Fertilizer Placement for Sugar Beet Production[1]

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The many questions regarding fertilizer efficiency as affected by placement have not received satisfactory answers. Perhaps they will never receive answers which will have wide spread application, but for specific soil, climatic, and cultural conditions there probably are positions of placement where the fertilizer materials approach maximum availability to growing plants. However, these positions may also vary with the stage of growth of the plants and with the type of fertilizer materials. Recent experiments conducted by Olsen and Gardner[3] with radioactive phosphate have shown that the most favorable placement for one type of phosphate may not be the best for another, and that the most favorable placement for a single type of material may vary during the season. The best position for a mixed fertilizer might not be the best for any of the single ingredients if applied separately.

A field experiment was started in 1947 in an attempt to determine the relative efficiencies of a few of the most commonly used methods of fertilizer placements for sugar beets. The experiment included commercial fertilizer alone and commercial fertilizer plus manure. The commercial fertilizer mixture consisted of ammonium nitrate, superphosphate (43% P_2O_5), and potassium sulfate at the rate of 65 pounds N, 86 pounds P.,0-, and 50 pounds K_2O per acre. Manure was applied at the rate of 10 tons per acre. The experiment involved 14 separate treatments, described as follows:

1. Commercial fertilizer drilled with fertilizer attachment on grain drill before plowing.
2. Commercial fertilizer drilled 4 inches under seed at planting time.
3. Commercial fertilizer; 1/5 placed with the seed and 4/5 placed 4 inches deep and 5 inches to side of seed.
4. Commercial fertilizer 2 inches deep and 5 inches to side of seed.
5. Commercial fertilizer 4 inches deep and 5 inches to side of seed.
6. Commercial fertilizer; P and K 4 inches deep and 5 inches to side of seed with N side dressed before first irrigation.
7. Commercial fertilizer; P and K 4 inches deep and 5 inches to side of seed with N in first irrigation water.
8. Commercial fertilizer; all ingredients in first irrigation water. (P from phosphoric acid) .

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[3] Olsen, Sterling R., and Gardner, Robert. Utilization of Phosphorus from Various Fertilizer Materials. IV, Sugar Beets, Wheat, and Barley in Colorado. Soil Sci. 68: 168-169, 1949.

9. Commercial fertilizer; plow-sole application.

10. Commercial fertilizer 4 inches deep and 5 inches to side of seed with additional N *in* water at each irrigation.

10a. Commercial fertilizer mixed with the soil in a 4x4 inch band by a rototiller attachment and seed planted in the band.

11. Commercial fertilizer mixed with 10 tons manure per acre and broadcast before plowing.

12. Commercial fertilizer drilled in soil before application of ten tons manure and plowing.

13. Commercial fertilizer drilled in soil before plowing. Ten tons manure added as top dressing after plowing.

13a. Ten tons manure before plowing. Commercial fertilizer 4 inches deep and 5 inches to side of seed at planting time.

14. No commercial fertilizer or manure.

14a. No P or manure. N and K 4 inches deep and 5 inches to side of seed at planting time.

All the treatment numbers not followed by the letter "a" were *in* the first year's tests. The treatments 10, 13, and 14 were changed the second or third year to 10a, 13a, and 14a. The experiment was conducted the first and third years on the same tract of land with barley as the intervening crop between beet crops. Except for the changes indicated after the numbers followed by the letter "a," the treatments were placed on the same plots in the 1947 and 1949 experiments.

EXPERIMENTAL RESULTS

Stand of Beets

The data obtained in the course of the experiment include stand of beets, yield of beets, sugar percentage, yield of sugar, and results of plant tissue analysis. The data for simplicity and ease of comparison are presented as percentages of the data from untreated plots rather than as absolute values. Table 1 shows the relative number of beets at harvest as affected by the various treatments. It is evident from the table that the only important effect on stand resulted from the treament where part of the commercial fertilizer was drilled *in* the same furrow with the beet seed in 1948 (Treatment 3) . This was an effect which did not occur in 1947 and probably would occur only under conditions of insufficient moisture at the time of germination. Commercial fertilizer placed with the seed reduced the stand to 54.7 per cent of the unfertilized check. In 1948 a dry period followed planting and placing the fertilizer with the seed probably intensified the drought effect which was not present in 1947. An apparent, but not significant, decrease in stand was caused by commercial fertilizer placed

directly under the seed (Treatment 2) and the rototiller treatment (Treatment 10a). In Treatment 2 the decrease probably was due to disturbance of the seed bed by the fertilizer shoes and resultant drought. In the case of the rototiller treatment, either disturbance of seed bed or drought aggravated by the fertilizer in the soil near the seed could have contributed to the reduced stand. There was an apparent but not significant average increase in stand on the fertilized plots over the non-fertilized plots in 1947 and 1948 which might have been due to the greater vigor of the fertilized plants.

