Optimum Starter Fertilizer Placement for Sugarbeet Seedlings as Determined by Uptake of Radioactive ^{32}P Isotope[1]

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Strategic placement of starter fertilizer is essential if sugar beet seedlings are to use it most efficiently. The ideal location for the fertilizer band is in the direct pathway of the seedling roots, particularly for immobile nutrients such as P. This means that root system differences and stages of plant development alter our concept of ideal placement. For example, a plant such as corn with a fibrous root system requires a different fertilizer placement than does sugarbeet with its predominantly tap-root system. These differences will be at their maximum at the earliest growth stages and become less as the plants develop more extensive root systems. Therefore if starter fertilizers are to be of maximum value, root system differences at early growth stages are of prime concern.

Starter fertilizer is of utmost importance in situations where there is limited root growth because of nutrient deficiencies. Work by Sipitanos and Ulrich (6)[3] showed that soil temperature can greatly influence P availability for sugarbeet seedlings. At temperatures below 60° F P concentrations in the plant tissue were below the "critical level" unless the plants were fertilized. Phosphorus fertilization had a relatively greater effect on plants grown at the cold temperatures than on plants grown at optimum temperatures. In many locations where sugarbeets are produced they are planted as early as possible in order to maximize yield potential. This results in seedbeds with potentially low soil temperatures and therefore a good probability of a P deficiency. Under these circumstances of potentially low root activity, proper placement of the immobile phosphate fertilizer is essential.

The National Joint Committee on Fertilizer Application (3) recommends in a general statement that banded fertilizer be placed not more than 1½ inches to the side and 1 to 2 inches below the seed. Recommendations such as this one have led to more or less

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[3]Numbers in parentheses refer to literature cited.

standard starter fertilizer placement practice, which is 2 inches to the side and 2 inches below the seed for all crops. This may be a good position for a plant like corn with its fibrous root system which grows predominantly in a lateral direction during early growth stages. However, it may not be the optimum placement for a tap root crop like sugarbeet.

Experiments by Davis *et al.* (1) in 1961 showed that placement of starter fertilizer 3 inches directly below the sugarbeet seed resulted in a 25% root yield increase compared to starter placed 1½ inches to the side and 3 inches below the seed in a case where no phosphate was plowed down. When phosphate at the rates of 200, 400, and 600 pounds of P_2O_5/A was plowed down, the placement directly below the seed resulted in root yield increases of 10, 8 and 4% respectively, compared to the 1½ inch by 3 inch placement.

Romsdal and Schmehl (5) showed that banding phosphate 2 inches below the seed resulted in the same yield response as plow down treatments at both the 50 and 200 pound P_2O_5/A rates. Early growth stimulation was observed for the banded treatment compared to plow down but no yield superiority was found.

Larson (2) concluded that plowed-down phosphate produced high yields and greater P concentration in the foliage than did banding 2 inches below and 2 inches to the side of the seed. Partridge (4) showed that plowed-down phosphates tend to be better than disc incorporated or side dressed 2 or 4 inches deep and to the side at thinning time.

It is apparent from these results that interception of the fertilizer band by the sugarbeet root was greater when placement was directly below the seed. Under cold soil conditions with very limited root activity the availability of fertilizer nutrients due to differences in placement could have been even greater. If the reason for using a starter fertilizer is to improve nutrient availability at early growth stages, then a more complete understanding of effective placement during these stages would be valuable.

To improve our understanding of starter fertilizer placement for sugar beets, an experiment was designed to determine: 1. the relative effectiveness of starter fertilizer placed directly below the seed compared to conventional starter placement, and 2. how rapidly the root system reaches the various placement points. Radioactive ^{32}P-tagged KH_2PO_4 was applied to the soil in various positions in relation to the seed and ^{32}P content of the sugar beet leaf tissue was used to determine the relative accessibility of the material in each position.

Materials and Methods

Pots for this experiment were constructed from redwood lumber to provide a soil area one foot square by three feet deep. An A horizon of a Tripp very fine sandy loam soil (Typic Haplustoll) was used as a planting medium. The soil had a pH of 7.4 but showed no effervescence when treated with HCl. A divider was placed in the center of each pot. Sugar beet seeds were planted in two rows, one on either side of the divider, 3 inches from the side of the pot. The divider ensured that roots did not grow into the P placement for the opposite row of beets.

