The Effect of Phosphorus Fertilization and Time of Application on Chemical Composition of Foliage and on Yield, Sucrose Content and Percent Purity of Sugar Beet Roots[1]

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Received for publication February 5, 1960

Michigan farmers use approximately 600 pounds of fertilizer per acre annually for their sugar beet crop. On the average, the most practical application is within the range of 100 and 150 pounds of P_2O_5 and 50 to 100 pounds of K_2O annually. In addition to causing increases in yield of roots, fertilizers have a marked stimulative effect on the early growth of the young plant. This latter effect is largely from the phosphate applied. Furthermore, there is some indication that phosphate fertilizers, particularly when banded close to the seed, will decrease the incidence of certain black root organisms. By stimulating the early growth of the seedlings, the beets can be blocked and thinned earlier resulting in a more economical use of labor. Earlier cultivation can be a factor in minimizing the weed control problem. Weather conditions, because of seasonal rains, may allow for only a few days of ideal planting weather. A rain can result in delayed planting and, in turn, reduced yields. If the amount of fertilizer applied at planting time could be reduced without a practical decrease in the rate of early growth and final yield, a substantial decrease in the spring labor requirement would result.

The objectives of the present study were to determine 1) the minimum amount of fertilizer to be applied at planting time in relation to the total application without significantly decreasing early growth or final yield of roots, and 2) the amount of preplant phosphate required to best complement the planting time fertilizer.

Materials and Methods

A rotation of beans, beets, and wheat, with a companion crop of sweet clover in the wheat was established near Bay City, Michigan, on a Kawkawlin loam soil. Each crop in the rotation appeared each year. For the sugar beet crop, 4 rates of P_2O_5 were broadcast ahead of planting: 0, 200, 400, and 800 pounds

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[1] Contribution from the Soil Science Department, Michigan Agricultural Experiment Station, East Lansing, Michigan, and Agricultural Department, Monitor Sugar Company, Bay City, Michigan, and approved by the director as Journal Article No. 2581.

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per acre. A basic application of 200 pounds of 60 percent of muriate of potash was plowed under. Treatments were replicated 3 times in an east-west direction of the field. Superimposed on these areas were 3 rates of fertilizer applied 1 inch to the side and 2 inches below the seed at planting time at rates of 0, 150 and 300 pounds of 5-20-10 per acre. The 5-20-10 fertilizer contained 2 percent manganese and 1½ percent boron. The rows were planted across the plots where the P_2O_5 was broadcast. The planting time fertilizer applications were replicated 4 times. The beans and wheat received 150 pounds per acre of 5-20-10.

The plot size was four 28-inch rows by 66 feet. Monogerm beet seed, variety SL108 x SP5481, was planted May 7 and stand counts were taken May 22 and June 12. Plant samples of 100 plants per plot were taken June 12, oven dried at 65° C, weighed and analyzed for phosphorus, potassium, calcium, and magnesium. Soil samples were taken in the spring before the fertilizer was applied and again in August. The soil samples were analyzed for phosphorus using .025 N HCl + .003 N NH_4Fl extractant. Potassium was determined from a 0.13 N HCl extracting reagent.

Petiole samples were taken July 15 and September 1 and a portion of each sample was extracted with a 10% sodium acetate in 3% acetic acid solution (1:20 ratio of green tissue to solution), and the percent phosphorus determined. The remainder of the tissue was dried and analyzed for total calcium and phosphorus using a perchloric acid digestion procedure.

The beets were harvested November 10 and the number, yield, percent sucrose, and percent apparent purity were determined.

Results and Discussion

The effect of fertilizer treatment on the weight and chemical composition of the plant samples taken June 12 are recorded in Table 1. There was no effect of fertilizers noted on stand.

Fertilizer applied at planting time increased the early growth of the plant, the percent phosphosus in the tissue, and the uptake of phosphorus. Phosphate plowed down caused similar effects. The greatest effect in planting time fertilizer both in regard to weight and percent phosphorus in the plants was obtained at the lower amounts of the preplanting application of phosphate. The values per 100 plants ranged from 34.0 to 102.0 grams dry weight, .356 to .625 percent phosphorus, and .121 to .638 grams of phosphorus taken up.

The potassium applied at planting time increased the percent and total amount of potassium in the plant. The effect was more pronounced where the lower rates of phosphate had been

Table 1.—The effect of time and method of application of fertilizers on the early growth of sugar beets and uptake of nutrients. (Monitor Sugar Co., 1959).

