Uptake of Phosphorus by Sugarbeets

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Introduction

Sugarbeets are an important cash crop in the Red River Valley of Minnesota and North Dakota. Proper fertilization and cultural practices are necessary to insure maximum net returns. Since the soils of the area are inherently low in phosphorus, the application of this element is essential for maximum yields. Any method which increases the uptake of phosphorus by sugarbeets and thereby increases the yield is of great interest to growers.

This experiment was initiated in 1964 to determine if sugarbeets take up more phosphorus from a mixture of ammonium nitrate and phosphate, or from phosphate fertilizer, and what effect these two fertilizer treatments may have on the yield, sucrose content, purity, total nitrogen and phosphorus content of the tops and roots.

Several workers (1,4,7,8)[2] have reported that corn and small grains absorb more fertilizer phosphorus when nitrogen in the ammonium form is mixed with the phosphate carrier than when fertilizer phosphate is applied.

Olsen et al. (6) reported that ammonium phosphate (11-48-0) and superphosphate were about equally available to sugarbeets. At the first sampling the plants absorbed less phosphorus from the ammonium phosphate than from the superphosphate, but thereafter about equal amounts were absorbed from the two fertilizers. Grunes et al. (3) found that the addition of ammonium nitrogen fertilizer generally increased the percent of total phosphorus absorbed by potatoes and sugarbeets from bands of concentrated superphosphate. Dubetz and Russel (2) reported that the early application of ammonium nitrate resulted in the highest dry matter and phosphorus content of seedling roots and that time of nitrogen application had no effect on seedling beet tops.

Materials and Methods

In this experiment 0, 40, 80, and 120 lb of phosphate (P as 0-46-0) alone and in combination with 0, 10 and 20 lb per acre

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[2] Numbers in parentheses refer to literature cited.

of nitrogen as ammonium nitrate (33-0-0) were applied in a narrow band at planting. A randomized block design on Bearden silt loam, a fine-textured soil retentive of moisture with a pH varying from 7.8 to 8.1, was used for the study. The plot area had been in black fallow the previous year, and no supplemental water was added during the growing season. Plots were six 22-inch rows wide and 50 feet in length, and the two middle rows were harvested for yield, percentage of sucrose, purity and total nitrogen and phosphorus content. May 13 was the average seeding date, and September 30 was the average date of harvest.

The roots and tops (petiole plus leaf blade) were sampled four times during the growing season for phosphorus determination. At each sampling, 12 plants were selected at random from each plot, and approximately six of the youngest leaves, both petiole and leaf blade, were taken. The average date for the first sampling was June 27 when the beets reached the eight-leaf stage and thereafter at monthly intervals.

Results and Discussion

Table 1 summarizes the data for the roots. The summer drought during 1964 reduced the yields and lowered the 3-year average yields given in Table 1. Since growing conditions during 1965 and 1966 were good, above average yields were obtained in those years.

Table 1.—Average sugarbeet yields and percentages of sucrose, purity, total nitrogen, and ppm of phosphorus in roots from the application of 10 fertilizer treatments made in 1964, 1965 and 1966.

Treatment rate/acre	Roots tons/acre	Percent sucrose	Percent purity	Percent total nitrogen	Phosphorus ppm
N P* K					
0-0-0	12.1	14.3	84.7	1.04	543
0-40-0	11.8	14.5	84.9	1.13	625
0-80-0	12.5	14.1	85.0	1.05	625
0-120-0	12.3	14.3	85.9	1.01	624
10-40-0	12.6	14.3	84.5	1.18	590
10-80-0	11.8	14.1	84.7	1.17	603
10-120-0	12.4	14.6	86.2	1.07	608
20-40-0	12.0	14.2	84.5	1.08	584
20-80-0	12.5	14.5	84.8	1.05	675
20-120-0	11.8	14.5	85.2	1.06	662
LSD (0.05)	N.S.	N.S.	N.S.	N.S.	72
LSD (0.01)	N.S.	N.S.	N.S.	N.S.	N.S.

