

The Effect of Soil Moisture and Compaction on Sugar Beet Emergence¹

B. A. STOUT, F. W. SNYDER, AND W. M. CARLETON²

Farm mechanization has been responsible for increased production even though the number of farm laborers has decreased. Although considerable progress has been made toward mechanized production of sugar beets, one of the unsolved problems is that of slow, erratic emergence of seedlings. Uniform emergence is a desirable prerequisite for complete mechanization of sugar beet production.

Of the factors known to affect germination and emergence of sugar beet seedlings, soil moisture is one of the most important. Hunter and Dexter (4) reported that air-dry segmented sugar beet seeds of variety U. S. 215x216 germinated in a Brookston soil only between 12 and 20 percent soil moisture. They observed that an additional small amount of water in contact with the seed induced germination in soils drier than the critical soil moisture of 12 percent. Hunter and Erickson (5) plotted the minimum soil moisture percentages required for germination of seeds of various species in several soils on a moisture tension curve for each soil.

They found the maximum moisture tension which produced satisfactory germination was constant at 3.5 atmospheres for sugar beets, 6.6 atmospheres for soybeans, 7.9 atmospheres for rice, and 12.5 atmospheres for corn. Hunter and Erickson concluded that greater attention should be paid to the soil moisture conditions when sugar beets are planted since they require considerably more moisture for germination than other field crops.

Another factor which may have an important influence on germination and emergence of sugar beet seedlings is that of soil compaction. Because of its effect on aeration, compaction of the soil in the seed zone undoubtedly has some effect on emergence, but available references do not fully explain the effects of this factor. Hunter (3), using U. S. 215x216 segmented sugar beet seed, found that the seed would not germinate under water unless an additional supply of oxygen was bubbled through the water. Greenhouse studies conducted by Cook (2) have shown a reduction in sugar beet yields of approximately 80 percent by compacting the soil from a volume weight of 1.0 to 1.43. However, Barmington (1) stated that the planter should exert high pressures on the soil in the immediate vicinity of the seed. These and other references indicate that soil compaction and aeration are influential during germination and emergence of sugar beets. More specific information is needed in regard to the pressures which should be applied to the soil during the planting operation in order to obtain optimum emergence.

¹ Cooperative investigations of the Michigan Agricultural Experiment Station and the Field Crops Research Branch, Agricultural Research Service, U.S. Department of Agriculture. Approved for publication as Journal Article No. 1879, Michigan Agricultural Experiment Station, East Lansing, Michigan.

² Instructor in Agricultural Engineering, Michigan State University; Plant Physiologist, U.S. Dept. of Agriculture; and Professor of Agricultural Engineering, Michigan State University.

This paper presents the results of an investigation into the effect of various soil moisture conditions and compaction pressures on emergence.

Methods and Materials

Air-dry Brookston sandy loam containing 63 percent sand, 23 percent silt, and 14 percent clay was screened through a U. S. No. 16 screen. Its moisture content was adjusted to the desired level by filling a gallon container approximately one-third full of air-dry soil and adding the amount of water calculated to produce the desired moisture content. The container was closed and the mixture allowed to come to equilibrium over a period of three days during which the container was shaken for a few minutes each day. At planting time, the soil was transferred to small plastic boxes having tight fitting lids to minimize moisture loss by evaporation.

In the first experiment, soil moisture was the only variable. Approximately 340 grams of moistened soil were placed in each box, and a pressure of approximately 0.1 pound per square inch was applied to the surface of the soil. Ten U. S. 400 whole sugar beet seedballs were planted in each box by pressing each seed three-eighths of an inch into the soil and covering uniformly. All plantings were replicated three times. Daily records of emergence were maintained in which only the first seedling from a seedball was recorded.

For the second and third experiments, both soil moisture and soil compaction were variables. A soil compactor³ actuated by compressed air was used to apply the desired pressures to the soil in the plastic boxes. This device, including the four inch square aluminum foot used throughout the experiment, is shown in Figure 1. A spring scale was placed under the box to measure the force applied to the soil. The planting technique, somewhat different from that described above, was as follows: Approximately 150 grams of moistened soil were placed in a plastic box. After the soil had been leveled off, sixteen U. S. 401 whole sugar beet seedballs were placed in each box in a predetermined pattern. An additional 150 grams of soil were placed loosely over the seeds and leveled off. The box, containing the soil and seeds, was then placed under the compactor and the desired pressure applied. In experiment 2, compaction pressures of 0, 2, 5, 7, 10, and 15 pounds per square inch were applied at soil moistures of 12, 16, and 21 percent. To verify the trends indicated in experiment 2, a third experiment was designed using pressures of 2, 15, and 30 pounds per square inch at the same moisture levels. All treatments were replicated three times. After planting, the boxes were placed in a darkened room where the temperature was maintained between 65 and 75 degree Fahrenheit. Emergence counts were made daily for twelve days. When the experiments were discontinued, a soil sample was taken from each box. The moisture content was determined by oven drying and was used as a check on the moisture content determined at planting time.