Carrier free $KH_2{}^{32}PO_4$ was applied at 50μC per pot as a tracer to measure P uptake. It was placed in a band at four positions relative to the seed placement: level with the seed and two inches to the side (0" x 2"), two inches below and two inches to the side of the seed (2" x 2"), two inches below and directly under the seed (2" x 0"), and four inches below and directly under the seed (4" x 0"). A completely randomized design with four replications was used. Four pots were prepared with no $KH_2{}^{32}PO_4$ to serve as checks for background levels of ^{32}P. Forty-eight sugar beet seeds were planted in each pot, 24 per row, to ensure an adequate number of plants for sampling. As soon as the sugar beets emerged (5 days after planting) they were thinned so that 12 beet plants remained per row in each pot. Whole plant samples were taken from each pot 7 days after emergence and each week thereafter for four weeks. The last sampling was four weeks from emergence. Ten, six, four, and four plants were taken from each pot at the one, two, three, and four week samplings respectively. Except for the seedlings taken at thinning time which were analyzed as whole plants, the plants were pulled from the soil, and the roots separated and discarded. Radioactive P determinations were obtained by a liquid scintillation method after digestion of the samples in HNO_3-$HClO_4$ acid.

Results and Discussion

Figure 1 and Table 1 show the results of the isotope placement and the analysis of variance, respectively. The most obvious feature in Figure 1 is the large difference in ^{32}P activity in plants where the tracer was placed directly below the seed compared to placements to the side of the seed. Thirteen days after planting the plants where isotope was placed directly below the seed showed activities of 6200 and 22,600 DPM for the 4" x 0" and 2" x 0" placements, respectively. Placements to the side of the seed had no activity at all at that time. This means that there was no root activity at positions 2 inches to the side of the seed whether at seed depth or even at 2 inches below seed level. At 20 or 25 days after planting the roots

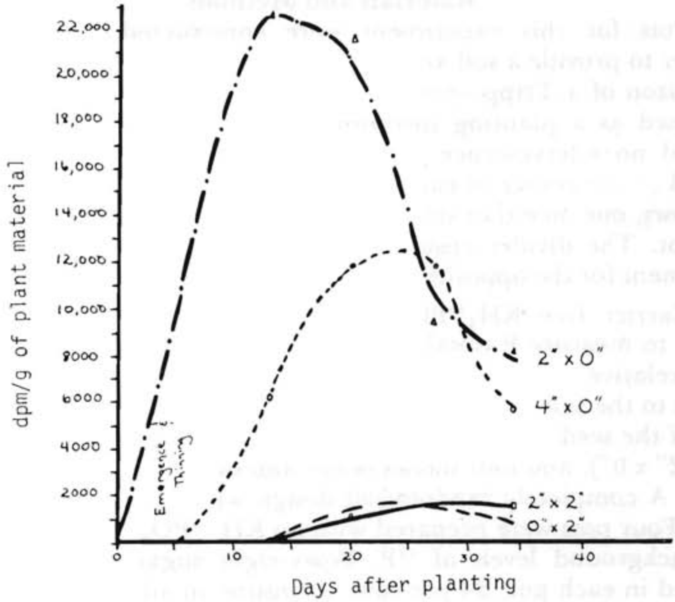

Figure 1. Radioactive ^{32}P uptake in sugar beet leaf tissue as affected by soil placement of the isotope and time of sampling. (Symbols denote depths below x distance to the side of the seed. Eg. 0" x 2" denotes seed level and 2" to the side.)

had apparently reached the positions 2 inches to the side of the seed as evidenced by the activities of about 1500 DPM. However, the degree of root activity in this zone at 20 to 25 days after planting was only a fraction of that found from the 2" x 0" and 4" x 0" placement

Table 1.—Analysis of variance mean squares for dpm of ^{32}P in sugar beet leaf tissue as related to placement and dates of sampling.

Source	d.f.	M.S.	F
Placements (P)	3	8.79×10^8	67.2**[1]
0 x 2, 2 x 2 vs. 2 x 0, 4 x 0	1	2.06×10^9	109.1*
0 x 2 vs. 2 x 2	1	4.91×10^5	1
2 x 0 vs. 4 x 0	1	5.82×10^8	30.9**
Error A	12	1.31×10^7	
Dates (D)	4	1.09×10^8	5.8**
Thinning vs. Others	1	2.46×10^8	13.0**
13 & 20 day vs. 25 & 34 day	1	1.22×10^8	6.4*
13 day vs. 20 day	1	2.81×10^7	1.5
25 day vs. 34 day	1	4.08×10^7	2.2
P x D	12	6.40×10^7	3.4**
Error B	48	1.89×10^7	

[1]**denotes significance at the 1% α level
*denotes significance at the 5% α level

points. Thirty-four days after planting, the side placements still had only 20% and 25% as much activity as the 2" x 0" and 4" x 0" placements, respectively.