* Rate in lb of P

There were no significant differences in the yield of roots as affected by the 10 fertilizer treatments. The three phosphate treatments average 12.2 tons per acre, which is 0.1 ton more than the check plot. The addition of 10 and 20 lb of nitrogen to each of the phosphate treatments did not increase the yield, as stated in the literature (1,2) in experiments with sugarbeets and other crops. The fertilizer ratio of nitrogen to phosphate was not a critical factor as measured by the yield of beets.

The percent sucrose was very similar for all the treatments. The three phosphate treatments averaged 14.3% sucrose, which is identical to the check. The addition of 10 and 20 lb of nitrogen to the phosphate treatments did not bring about any significant change.

Purity is an important factor in the processing of sugar, and the additon of nitrogen fertilizer may influence this factor. The purity for the three phosphate treatments was higher than the check, but the differences were not significant. When 10 to 20 lb of nitrogen were added to the phosphate treatments, three of the purity values were above and three below the check, but the results were not significant.

The percentage of total nitrogen varied from a low of 1.01 to a high of 1.18, but this variation is not significant. Eight of the treatments were higher than the check. The percentage of total nitrogen decreased as the rate of phosphate increased both for the phosphate alone and with the addition of 10 and 20 lb of nitrogen.

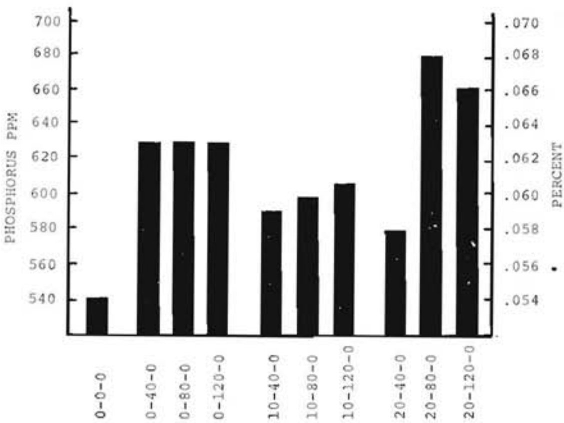

Figure 1.—Phosphorus content of sugarbeet roots as affected by 10 fertilizer treatments, Avg 1964 - 1966.

Figure 1 gives the phosphorus content of the roots in ppm and percentage for the 10 fertilizer treatments. The phosphorus content varied from a low of 543 in the check to a high of 675 ppm for the 20-80-0 treatment. The results from the three phosphate treatments were identical and were significantly different from the check at the 5% level. The addition of 10 lb of nitrogen to each of the phosphate treatments lowered the phosphorus content, but they were not significantly different from the check or the three phosphate treatments. The 20-80-0 and 20-120-0 treatments were the highest in phosphorus content and were significantly higher than the check.

The average phosphorus content of the tops and roots for the three growing seasons at the four sampling dates is given in Tables 2 and 3, respectively. The greatest uptake of phosphorus by both tops and roots occurred in the early spring, and the amount decreased as the growing season progressed. The tops contained considerably more phosphorus than the roots. On June 27, the first sampling date, the percentage of phosphorus in the tops varied from a low of .591 for the check to a high of .697 for the 0-120-0 treatment. This treatment had the highest phosphorus content for three of the four sampling dates and also for the total average. There was no significant increase in the phosphorus content of the tops by increasing the rates of phosphate. The addition of 10 and 20 lb of nitrogen did not produce any consistent results for the different sampling dates.

When one considers the average data for the four sampling dates in Table 2, all the treatments, except 10-40-0, were significantly higher in phosphorus than the check. The amount of phosphorus varied from a low of .370% for the check to a high of .428% for the 0-120-0 treatment. This treatment did differ from the check and the other treatments except the 20-120-0 at the 5% level.

