256 abc	.243 abc	.317 a	

<sup>1</sup>Side — 1½" to side of and 3" below seed.

Under — 3" below seed.

<sup>2</sup>All values reported on an oven-dry weight basis. Green tissue extracted with a 10% sodium acetate in 3% acetic acid solution (1:20 ratio of green tissue to solution). Moisture content of green tissue approximated 90%.

Potassium applied at planting time increased the percent potassium in the tissue and also the total uptake. More potassium was taken up where the 300 pounds of 6-24-12 was applied than where the 150 pounds was used. There was a trend for a higher amount of potassium both percentagewise and total uptake to occur where the fertilizer was applied directly below the seed than where it was applied to the side and below the seed, particularly where the higher rate of potash was applied.

There was a trend for the calcium in the tissue to decrease as the weight of the tissue increased. The percent of calcium in plant tissue was decreased when fertilizer was applied. The lowest percentage of calcium was found where the fertilizer was placed in a band directly below the seed. However, the total uptake of calcium was more dependent on the yield of the beet tissue at blocking time than on the amount of fertilizers applied either at planting time or when preplanting applications were made.

The phosphorus composition of the petioles (Table 2) increased as the phosphate applied prior to planting increased. The amount of phosphate applied at planting time did not appreciably affect the percent of phosphorus in the petioles. The amount of phosphorus in the tissue decreased from that contained in the tissue at blocking time for all subsequent sampling dates. The phosphorus content of the tissue taken September 11 was about equal to that obtained from the July 11 sampling whereas the P content of tissue sampled August 3 was lower than that sampled at any other date. Placement of planting-time fertilizer did not materially affect the percent of phosphorus in the tissue at any of the sampling dates.

A larger percentage of the total phosphorus in the plant was accounted for in the green tissue where a preplanting application of phosphate was made.

The percent of potassium (Table 3) in the sugar beet petioles decreased with each successive sampling date. In general, the percent potassium was highest in the petioles of the beet plants where no planting-time fertilizer was applied. The method of applying the planting-time fertilizer did not have any definite effect on the percent of potassium in the petioles. The percent of calcium (Table 3) in the tissue was lower at the July 11 sampling date than at blocking time but was higher at the August 3 sampling date. It then decreased on September 11 sampling date below that obtained at any other of the sampling periods. The amount of fertilizer whether plowed down or applied at planting time did not materially affect the percent of calcium in the tissue.

Table 3.—The effect of time and method of application of fertilizer on the calcium and potassium contents of sugar beet petioles at three sampling dates (Monitor Sugar Co., 1961)

P <sub>2</sub> O <sub>5</sub> plowed under	6-24-62 planting time	Placement <sup>1</sup> of fertilizer	7-11-61 <sup>2</sup>		8-3-61		9-11-61	
			Total K	Total Ca	Total K	Total Ca	Total K	Total Ca
0	0		5.15 a	1.29 bc	4.34 a	1.53 abc	3.99 abc	1.03 abc
	150	Side	4.75 abc	1.66 a	4.14 abc	1.36 abcd	3.87 abc	1.13 ab
		Under	4.77 abc	1.29 bc	3.82 abc	1.44 abcd	3.59 abc	.91 abc
	300	Side	4.86 ab	1.28 bc	3.95 abc	1.59 a	4.12 abc	1.18 a
		Under	4.49 abcd	1.32 b	4.18 abc	1.57 ab	4.39 a	.99 abc
	200	0	-----	4.35 bcd	1.11 bc	3.58 c	1.21 cd	4.10 abc
150		Side	4.22 bcd	1.13 bc	4.15 abc	1.42 abcd	3.51 bc	.99 abc
		Under	4.28 bcd	1.14 bc	3.87 abc	1.43 abcd	4.12 abc	.87 bc
300		Side	4.32 bcd	1.20 bc	3.93 abc	1.37 abcd	4.09 abc	1.01 abc
		Under	4.17 bcd	1.18 bc	3.92 abc	1.30 abcd	4.33 ab	1.05 abc
400		0	-----	4.35 bcd	1.27 bc	3.66 bc	1.24 bcd	3.78 abc
	150	Side	4.14 cd	1.21 bc	3.69 abc	1.32 abcd	3.79 abc	1.00 abc
		Under	4.01 d	1.29 bc	3.93 abc	1.35 abcd	4.22 ab	.91 abc
	300	Side	4.19 bcd	1.18 bc	3.74 abc	1.41 abcd	4.24 ab	1.04 abc
		Under	3.99 d	1.18 bc	3.88 abc	1.28 abcd	4.00 abc	.91 abc
	800	0	-----	3.91 d	1.14 bc	4.03 abc	1.16 d	3.79 abc
150		Side	4.20 bcd	1.14 bc	4.20 ab	1.25 abcd	3.37 c	.90 bc
		Under	4.04 d	1.10 bc	3.89 abc	1.15 d	4.00 abc	.84 c
300		Side	4.15 cd	1.05 bc	4.04 abc	1.24 bcd	3.97 abc	.87 bc
		Under	4.20 bcd	1.02 c	4.10 abc	1.24 bcd	4.15 abc	.93 abc

<sup>1</sup>Side — 1½" to side of and 3" below seed.

Under — 3" below seed.

<sup>2</sup>All percentage values based on oven-dry weights.

