

Effect of Moisture and Fertilization on Emergence of Sugar Beet Seedlings¹

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Collings (1)³ has discussed the effect of fertilization practices on germination and emergence of field crops and has indicated that soil moisture is a key factor in the response obtained. As an aid in evaluating best field conditions for emergence of sugar beets, emergence data were obtained, in the laboratory, under controlled conditions of soil texture, moisture, and temperature; and rate, analysis, and placement of fertilizer.

Methods and Materials

Lock sandy loam top soil, obtained from a field on the Michigan State University farm at East Lansing, Michigan, was air dried, screened through a No. 20 mesh sieve, and mixed. The textural analysis was as follows: 60.4 percent sand, 26.7 percent silt ($< 50\mu$ and $> 2\mu$), and 12.9 percent clay. The moisture curve is shown in Figure 1. This soil was of medium fertility as determined by the Spurway reserve test. Moisture of the air-dried soil was determined and corrections made to give the percentage of moisture desired on an oven-dry basis (105° C.).

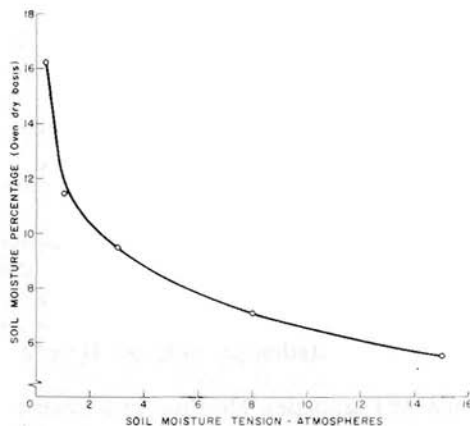


Figure 1.—Soil moisture curve for the Lock sandy loam used in this investigation.

Three hundred and forty grams of air-dried soil were placed in each plastic sandwich box ($4\frac{1}{2}'' \times 4\frac{1}{2}'' \times 1\frac{1}{8}''$). The fertilizer, broadcast or banded, was applied to the air-dried soil. In each box, eight carefully selected and sized whole seedballs of sugar beet variety US 401 were planted at a uniform depth of one-half inch. Finally, distilled water was added over the surface to give the desired soil moisture. The shallow depth of the soil, approximately seven-eighths of an inch, permitted moisture equilibrium

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³ Numbers in parentheses refer to literature cited.

sufficiently rapid to avoid any serious difficulty. In experiments involving more than four days, distilled water was added every three to five days to replace that lost by evaporation. The plastic covers were loose enough to permit a loss of up to 0.6 percent soil moisture in a four-day period. The boxes were kept in an incubator at $20^{\circ}\text{C.} \pm 2^{\circ}$ for the duration of each experiment. Counts of seedlings were made every 24 hours. Only the first seedling from each seedball was counted. Each treatment was replicated four times. The maximum duration of an experiment was 20 days.

For broadcast fertilization, the fertilizer incorporated in each box was equal to the amount that would have been broadcast over and thoroughly mixed in the top three inches of the soil of comparable surface area (1000 lbs. per 1,000,000 lbs. of soil or 0.34 gms. fertilizer per 340 gms. of air-dried soil). For band application the fertilizer was placed as evenly as possible in a band approximately a quarter-inch in width. The amount applied per lineal inch was calculated at the acre rate for 28-inch rows. Where seedballs were to be in contact with fertilizer, the band of fertilizer was applied and the seedballs placed directly on the band of fertilizer.

Results

The number of days required for 75 percent emergence with different moisture levels and rates and placement of 10-10-10 fertilizer are shown graphically in Figure 2. High soil moisture minimized the effect of quantity and placement of fertilizer. On the other hand, soil moisture in the range in which field operations are done was sufficiently limiting to delay emergence where 50 and 100 pounds of fertilizer per acre were banded in contact with the seed.

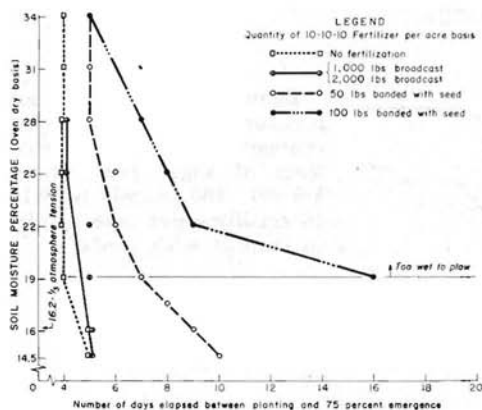


Figure 2.—Effect of soil moisture and fertilization on emergence of seedlings of sugar beet variety US 401.

The marked effect of different rates of fertilization on emergence at a given soil moisture is shown in Figure 3. Figure 4 reveals the effect of given levels of soil moisture, when the rate and placement of fertilizer were maintained constant. With reductions in soil moisture, emergence was not only delayed, but there was a substantial reduction in percentage of emergence.