Table 2.—Phosphorus content of sugarbeet tops for four dates of sampling resulting from the application of 10 fertilizer treatments, Avg 1964 - 1966.

Treatment	Date of sampling				
rate/acre	June 27	July 29	Aug. 31	Sept. 22	Avg
N P K	Percent phosphorus				
0-0-0	.591	.346	.284	.258	.370
0-40-0	.627	.371	.287	.293	.395
0-80-0	.604	.365	.307	.304	.395
0-120-0	.697	.368	.341	.305	.428
10-40-0	.620	.318	.296	.281	.386
10-80-0	.647	.374	.300	.301	.406
10-120-0	.639	.381	.299	.296	.405
20-40-0	.648	.355	.309	.280	.398
20-80-0	.657	.358	.313	.297	.406
20-120-0	.671	.379	.296	.296	.411
LSD (0.05)	NS	NS	NS	NS	.020
LSD (0.01)	NS	NS	NS	NS	.026

When treatments were separated in the analysis of variance for the tops, the nitrogen and nitrogen-phosphorus interactions were not significant. The phosphorus, however, was significantly different from the check.

The uptake of phosphorus by the roots as shown in Table 3, paralleled that of the tops. On the first sampling date, the phosphorus content varied from a low of .394% for the check to .484% for the 10-120-0 treatment, a variation of .090%. At the last sampling date, the phosphorus content of the roots was the lowest and varied from a low of .091% for the check to a high of .115% for 20-120-0 treatment. The increased rates of phosphate did not produce any consistent increase in phosphorus content. When 10 lb of nitrogen were added to each of the phosphate treatments, the results were variable and followed no definite pattern.

Table 3.—Phosphorus content of sugarbeet roots for four dates of sampling resulting from the application of 10 fertilizer treatments, Avg 1964 - 1966.

Treatment	Date of sampling				
rate/acre	June 27	July 29	Aug. 31	Sept. 22	Avg
N P K	Percent phosphorus				
0-0-0	.394	.172	.125	.091	.196
0-40-0	.476	.191	.139	.097	.226
0-80-0	.475	.211	.142	.111	.235
0-120-0	.454	.209	.152	.113	.232
10-40-0	.451	.180	.137	.106	.219
10-80-0	.449	.188	.134	.099	.218
10-120-0	.484	.191	.152	.112	.235
20-40-0	.450	.175	.143	.102	.218
20-80-0	.466	.209	.146	.114	.234
20-120-0	.465	.233	.147	.115	.240
LSD (0.05)	NS	NS	NS	NS	.013
LSD (0.01)	NS	NS	NS	NS	.017

The addition of 20 lb of nitrogen to the three phosphate treatments did produce a slight successive increase in the phosphorus content of the roots at each sampling date.

Examining the average results for the four sampling dates in Table 3, we observed that all the treatments were significantly different from the check at the 1% level. The 20-120-0 treatment contained the highest amount of phosphorus, and the 10-80-0 and 20-40-0 had the lowest.

Figures 2 and 3 give the phosphorus content of the sugarbeet roots and tops, respectively, for the four sampling dates with an average for each treatment. The largest uptake of phosphorus was on the first sampling date and is indicated by the longest bar on the left hand side of each figure. The results for both roots and tops for all the sampling dates were rather uniform and exhibited no definite pattern as a result of the different rates of phosphate or the addition of 10 and 20 lb of nitrogen.