Table 1.—Relative Stand of Beets

Placement	1947	1948	1949	Weighted Average***
1	112.1	104.3	99.8	105.1
2	99.3	97.7	96.0	97.7
3	108.1	54.7**	.....	.....
4	102.7	108.5	98.4	104.5
5	106.4	108.6	99.5	105.8
6	106.1	110.6	101.0	107.1
7	106.7	112.4*	103.1	108.7
8	105.7	101.6	99.1	102.0
9	107.7	105.0	99.8	104.1
10	108.8	.....	.....	.....
10a	.....	99.4	96.1	.....
11	113.1	106.0	96.7	105.5
12	112.5	101.1	100.0	103.7
13	105.1	.....	.....	.....
13a	.....	111.3	97.1	.....
14	100.0	100.0	100.0	100.0
14a	.....	.....	104.1	.....
Mean	106.7	101.5	99.4	104.0
LSD .05	N. S.	11.65	N. S.	N. S.
LSD .01		14.49		

* Significant .05 point
** Significant .01 point
*** Since 1947 and 1949 treatments were on the same plots, the averages of 1947 and 1949 yields were averaged with 1948 yields for "weighted average"

Yield of Beets

The average yield of beets per treatment for each of the three years was 13.76 tons per acre in 1947, 20.19 tons in 1948, and 20.51 tons in 1949. The lower yield in 1947 was probably due to late planting rather than a marked difference in fertility or moisture. In 1947 (Table 2) the average yield of the 14 treatment was 104.3 percent of the untreated check. In 1948 the average was 120.5 per cent of the check, and in 1949 it was 112.9 per cent.

In 1947 the manure and commercial fertilizer plowed under (Treatment 12) and P and K in a band at planting time with N side dressed just before irrigation (Treatment 6) yielded significantly more than the check. These treatments also yielded significantly more than commercial fertilizer plowed under (Treatment 1), plow-sole application (Treatment 9), all fertilizer in irrigation water (Treatment 8), and commercial fertilizer plowed

under with manure as a top dressing (Treatment 13). The average of the band placement at the time of planting was significantly better than commercial fertilizer drilled before plowing or the plow-sole application.

In 1948 the application of part of the fertilizer with the seed (Treatment 3) gave a yield not quite significantly lower than the unfertilized check, but significantly lower than any of the other fertilizer treatments. All of the fertilizer treatments except 3 gave yields significantly better than the non-fertilized check. The average of the manure treatments plus commercial fertilizer was significantly higher than the average yield of the commercial fertilizer treatments without manure. The yield for the treatment with the

Table 2.—Relative Yield of Beets

Placement	1947	1948	1949	Weighted Average***
1	92.7	122.4*	116.7*	113.6*
2	111.2	115.7*	112.4	112.8*
3	105.9	93.2	.....	.....
4	107.9	127.8**	110.0	118.4**
5	103.1	123.0**	106.9	113.9*
6	114.8*	122.9**	113.0*	118.9**
7	108.3	123.9**	105.0	115.3*
8	99.8	120.0**	116.0*	114.0*
9	95.6	121.6**	113.0*	112.5*
10	100.0	.....	.....	.....
10a	.....	117.5*	109.0	.....
11	105.2	139.6**	132.4**	129.2**
12	112.3*	129.6**	121.0**	123.5**
13	95.0	.....	.....	.....
13a	.....	137.4**	127.5**	.....
14	100.0	100.0	100.0	100.0
14a	.....	.....	107.9	.....
Mean	104.5	120.5	112.9	115.6
LSD .05	12.42	13.25	12.49	11.11
LSD .01	16.59	17.66	17.18	15.81

* Significant .05 point
** Significant .01 point
*** See Table 1

fertilizer directly below the seed (Treatment 2) was significantly lower than the treatment with the fertilizer two inches deep and five inches to the side of the seed (Treatment 4).