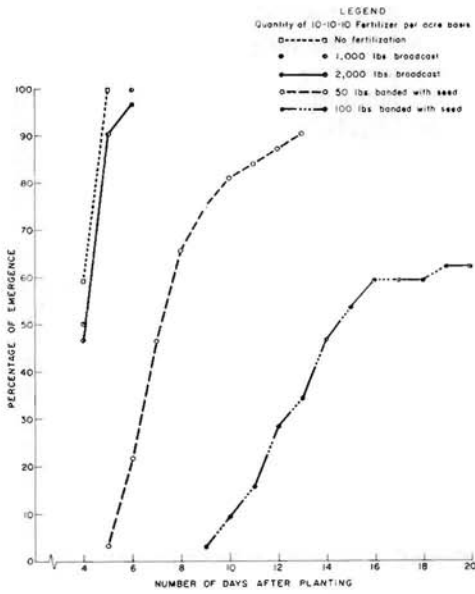


Figure 3.—Effect of fertilization on accumulated percentage emergence of seedlings of sugar beet variety US 401 at 16.2 percent soil moisture.

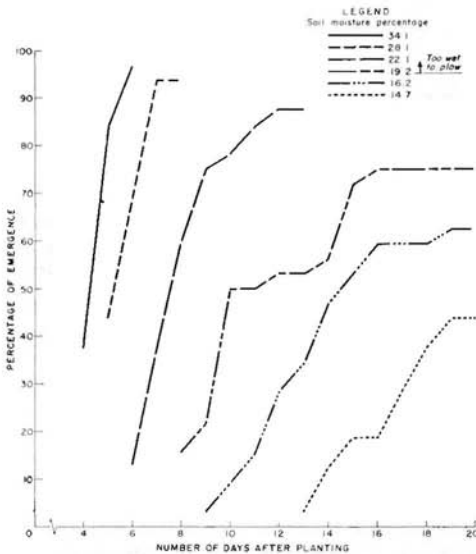


Figure 4.—Effect of soil moisture on accumulated percentage emergence of seedlings of sugar beet variety US 401. 100 pounds of 10-10-10 fertilizer per acre banded in contact with seeds.

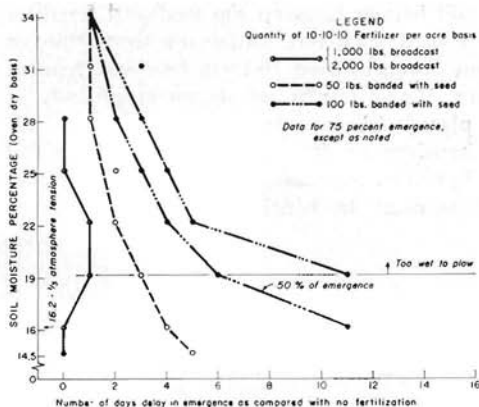


Figure 5.—Delays in emergence of sugar beet seedlings of variety US 401 resulting from specific fertilization practices at given soil moisture percentages.

The extent of delay in emergence of seedlings because of a given fertilization practice may be determined by a comparison with the emergence where no fertilizer was applied. This delay has been expressed graphically in Figure 5. At 28.1 percent soil moisture, 100 pounds of 10-10-10 banded with the seed delayed emergence three days as compared with emergence of seedlings receiving no fertilization. However, at 19.2 percent soil moisture, the delay in attaining 75 percent emergence was eleven days. In an experiment at 16.2 percent soil moisture, 0-45-0 fertilizer banded in contact with the seed at a calculated rate of 50 pounds per acre delayed emergence two days as compared with no fertilization.

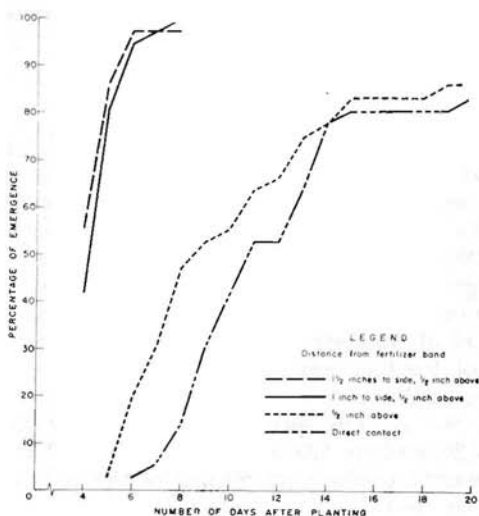


Figure 6.—Effect of distance of seeds from fertilizer band (100 pounds 10-10-10 per acre basis, 28-inch rows) on emergence of sugar beet seedlings of variety US 401. Soil moisture 16.2 percent.

To determine the effect of a soil barrier between the seed and fertilizer on emergence, six replications were used, each box containing three rows of six seeds per row placed at different distances from 10-10-10 fertilizer, banded at the rate of 100 pounds per acre. These results are shown graphically in Figure 6. Where seedballs were placed (a) in contact with fertilizer, (b) one-half inch directly above the fertilizer, or (c) one inch to the side and one-half inch above the band of fertilizer, those seeds placed at the greater distance germinated most rapidly. Seeds at the 1-inch and 1½-inch distances germinated equally well.