³ Designed and built by George W. French, Agricultural Engineering Research Branch, Agricultural Research Service, U. S. Dept. of Agriculture, East Lansing, Michigan.

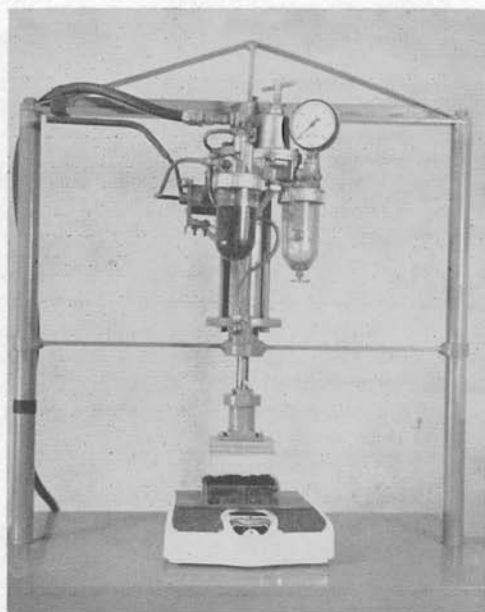


Figure 1.—Soil compactor, plastic box filled with soil, and the spring scale.

Discussion of Results

The effect of soil moisture on emergence seven days after planting is shown in Figure 2. This graph indicates an optimum range of soil moisture for sugar beet seedling emergence from 12 to 21 percent and it is in close agreement with the results of Hunter and Dexter (4). Only 3 of the 120 seedballs planted in soil having a moisture content less than

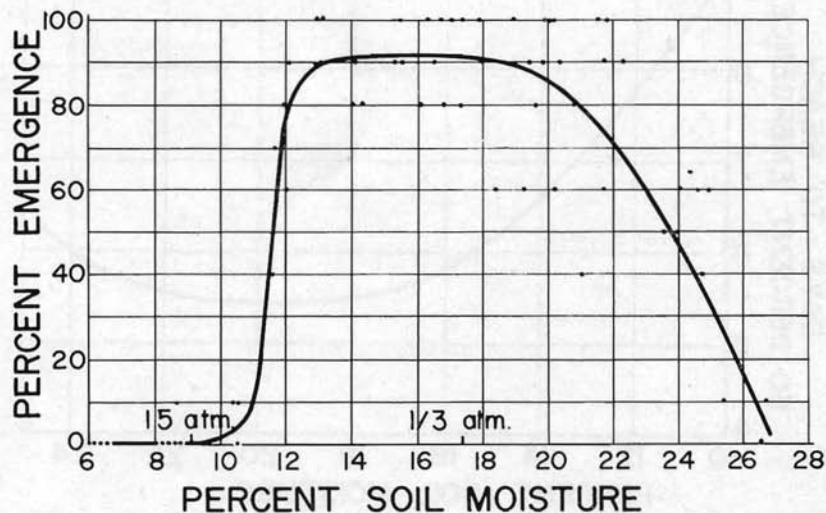


Figure 2.—Effect of soil moisture on sugar beet seedling emergence (Experiment 1).

11 percent had produced seedlings by the seventh day after planting. As the soil moisture content increased above 21 percent, there was a gradual decrease in emergence. The low percentage of emergence observed in soil having a moisture content less than 12 percent may explain, in part, the slow erratic emergence noted in the field.

Another important aspect of this problem is the rate of emergence. Rapid emergence is desirable to reduce the possibility of erratic stands resulting from surface crusting following rains. Figure 3 was plotted from the data of experiment 1. It shows the time required to reach fifty-percent emergence at various soil moisture levels. The maximum rate as well as the highest percentage of emergence occurred in soil having a moisture content ranging from 16 to 21 percent (Figures 2 and 3).

In soils with a moisture content less than the critical soil moisture required for emergence, many seeds were observed that had germinated but failed to emerge. One or two cubic centimeters of water were added to the soil surface just above a few of these seeds. These small quantities of "added" water produced marked increases in the percentage of emergence. The principle of adding water was tested in a field experiment to determine if, under dry soil conditions, emergence could be improved by adding water along the row at planting time. The results will be cited later.