The number of beets harvested per plot (128 feet of row) was significantly influenced by fertilizer treatments. The number of beets per plot where 0, 200, 400, and 800 pounds of  $P_2O_5$  were plowed under was 119, 124, 127, and 128, respectively. The number was higher where phosphate was plowed under. Similarly, 6-24-12 fertilizer applied at planting time significantly increased the number of harvested beets per plot from 118 where no fertilizer was used to 127 where fertilizer was used. There were 127 beets per plot where the fertilizer was placed 3 inches below the seed as compared to 121 beets for the side band placement ( $1\frac{1}{2}'' \times 3''$ ). This difference was significant.

Data in Table 4 show that the highest yield of beets was obtained where the maximum amount of fertilizer was applied. The effect of planting-time fertilizer was greatest where no preplant application of phosphate was made. However, there was a trend for planting-time fertilizer to increase beet yields regardless of whether phosphate had been plowed under or not. This effect decreased as the amount of phosphate plowed under increased.

Table 4.—The effect of time and method of application of fertilizer on the yield, percent sucrose and percent purity of sugar beets (Monitor Sugar Co., 1961).

$P_2O_5$ plowed under	6-24-12 planting time	Placement* of fertilizer	Tons per acre	Percent sucrose	Percent purity	Lbs. gross sugar per acre
	Lbs./acre					
0	0	—	13.2 i	14.5	87.7	3357
		Side	14.3 hi	—	—	—
	150	Under	17.9 abcdef	15.0	89.4	4800
		Side	15.3 fghi	15.4	89.0	4194
		Under	17.3 bcdefg	14.7	88.9	4522
		Side	15.0 ghi	15.2	90.7	4136
200	0	—	15.0 ghi	15.2	90.7	4136
		Side	15.4 fghi	—	—	—
	150	Under	17.0 cdefg	15.3	91.1	4739
		Side	16.0 efgh	14.3	87.7	4013
		Under	16.5 defgh	15.7	91.2	4725
		Side	14.7 ghi	15.4	90.6	4102
400	0	—	14.7 ghi	15.4	90.6	4102
		Side	16.6 cdefgh	—	—	—
	150	Under	18.0 abcdef	14.8	85.3	4545
		Side	16.8 cdefg	15.1	87.4	4434
		Under	18.4 abcde	15.2	89.2	4989
		Side	17.9 abcdef	15.6	86.4	4825
800	0	—	17.9 abcdef	15.6	86.4	4825
		Side	19.2 abcd	—	—	—
	150	Under	20.0 ab	15.5	89.2	5530
		Side	19.3 abc	15.2	88.1	5169
		Under	20.6 a	15.1	86.9	5406
		Side	—	—	—	—

\*Side —  $1\frac{1}{2}''$  to side of and 3" below seed.

Under — 3" below seed.

There was a marked effect of fertilizer placement on the yield of beets. Fertilizer placed directly below the seed caused a greater increase in yield than where it was placed to the side and below the seed. This trend was noted on all areas where different amounts of phosphate were plowed under prior to planting.

Fertilizers or methods of application did not have a significant effect on the percent sucrose or percent apparent purity of the sugar beet roots.

There was a slight indication, however, that as the amount of phosphate plowed under increased, the percent sucrose in the beets increased. This increase was from 14.5% to 15.6%.

### Summary

The effect of time and method of application of fertilizers on sugar beets was investigated on a Kawkawlin-Wisner loam soil complex. Four rates of phosphate fertilizer, 0, 200, 400, and 800 pounds of  $P_2O_5$  per acre, were plowed under the fall before planting the beets. Three rates of 6-24-12 fertilizer, 0, 150, and 300 pounds per acre, were applied in two methods; in a band 3 inches below the seed, and in a band  $1\frac{1}{2}$  inches to the side and 3 inches below the seed. A basic application of 200 pounds of KCl was applied on all plots.

The data can be briefly summarized as follows: 1) there was a marked response of early growth, phosphorus content of tissue and yield of beets to phosphate application; 2) planting-time applications of 6-24-12 fertilizer increased early growth of beets at each of the four levels of plowed down phosphate fertilization, increased the phosphorus and potassium contents of plants at blocking time, but did not increase the phosphorus content in the petioles of the leaves at any of the sampling dates; 3) Planting-time fertilizer placed in a band directly below the seed markedly increased the early growth of the plant over that where the fertilizer was placed  $1\frac{1}{2}$  inches to the side and 3 inches below the seed. In general, the percent of phosphorus in the tissue at blocking time was higher where the fertilizer was placed to the side of the seed than directly below the seed. The phosphorus uptake at time of blocking was greatest where the planting-time fertilizer was applied in a band directly below the seed. Similarly, the uptake of calcium and potassium was highest where the fertilizer was placed in a band directly below the seed than when placed in a band to the side and below the seed. Placing the planting-time fertilizer in a band directly below the seed in-

creased yields at both levels of application, 150 and 300 pounds per acre. The increase was least on the plots where 800 pounds of phosphate had been plowed down previously; 4) The percent of phosphorus in the tissue decreased with the first two sampling dates, July 11 and August 3, and increased when the petioles were sampled on September 11. The data suggest that the percent extractable P in the petioles should not be allowed to fall much below 0.15 at any time during the season to insure an adequate supply of P for highest yields; 5) The potassium content of the petioles tended to decrease with each successive sampling date. However, the calcium content of the petioles was lower than that of the beet tissue sampled at blocking time for all three sampling dates. It was higher on August 3 than on July 11 or September 11; 6) There was no significant effect on the percent of sucrose or percent apparent purity due to the fertilizer applications; 7) Yield of gross sugar increased as the amount of phosphate applied increased.

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