In 1949 the three manure treatments, commercial fertilizer plowed under (Treatment 1), band placement of P and K with delayed side dressing of N (Treatment 6), the plowsole application (Treatment 9) and commercial fertilizer all in the irrigation water (Treatment 8) yielded significantly higher than the check.

In comparing the average of the treatments which were carried through

all three years, the manure plus commercial fertilizer ranked highest and the treatment with delayed nitrogen application (Treatment 6) ranked highest of the treatments without manure. The two lowest in rank were the commercial fertilizer plowed under and the plow-sole application (Treatments 1 and 9).

Table 3.—Relative Yield of Sugar

Placement	1947	1948	1949	Weighted Average***
1	91.1	119.6**	110.5	110.2
2	109.6	113.0	108.5	111.0
3	102.5	88.0	.....	.....
4	105.3	128.0**	106.0	116.3
5	102.7	124.9**	100.0	114.2
6	112.4*	122.8**	108.3	116.6
7	106.7	122.3**	100.0	112.8
8	94.4	118.5**	111.6*	110.8
9	92.5	125.2**	112.7*	113.9
10	110.5	.....	.....	.....
10a	.....	117.6*	105.1	.....
11	103.0	130.9**	123.5	122.1
12	106.0	127.5**	113.8	118.7
13	91.3	.....	.....	.....
13a	.....	136.2**	119.9	.....
14	100.0	100.0	100.0	100.0
14a	.....	.....	105.7	.....
Mean	101.9	119.6	108.8	113.3
LSD .05	12.05	14.43	10.94	N. S.
LSD .01	16.12	19.24	14.51	

* Significant .05 point
** Significant .01 point
*** (See Table 1)

Yield of Sugar

The yield of sugar in general parallels the yield of beets (Tables 2 and 3) but the differences due to placement were much less pronounced in the sugar yield than in the beet yields. From the standpoint of sugar yield over the three-year period, there seems little choice between fertilizer placements. Most of the differences which were noted in individual years were less pronounced in the average. There evidently is a differential effect of placement and years, but the plan of the experiment would not permit calculation of the significance of this interaction.

There was no significant difference in sugar percentage during the three-year period but for individual plots there was a sufficient tendency toward an inverse relationship between sugar percentage and yield of beets to produce smaller differences in the yield of sugar than in the yield of beets.

A differential effect of stand of beets on the yield of beets and yield of sugar was noted in the case of the treatment with part of the fertilizer placed with the seed. Yield was only slightly reduced, but sugar percentage was also reduced, resulting in a greater effect on sugar yield.

Tissue Analyses

Differences in available nutrients in the soil frequently can be detected in analyses of plant tissues. Tissue analyses therefore are useful in comparing the efficiency of fertilizers and fertilizer placement. One advantage which tissue analyses have over yield response in such a comparison is that they show differences under high fertility conditions where there is no measurable yield response. Since this placement study was conducted on relatively high fertility land, they have been useful and might well have been conducted more extensively.

Table 4.—Relative Inorganic P in Petioles

Placement	1948	1949	Average
1	172.1**	119.5	145.8*
2	153.5**	126.2*	139.9*
3	165.1**	.....	.....
4	114.0	118.9	116.5
5	146.5**	118.2	132.4
6	132.6*	120.1	126.4
7	151.2**	121.7	136.5
8	107.0	89.6*	98.3
9	175.0**	110.9	142.9*
10a	100.0	137.8	118.9
11	204.7**	148.2**	176.5**
12	179.1**	161.6**	170.4**
13a	170.9**	143.3**	157.1**
14	100.0	100.0	100.0
14a	.	80.5	. ...
Mean	147.9	117.2	135.4
LSD .05	32.53	23.78	37.66
LSD .01	41.86	31.70	53.56