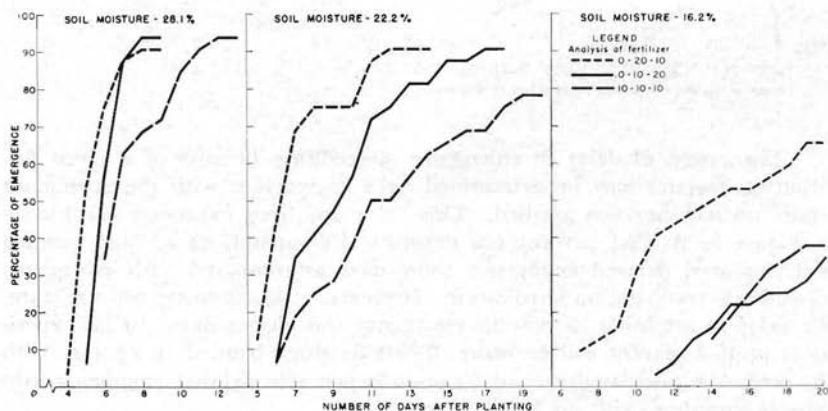


Figure 7.—Effect of 100 pounds per acre basis (28-inch rows) of different analyses of fertilizer banded in contact with the seeds of sugar beet variety US 401 on emergence.

The effects of each of three fertilizers banded in contact with the seedballs on emergence is illustrated graphically in Figure 7. The 10-10-10 analysis was a commercial mix while the 0-10-20 and 0-20-10 were compounded by hand mixing. At the same rate of application and the same soil moisture percentage, the 0-20-10 caused the least delay in emergence while the 10-10-10 caused the greatest delay. This differential delay in emergence of the seedlings appears to be linked directly with the degree of solubility of these three grades of fertilizer. The solubility data³ were obtained as follows: One part of fertilizer was dissolved in 100 parts of distilled water for one hour. The conductance readings were then obtained on the Solu-bridge soil tester at 80° F. The specific conductance for the 0-20-10 was 380×10^{-5} ; the 0-10-20 analysis 505×10^{-5} , and the 10-10-10 analysis 1000×10^{-5} . The high specific conductance reading of the 10-10-10 fertilizer was associated with the greatest delay in emergence.

³ Data determined by J. C. Shickluna, Soil Science Department, Michigan State University.

Discussion

The interpretation of these results must be guided by the fact that the maximum soil moisture at which the plowing operation could be done under field conditions without serious detrimental effect upon the physical properties of the soil is approximately 19 percent. Thus, unless soil moisture is added by rain or irrigation after planting, critical delays in emergence may occur when fertilizer is placed with the seed at planting time.

The curves obtained suggest a good quantitative relationship between the effect of soil moisture and fertilization and the emergence pattern obtained. Surprisingly good prediction was possible from just one curve and a portion of another. Where fertilizer is placed with the seed, at moderate soil moisture, the data show that only relatively small differences in rate of application and placement may cause appreciable differences in rate of emergence of the sugar beet. This certainly substantiates the field observations cited by Collings (1) concerning the effect of fertilizer in contact with the seed. The delayed emergence resulting from fertilizer placed one-half inch from the seed emphasizes the danger of applying fertilizer with the seed.

The germination response is intimately controlled by rate of water uptake by the seed. This rate of uptake is decreased as the osmotic pressure of the soil solution is increased by depletion of the soil moisture, and the addition of fertilizer salts would intensify the effect.

Two practical implications of this study should be stressed. First, conservation of soil moisture during tillage operations is paramount in helping avoid delayed emergence. This suggests some form of minimum seedbed preparation. Secondly, proper placement of fertilizer may aid materially in obtaining rapid emergence and the establishment of a good stand of seedlings.

Summary

The effect of controlled soil moisture levels and specific fertilization practices on emergence of the sugar beet was determined. Plastic sandwich boxes were used to reduce moisture losses. The experiments were conducted at $20^{\circ}\text{C.} \pm 2^{\circ}$.

1. For a given fertilizer rate and placement, as the soil moisture level was decreased, emergence was progressively delayed. A substantially lower percentage of seedlings emerged at the lower moisture levels.

2. Banding 100 pounds per acre (28-inch rows) of 10-10-10 fertilizer in contact with the seed at 14.7 percent soil moisture resulted in emergence of less than 50 percent of the potential stand in twenty days.

3. Emergence was substantially delayed when seeds were placed one-half inch above the band of fertilizer as compared with seeds placed one inch to the side and one-half inch above the fertilizer.

4. At the same rate of application in contact with the seeds, 0-20-10 delayed emergence least, 0-10-20 was intermediate, and 10-10-10 delayed emergence most. This was correlated with solubility of the fertilizers.

5. It is recommended that fertilizer be placed away from the sugar beet seeds to avoid delays in emergence at the lower soil-moisture levels.

Acknowledgment

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Reference

- (1) COLLINGS, G. H. 1955. Commercial Fertilizers. McGraw-Hill Book Co., Inc., 5th Ed.