The results of experiment 2, in which various static compaction pressures were applied to the soil at three moisture levels, are shown in Figure 4. Reduced emergence occurred where no compaction was applied and also where the higher compaction pressures were used. On the fourth day after planting, the highest percentage of emergence was observed in soil that was compacted with pressures of 2 and 5 pounds per square inch. After the fourth day the effect of compaction in soil having a moisture content

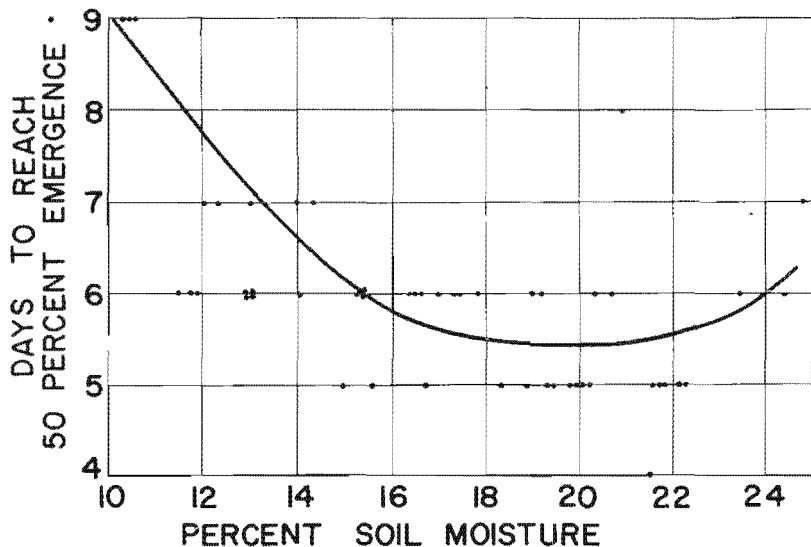


Figure 3.—Time required for sugar beets to reach fifty percent emergence (Experiment 1).

of 21 percent was no longer significant, and the emergence became somewhat erratic at all moisture levels. Possibly, after four days, the lack of oxygen and growth of micro-organisms affected emergence more than the initial compaction.

To verify the trends indicated in experiment 2, a third experiment was performed using compaction pressures up to 30 pounds per square inch. The results are shown graphically in Figure 5. In soil at 12 and 16 percent moisture a marked decrease in emergence was observed at the higher pressures. However, this effect was not apparent in soil at 21 percent moisture. At this high soil moisture level, the emergence was nearly constant over the entire range of compaction pressures from 2 to 30 pounds per square inch. Essentially the same trends are found in the data of the two compaction experiments (Figures 4 and 5).

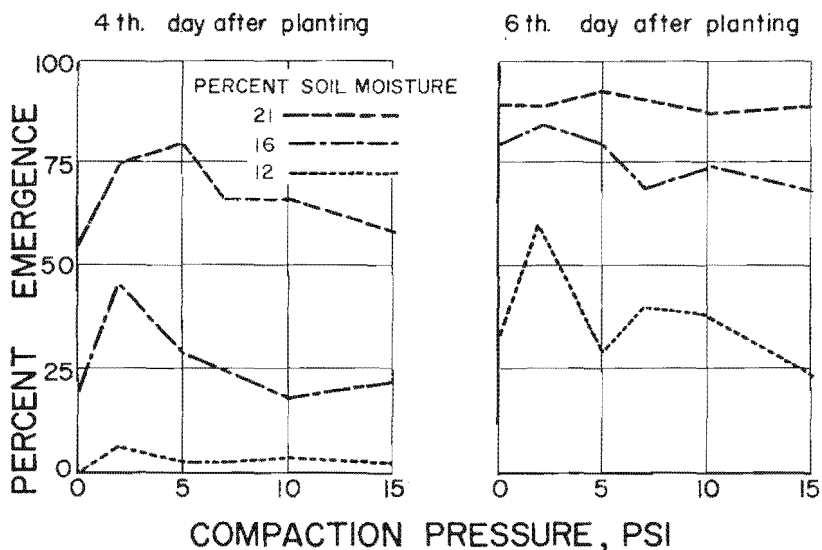


Figure 4.—Effect of soil compaction and moisture level on sugar beet seedling emergence (Experiment 2).