* Significant .05 point
** Significant .01 point

Tissue analyses were made only in the 1948 and 1949 seasons and for only one sampling each year. The 1948 samples were taken June 22, and the 1949 samples July 15. Differences in plant tissue phosphate between treatments (Table 4) were greater than differences in nitrate nitrogen (Table 5), probably because the N in the soil from sources other than fertilizers was relatively high at the time of sampling, and the amount from the fertilizers compared with the total available amount was relatively small. The most pronounced increase in phosphate in the plant tissues resulted from commercial fertilizer plus manure treatments. The large increase resulting from the combination compared to that from commercial fertilizer alone might have resulted from the high availability of the phosphate in the manure, the effect of manure on the availablity of applied phosphates, or the effect of manure on the availability of the natural soil phosphates. Of the commercial fertilizer treatments, the fertilizer drilled into the soil and plowed under and the plow-sole application were the highest in 1948, and the fertilizer directly under the seed was among the high treatments for both years.

For the average of the two years, the fertilizer plowed under ranked highest and the plow sole application second. The two treatments with the fertilizer plowed under gave the highest content of inorganic phosphates in the plant tissues, but were among the lowest yielding treatments. This may indicate that these were the best treatments so far as phosphate is concerned, but not the best for nitrogen, or that these treatments are best only in the early part of the season and that the phosphate in the band might be more available at a later period. More experimentation will be necessary to clarify these points.

Table 5.—Relative Nitrate N in Plants

Placement	1948	1949	Average
1	106.3	100.0	103.2
2	105.3	107.5	106.4
3	137.0*	. .	. ....
4	114.8	98.7	106.8
5	115.3	94.3	104.8
6	98.4	89.9	94.2
7	84.1	88.1	86.1
8	127.5*	95.0	111.3
9	112.2	100.0	106.1
10a	94.7	105.0	99.9
11	121.2	102.5	111.8
12	112.7	105.0	108.9
13a	121.7	110.7	116.7
14	100.0	100.0	100.0
14a	.....	103.8	.. ..
Mean	110.80	100.04	104.3
LSD .05	25.92	N. S.	N. S.

* Significant .05 point

The only significant differences in the N during the two years occurred in 1948, and the only treatments differing significantly from any of the others were the treatment with part of the N fertilizer placed with the seed (Treatment 3) and the treatment with N applied in the irrigation water (Treatment 8) . The larger increase in N from Treatment 3 can be explained from the poor stand and less competition for the N. There is no apparent reason why the N from Treatment 8 should have been higher than from Treatments 6 and 7 which were also delayed applications of N.

SUMMARY

The results of three years comparison of methods of fertilizer placement on relatively high fertility land have failed to show that on the average there is any outstanding difference between most of the fertilizer placement methods studied. The following differences were observed:

(1) There was an evident differential effect of season or location of experiments on the comparative results from the different treatments.

(2) The treatment where 100 pounds of the 500 pounds of commercial

fertilizer per acre used was placed in the same furrow with the sugar beet seed at the time of planting was found to be hazardous when moisture at the time of germination was critically low, and resulted in nearly a fifty per cent reduction in stand in 1948.

(3) The treatment where manure was spread on the surface after plowing gave poor results the one year that it was tried.

(4) For the fertilizer placements conducted through the three-year period, the commercial fertilizer drilled on the surface and plowed under and that put on the plow sole gave the lowest average yield of beets. The treatment with P and K placed in the band at the side of the seed at the time of planting and the N applied as a side dressing before the first irrigation gave the highest results of the treatments without manure. There was no significant difference at odds of 19:1 between placements 11, 12, and 13 when manure and commercial fertilizer were both applied and the manure was plowed under. However, commercial fertilizer applied in a band at the time of planting and commercial fertilizer placed on the manure before plowing gave better results than commercial fertilizer drilled into the soil before the application of the manure and plowing.

(5) The average of the treatments of both manure and commercial fertilizer gave significantly higher yields than commercial fertilizer alone, and the average of the treatments with commercial fertilizer alone gave significantly higher yields than the unfertilized plots.

(6) There was less difference in yield of sugar due to placement than in yields of beets.

(7) The phosphate in the plant tissues was highest early in the season for the treatments where the fertilizers were plowed under, indicating a higher availability of phosphate placed *in* that position for the early part of the season, if not the whole season. No significant differences in nitrate nitrogen in tissues were observed except for the treatment with low stand in 1948, which probably was due to less competition for N, and the treatment with all the fertilizer in the irrigation water. Both were significantly higher than the check.