Lbs./acre P_2O_5 plowed down —spring	Lbs./acre 5-20-10 planting time	Grams per 100 plants at blocking time	Percent P in tissue[1]	Grams P per 100 plants	Percent K in tissue	Grams K per 100 plants	Percent Mg in tissue[1]	Grams Mg per 100 plants	Percent Ca in tissue[1]	Grams Ca per 100 plants
0	0	34.0	.356	.121	6.66	2.26	.71	.241	.805	.273
0	150	68.6	.430	.295	9.97	6.84	.82	.563	.901	.612
0	300	78.0	.458	.357	10.86	8.47	.89	.694	.928	.724
200	0	56.3	.479	.276	8.43	4.75	.76	.428	.863	.486
200	150	78.5	.521	.409	9.18	7.20	.87	.683	.970	.762
200	300	91.4	.527	.480	11.76	10.71	.82	.747	.968	.882
400	0	67.6	.513	.347	10.74	7.26	.82	.544	1.005	.679
400	150	84.9	.576	.489	11.24	9.54	.92	.790	.997	.845
400	300	95.0	.584	.555	10.78	10.24	1.01	.960	.939	.892
800	0	79.1	.588	.465	11.22	8.87	.82	.649	.863	.685
800	150	99.2	.616	.611	9.37	9.29	.78	.684	.902	.895
800	300	102.0	.625	.638	11.93	12.16	.84	.857	.898	.916
L.S.D. 5% Level:										
Rates P_2O_5		15.76	.076		1.73		NS		NS	
Rates 5-20-10		4.41	.029		1.57		.087		.055	

[1] Oven dry

applied. There were no significant differences in either percent magnesium or percent calcium in the tissue, although the amounts of magnesium and calcium taken up by the plants increased with the yield.

These data indicate that in order to get maximum early growth of the plant, some fertilizer at planting time should be applied. They also show that the early growth of the plant is increased if sufficient P_2O_5 is broadcast and plowed under ahead of planting. For example, the plants from the plots receiving 300 pounds of planting time fertilizer weighed 78 grams in contrast to 34.0 grams where no planting time fertilizer was used. The respective weights for 400 pounds of P_2O_5 plowed under and 800 pounds plowed under were 67.6 and 79.1 grams. Although the growth of the plants tended to increase in weight with the amount of planting time fertilizer applied, the results indicate that it is not necessary to apply more than 150 pounds of fertilizer at planting time, provided the phosphorus level in the soil is sufficiently high.

Data in Table 2 show that on the July 15 sampling date as the amounts of phosphate plowed under increased, the percent extractable phosphorus in the green petioles increased. The

Table 2.—The effect of time and method of application of fertilizers on the chemical composition of leaf petioles at two sampling dates.[1] (Monitor Sugar Co., 1959).

Lbs./acre P_2O_5 plowed down —spring	Lbs./acre 5-20-10 planting time	Beet sample taken July 15			Beet sample taken Sept. 1		
		P in green tissue	Total P	Total Ca	P in green tissue	Total P	Total Ca
		percent	percent	percent	percent	percent	percent
0	0	.124	.180	.97	.089	.110	1.15
0	150	.129	.167	.90	.079	.114	1.41
0	300	.168	.195	1.00	.120	.146	1.20
200	0	.173	.220	.98	.215	.236	.97
200	150	.195	.231	.88	.189	.208	1.10
200	300	.184	.224	1.02	.168	.218	1.17
400	0	.193	.237	.93	.248	.256	.93
400	150	.204	.249	.83	.229	.217	1.01
400	300	.191	.240	.96	.205	.243	.91
800	0	.216	.243	.95	.242	.234	.88
800	150	.219	.260	.80	.223	.232	.91
800	300	.223	.267	1.05	.230	.247	.93
L.S.D. 5% level:							
P levels		.030	.026	NS	.040	.026	.16
Planting time		NS	NS	.06	.017	NS	NS

[1] Green tissue extracted with a 10% sodium acetate in 3% acetic acid solution (1.20 ratio of green tissue to solution). All values reported on an oven-dry weight basis.

largest increase in extractable and total phosphorus from the planting time fertilizer occurred where the 0 and 200 pounds of phosphate per acre were plowed down.