It can be concluded that if the starter fertilizer is to be of maximum use to the young beet seedling it must be closer to the seed than 2 inches to the side. Optimal placement for earliest uptake appeared to be 2 inches directly below the seed. However, by 34 days after planting the 4" x 0" placement was equivalent to the 2" x 0" placement. On a practical basis, an advantage of a 4" x 0" placement, even though it may delay uptake compared to the 2" x 0", would be less opportunity for seedling damage due to salt injury from fertilizer materials.

It is interesting to note that both side placements, whether even with the seed or below the seed, were of equal effectiveness. Apparently the amount of lateral root development at early growth stages is very minimal compared to the main taproot development. This re-emphasizes the point that if starter fertilizer containing immobile nutrients is to be of maximum use to the beet seedling in the initial 3 to 4 weeks growth period it should be placed directly below the seed.

From the time standpoint, it can be noted that the 2" x 0" placement was supplying tracer to the root five days after planting. In contrast, it was 14 days after emergence before the 2" x 2" to 0" x 2" placements supplied any tracer and then only in a small amount compared to the 2" x 0" or 4" x 0" placements.

These data help explain the differences in the findings of several investigators who have studied the placement of phosphate fertilizers for sugarbeets. Davis (1) reported better response to banded phosphate when placed below the seed than to the side. Romsdal and Schmehl (5) found no difference between plow down and banded phosphate. They had banded phosphate 1½ to 2 inches below the seed. On the other hand Larson (2) and Partridge (4) reported poor response to banded phosphates compared to plowdown treatments. They had banded or sidedressed to the side of the seed. Data presented here definitely confirm the necessity of placing the phosphate in the "path" of the seedling root to maximize the effects of the banded fertilizer.

Larson (2) also makes a point of recommending plowdown because it leaves a layer of phosphate near the surface for the young seedling and at the same time a larger amount at a deeper point (5 to 7 inches below the surface). He ascribes the benefits of this stratified placement to a more favorable moisture and P availability relationship later in the growing season. As we can see from the data presented in this paper, it may be that the stratification merely placed the phosphate below the seed and thus directly in the path of the taproot.

Conclusions

The objectives of the experiment reported here were to determine: 1. the relative effectiveness of starter fertilizer placed directly below the seed compared to conventional placement, and 2. how rapidly the root system reached the various placement points. The data showed that the side-band placement points allowed only 20 to 25% as much ^{32}P tracer uptake as placements directly below the seed when sampled four weeks after emergence. Two weeks after emergence the side-band 2" x 2" placement had only allowed 7% as much tracer uptake as placement 2" directly below the seed. In contrast the roots had reached the 2" x 0" placement point five days after planting. The placement 4" directly below the seed was reached one week after emergence. No evidence of root and tracer contact was found until two weeks after emergence with the side placements.

These data suggest that plants with taproot systems, like sugarbeet, can optimize starter fertilizer usage if it is placed directly under the seed. This is especially true if there is nutritional need within the first two-week period following emergence.

Literature Cited

(1) DAVIS, J. F., G. NICHOL, AND D. THURLOW. 1961. The interaction of rates of phosphate application with fertilizer placement and fertilizer applied at planting on the chemical composition of sugar beet tissue, yield, percent sucrose and apparent purity of sugar beet roots. J. Am. Soc. Sugar Beet Technol. 12:259-267.

(2) LARSON, W. E. 1954. Effect of method of application of double superphosphate on the yield and phosphorus uptake by sugar beets. Proc. Am. Soc. Sugar Beet Technol. 8:25-31.

(3) National Plant Food Institute. 1958. Methods of Applying Fertilizer. Nat'l Fertilizer Assoc., Washington, D.C.

(4) PARTRIDGE, J. R. 1960. Phosphorus placement for sugar beets. Wyo. Agr. Exp. Sta. Bul. 369.

(5) ROMSDAL, S. D. AND W. R. SCHMEHL. 1963. The effect of method and rate of phosphate application on yield and quality of sugar beets. J. Am. Soc. Sugar Beet Technol. 12:603-607.

(6) SIPITANOS, K. M. AND A. ULRICH. 1971. The influence of root zone temperature on phosphorus nutrition of sugar beet seedlings. J. Am. Soc. Sugar Beet Technol. 16:408-421.