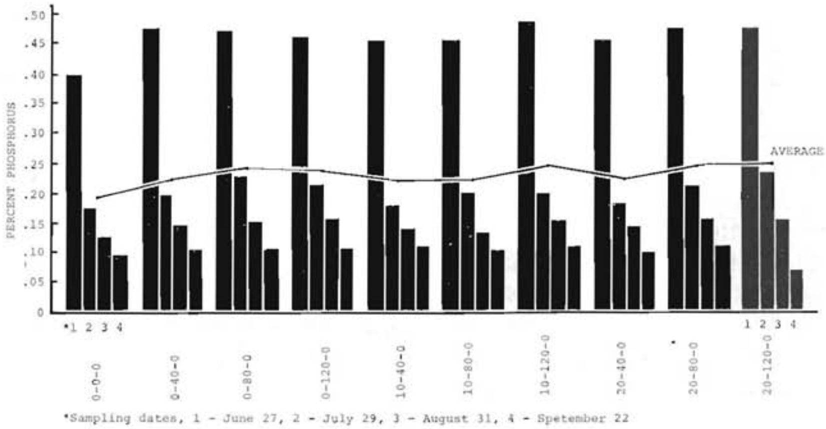

Figure 2.—Phosphorus content of sugarbeet roots for four dates of sampling as affected by 10 fertilizer treatments, Avg 1964 - 1966.

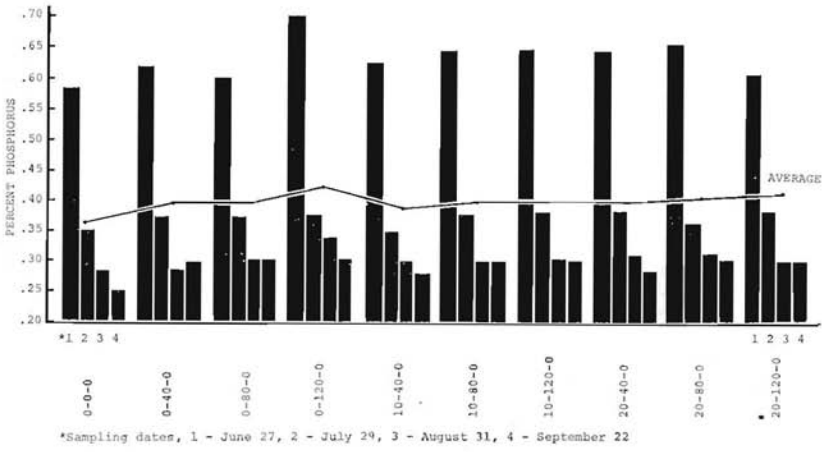

Figure 3.—Phosphorus content of sugarbeet tops for four dates of sampling as affected by 10 fertilizer treatments, Avg 1964 - 1966.

From previous work (5,9) high rates of nitrogen alone and in combinations with phosphate have lowered the percentage of sucrose and purity, and increased the total nitrogen content in sugarbeets. No adverse effects have been noted when lower rates of nitrogen (10-20 lb N) were used alone and in combinations with phosphate on this crop. In this trial there were no significant differences in the percent sucrose, purity and total nitrogen, and no great differences were anticipated.

The application of high rates of phosphate have not always increased the yield of beets in this area. With a pH of 7.8 to 8.5, some phosphate reverts to the insoluble tricalcium phosphate. The plot area in this trial tested medium in available phosphate and had been in black fallow the previous year. The phosphorus levels of both tops and roots on the check plots were high, indicating an available supply of this element was present in the soil. All of these factors may have influenced the yields and uptake of phosphorus by sugarbeets in this trial.

Summary

This experiment was undertaken to determine whether sugarbeets take up more phosphate from a mixture of ammonium nitrogen and phosphate or from phosphate fertilizer alone, and what effect this addition might have on the yield, sucrose content, purity, total nitrogen and phosphorus content of the tops and roots.

The addition of nitrogen (ammonium ion) to the three phosphate treatments did not significantly increase the yields of roots in this experiment. There were no significant differences among treatments in the percent sucrose, purity and total nitrogen content of the roots.

The greatest increase in the phosphorus content of the tops and roots took place at the first sampling date, and this amount decreased rap'dly as the growng season progressed. There were no significant differences among treatments in the phosphorus content of the tops and roots for the individual sampling dates. However, the treatment averages for the tops, except 10-40-0 treament, were significant at the 5% level, and all treatment averages for the roots were significant at the 1% level.

Acknowledgment

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