The depression of emergence caused by high compaction pressures at low and medium soil moistures and the absence of the effect at high soil moisture cannot be adequately explained. It seemed logical that in dry soil the higher compaction pressures would give a better seed-soil contact, thereby permitting easier transfer of moisture to the seed which, in turn, would result in faster and more uniform emergence. Also, in wet soil where moisture was not a problem, it was expected that high compaction pressures would cause decreased emergence due to poor aeration.

A field experiment was designed to further test the results found in the laboratory. Sugar beet rows were spaced 26 inches apart in Conover loam. Water was directed into the furrow just before the seed at rates equivalent to 50 and 100 gallons per acre. The planting depth was one inch. Forces

of 0, 150, and 180 pounds were applied to the soil by means of press wheels. In the first planting neither "added" water nor compaction produced any significant effect on emergence. This probably was due to rainfall totaling over five inches between planting time and the time stand counts were made. A later planting using the same rates of "added" water and forces of 0, 120, and 150 pounds on the press wheels was made under drier soil conditions. Water added at a rate of 100 gallons per acre and a force of 150 pounds on the press wheels, both produced significantly higher emergence.

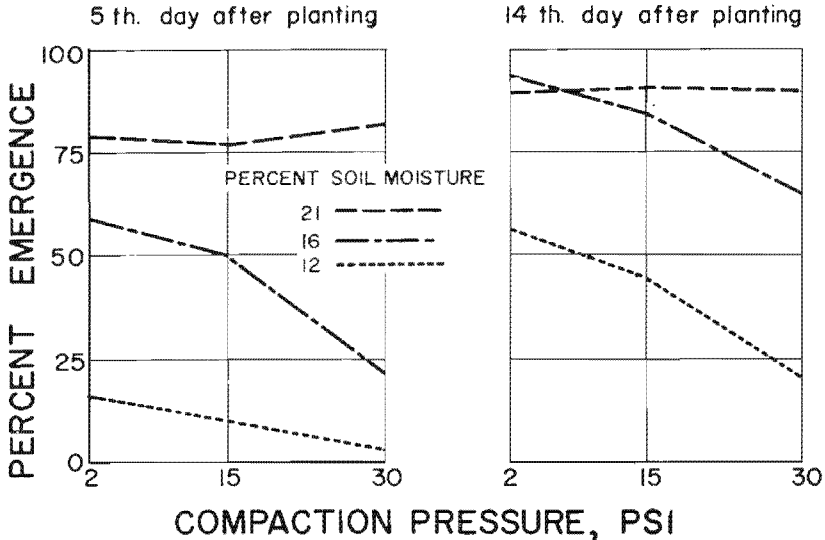


Figure 5.—Effect of soil compaction and moisture level on sugar beet seedling emergence (Experiment 3).

Summary

A laboratory study was made to determine the range of soil moisture and compaction which would produce optimum emergence of sugar beet seedlings. The results of this study were as follows:

1. Soil moistures from 12 to 21 percent produced satisfactory percentages of emergence while soil moistures from 16 to 22 percent produced highest rates of emergence.

2. In soil near the critically low moisture level, the addition of small quantities of water directly over the seeds increased the emergence considerably.

3. The optimum compaction pressure was from 2 to 5 pounds per square inch. Decreased emergence was obtained when no compaction pressure was applied, and also when pressures above five pounds per square inch were applied.

4. The effect of compaction varied with the soil moisture content. In soil at 12 and 16 percent moisture, compaction pressures above 5 pounds

per square inch reduced emergence, while in soil at 21 percent moisture and compaction pressures ranging from 2 to 30 pounds per square inch equal emergence resulted.

From a practical standpoint, this study indicates that conservation of soil moisture during seedbed preparation is of paramount importance. The use of minimum tillage practices is suggested as the most effective means of conserving soil moisture in order that the seed may be planted in soil having approximately the optimum moisture content.

References

- (1) BARMINGTON, R. D. 1948. A press-wheel study to improve beet seedling emergence. Proc. Amer. Soc. Sugar Beet Tech. pp. 225-228.
 - (2) COOK, R. L. 1950. Tillage practices and sugar beet yields. Proc. Amer. Soc. Sugar Beet Tech. pp. 286-293.
 - (3) HUNTER, J. R. 1951. Some factors affecting germination in sugar beet seeds (*Beta Vulgaris* L.) Unpublished Ph.D. Thesis Michigan State University.
 - (4) HUNTER, J. R. and DEXTER, S. T. 1950. Some seed-soil moisture studies with sugar beets. Proc. Amer. Soc. Sugar Beet Tech. pp. 270-274.
 - (5) HUNTER, J. R. and ERICKSON, A. E. 1952. Relation of seed germination to soil moisture tension. Agron. J. 44:107-109.
-