Physical Factors of the Soil Affecting Beet Seedling Emergence[1]

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There are, perhaps, many factors influencing the germination of sugar beet seed which have never been recognized and still others which are known to exist but are not fully understood. Experience has shown that firmness of the seed bed is vitally important, that the shape of the furrow or the manner in which it Avas made has an influence on seedling emergence. Everyone recognizes that a certain amount of moisture is essential to germination of any kind of seed, yet very little is known definitely about these relationships. In the past it has been common practice for farmers or fieldmen to walk over a seed bed and judge the condition of the seed bed by the "feel" or by the depression left by the heel of the shoe. Such practice requires a great deal of skill and years of experience to be of any real value and has the distinct disadvantage of not being measurable in units which can be recorded or communicated to interested persons in other communities.

In some cases devices intended to improve germination have failed to give the expected results, which indicates that some of the conditions required by nature to produce germination have not been met. In order to get more accurate information on what happens in the area near the seed, the mechanical engineering section of the Colorado A & M Agricultural Experiment Station, cooperating with the Beet Sugar Development Foundation, has used two tools to obtain fundamental data which may help to explain some of the difficulties. A soil firmness probe for determining soil density and a soil sampler for taking samples in the seed zone for subsequent moisture analysis were used to study soil and moisture conditions.

The idea of using a soil probe to determine soil firmness is not original, but the probe used in these tests was designed for simplicity of operation and easy carrying in the field. The probe is a fiat disc one-half square inch in area which is forced into the ground by hand pressure. A compression spring inside a telescoping tube which has been calibrated in pounds provides an easy means of determining the pressure being applied. The probe extends through a large flat plate which rests on the surface of the ground as the probe is pushed down. There is just enough spring tension between the plate and probe to hold the plate in place for reading when the probe is removed from the soil. Graduations on the probe indicate the depth of penetration. This depth along with the spring pressure applied enables the operator to calculate the force required to displace one cubic inch of soil. The entire instrument resembles a walking cane and weighs about two and one-half pounds.

The probe was used following four types of furrow opener and press wheel combinations in ten farmers' fields in northern Colorado on soils

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varying from sand to heavy adobe. The tests were made in the undisturbed field and again directly in the row after the planter had passed over the ground. The combined results of these tests are shown in Table 1. Each figure represents the average of ten tests and the average figure for each treatment represents 100 individual tests.

In this test four different planter units were mounted in a four-row planter frame. Treatment one has been called the "Mutt and Jeff" arrangement in which a 714" diameter wheel with a y_s" high ridge in the center of the rim was used to form a shallow groove in the soil. This was followed by a very small shoe on the end of the seed tube which deposited the seed in the groove made by the small wheel. Following the shoe was a larger wheel $I2y_2$" in diameter with a ridge I14" high in the center of the rim

Table 1.—Combined Resulted of Soil Firmness Test[1]

Farm	Field Before Planting	(Tests made directly over the row) 1	2	3	4
Schwindt	25.7	48.6	42.0	37.9	46.4
Schmier	18.3	63.5	41.4	45.2	69.1
Neubauer	36.5	81.6	47.8	53.4	56.6
York	32.2	63.7	50.1	51.0	58.6
Pitcher	22.1	46.4	35.2	39.5	47.5
Weichel	40.3	64.1	46.6	45.4	89.6
Knotwell	16.9	45.8	24.5	23.7	39.7
Morgan	22.4	43.9	29.9	37.2	42.7
Lohrey	34.1	48.0	35.1	46.8	51.4
Schilling	36.6	59.3	56.7	57.1	49.5
Total	285.1	564.9	409.3	485.2	565.1
Average	28.51	56.49	40.93	43.52	56.51

Difference required for significance—5% level—6.53
Difference required for significance—1% level—8.81

[1] Figures represent force in pounds required per cubic inch of soil displaced by a one-half square inch soil probe.

running directly on the seed to push the seed down to planting depth. This wheel was in turn followed by an English-type press wheel. Treatment 2 was the standard check consisting of a commercial John Deere No. 64 double disc opener with a standard deep concave press wheel. Treatment three was the same as treatment two except that an English-type press wheel was used instead of the standard deep concave type. Treatment four was a furrow former wheel $11\,^1/_2$ in diameter with a "V-shaped ridge $1\,^1/_4$ high in the center of the rim which pressed a furrow in the ground. A small shoe close behind the wheel held the furrow open as the seed was deposited in the bottom of the furrow. An English-type press wheel then closed the furrow and packed the soil over the seed.

Soil samples for moisture analysis were taken on the same planter treatments, but due to the extensive nature of such a sampling project only five farms were used. Sixteen cubic inches of soil were taken in the seed zone by taking a section of soil two inches wide, two inches deep and four inches

lengthwise of the row. Samples were taken from two to three days after planting to show the effect of moisture movement after using various planting treatments. The percent moisture shown in Table 2 was determined by standard laboratory moisture technique.

Results of seedling emergence shown in the first half of Table 3 give a rough comparison with the farmers' planting. Direct comparison with the farmers' planting could not be made because his seeding rate could not be checked. The second half of Table 3 shows direct comparisons between treatments with differences required for statistical significance.