Beets sampled September 1 showed similar trends as those sampled July 15. There was some indication, however, that the extractable phosphorus in the plants where planting time fertilizer only was used was lower on the September 1 sampling than on the July 15 sampling. The phosphorus contents of the petioles increased where phosphate had been plowed under ahead of planting. This indicates that the phosphate supply for the beet plants was insufficient where no phosphate had been plowed under. The comparison was not as clear-cut for the total phosphorus content as for extractable phosphorus in the green tissue. Approximately 85 percent of the total phosphorus in the plant was accounted for by the extractant used. The percent of total calcium found in the tissue July 15 was lower than that found on September 1. There was a tendency for the calcium content of tissue to decrease where 800 pounds per acre of P_2O_5 was plowed down.

These data show that at low residual fertility levels, the amount of phosphate applied at planting time significantly increased the extractable phosphorus content in the green tissue of the plant. However, if there was sufficient phosphate fertilizer in the soil the effect of planting time fertilizer on the phosphorus content of tissue was largely masked.

The sugar beet crop responded very well to both planting time fertilizer and phosphate plowed down (Table 3). It was only at the zero level of phosphate plowed down in the spring that a singificant response in yield was obtained from planting time fertilizers. Highest yields were obtained where 400 and 800 pounds had been applied as a plow-down application. These data show very clearly that the phosphorus fertility of the soil determines, for a large part, the yield response obtained by fertilizer application at planting time.

There was no over-all effect of fertilizer on percent sucrose. Beets from plots receiving 0 and 150 pounds of planting time fertilizer and no phosphate plowed down had the lowest sugar contents. There was no further evidence that an increase in sucrose content would result from additional fertilizer regardless of amount or method of application.

While the differences for percent purity were not statistically significant, there does appear to be a slight reduction in purity as the amount of planting time fertilizer was increased in

Table 3.—The effect of time and method of application of fertilizer on percent sucrose, purity and yield of roots, and gross sugar. (Monitor Sugar Co., 1959).

Lbs./acre P_2O_5 plowed down —spring	Lbs./acre 5-20-10 planting time	Tons/acre	Sucrose	Purity	Cwt gross sugar/acre
			percent	percent	
0	0	13.0	16.1	91.7	39.0
0	150	15.0	16.3	91.1	44.5
0	300	16.0	16.8	90.1	48.1
200	0	16.7	16.7	91.2	50.9
200	150	16.8	16.7	88.9	49.3
200	300	16.8	16.4	88.3	48.4
400	0	18.7	17.3	89.2	57.4
400	150	19.1	17.0	88.5	57.1
400	300	19.2	17.1	89.7	56.1
800	0	18.0	16.8	88.4	52.6
800	150	19.2	16.9	90.0	58.4
800	300	19.2	17.0	89.3	58.3
L.S.D. 5% level:					
P levels		1.92	NS	NS	
Planting time		0.60			

plots where 0 and 200 pounds of phosphate were plowed down. The gross sugar yields per acre were closely correlated with the tons of roots per acre.

Summary

The effect of planting time (5-20-10) fertilizer and rates of application of phosphate plowed under prior to planting on sugar beets was investigated on a Kawkawlin loam soil.

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 applications.
2. Planting time applications of 5-20-10 fertilizer increased early growth at each of the four levels of plow-down phosphate fertilization, increased the phosphorus and potassium contents of plants at blocking time, and increased the phosphorus content in the petioles of leaves where 0 and 200 pounds of phosphate were plowed under.
3. The percent extractable phosphorus in the green tissue decreased as the season progressed where no phosphate had been plowed down. The reverse of this situation occurred where phosphate had been plowed under.
4. There was no significant effect on the percent of sucrose or percent apparent purity due to the fertilizer application.

However, there appeared to be a decrease in apparent purity as the amount of planting time fertilizer was increased in the plots with 0 and 200 pounds of phosphate (P_2O_5) plowed down.

5. The treatments had no definite effect on the percentage of calcium or magnesium in the tissue, but at the last date of sampling where the highest rate of phosphate was applied, significant decreases in calcium content of the tissue were noted.

6. The effect of planting time 5-20-10 fertilizer in the growth of sugar beets was more marked at the lower rates of phosphate fertilizer plowed down. There did not appear to be any practical advantage of applying more than 150 pounds of fertilizer at planting time, providing there was a rather high level of phosphorus in the soil.