Table 2.—Average Soil Moisture Percent on Five Farms[1 2]

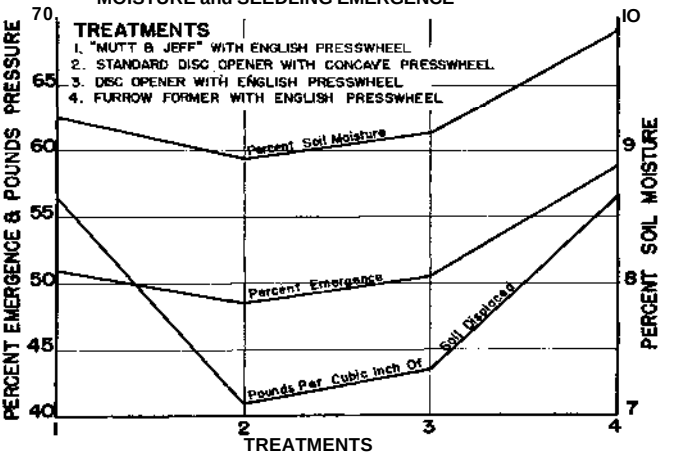
Farmer	Treatments			
	1	2	3	4
Pitcher	8.6	9.5	9.6	13.1
York	8.4	8.2	10.1	7.9
Neubauer	8.1	8.0	8.6	9.6
Weichel	9.9	9.6	8.2	8.9
Knotwell	11.3	9.4	9.2	10.1
Average	9.26	8.94	9.14	9.92
Differences not statistically significant				

[1] Average for top two inches of soil.
[2] Analysis made on wet basis.

The correlation between soil moisture, soil firmness and seedling emergence is shown graphically in Figure 1. There was a striking similarity between the shapes of the curves, which indicates the relation of the three factors. Although the percentage of moisture in the soil appears low, ranging from 8.94 to 9.92, the percent increase produced by the experimental equipment is 9.9%. Individual cases have shown increases in soil moisture as large as 22.4%. The amount of soil packing produced by the various treatments was apparent by the wide range of figures representing pounds per cubic inch of soil displaced by the probe. The range of these figures was from 40.93 pounds to 56.51 pounds. The average of all ten farmers' fields before passing over with any kind of planter equipment was 28.51 pounds per cubic inch as shown in Table 1. The poorest planting equipment increased this figure by 43% and the best planting equipment by almost 100%. The difference between treatments 2 and 3 was due to the English-type press-wheel. Theoretically, the difference between treatments 1 and 4 should be slight because both treatments used a furrow-forming wheel. Actually the difference was considerable, as shown, because of functional troubles with treatment 1. In replicated plots on nearly ideal seed bed conditions treatment 1 was best of all, but in farmers' fields, where the texture of the seed bed tended to be lumpy or cloddy, the small wheel making the shallow furrow in which to deposit the seed did not produce a definite groove to hold the seed in line and a high percent of the seeds was not pushed down to planting depth by the second wheel. This wheel arrangement is not thought to be as universally acceptable to all field conditions as treatment 4, but appeared to have enough merit to warrant further study.

It was evident from the experience of two years that planting equipment which pushes a furrow into the ground to deposit the seed produced more plants from a given amount of seed than any other type of equipment even when the field was irrigated after planting. Just why this should be is not known. It is quite conceivable that a seed bed could be rolled and packed to produce a firm condition which would facilitate movement of water to the surface by capillary action. In this case movement of water

FIGURE I. THE RELATION BETWEEN SOIL FIRMNESS, SOIL MOISTURE and SEEDLING EMERGENCE



to the surface and evaporation from it would be spread uniformly over the field. Use of the "V'-shaped furrow former to press a groove into the soil and depositing the seed in the bottom of the furrow thus formed seemed to cause capillary action to bring moisture to the point where the seed was and to continue to bring moisture to this point during the germination process. As the seedling develops the firm soil under the seed provides a good place for the plant root to establish itself.

Even with the best techniques and the best planting equipment known, preparation for a good stand of sugar beets must start the year before or even two or three years before the beet crop is to be planted. Good general cultural practices are just as important as the proper equipment or good

Figure 2. This soil firmness probe was used to determine soil density. The probe is a flat disc *Vi* sq. in. in area which is forced into the ground by hand pressure. A compression spring inside a telescoping tube which has been calibrated in pounds provides an easy means of determining the pressure being applied. The probe extends through a large flate plate which rests on the surface of the ground as the probe is pushed down. The author is shown here holding it.

Table 3.—Beet Seedling Emergence in Ten Farmers' Fields.

Farmer	Farmers' Planting	Average No. Plants Per 100 inches of Row Treatments 1	2	3	4
Knotwell	35.0	61.9	75.1	67.1	70.7
Lohrey (1st count)	66.9	59.4	49.4	49.0	64.5
Lohrey (2nd count)	67.9	59.7	55.0	58.4	62.4
York	58.1	44.0	50.2	41.5	43.1
Morgen	59.9	45.8	38.5	35.9	37.3
Schwindt	29.3	44.6	24.5	36.9	45.3
Weichel	41.2	62.9	73.1	66.9	63.2
Pitcher	62.7	64.9	62.8	66.4	57.9
Neubauer	39.6	58.8	48.2	55.4	55.4
Schilling	48.3	63.6	65.8	59.7	60.7
Schmier	4.8	35.7	39.5	60.8	68.7
Average	46.7	54.7	52.9	54.4	58.6

Farmer	Percent of Potential Emergence Treatments 1	2	3	4
Knotwell	60.91	67.28	64.44	73.18
Lohrey (1st count)	54.85	46.70	45.60	64.33
Lohrey (2nd count)	55.13	51.99	54.35	68.43
York	44.02	46.31	38.62	44.22
Morgen	43.29	33.98	32.40	38.27
Schwindt	37.18	23.16	33.31	44.43
Weichel	57.64	63.50	63.73	67.74
Pitcher	60.39	56.68	62.77	60.44
Neubauer	55.58	51.22	53.20	56.84
Schilling	58.28	58.95	55.13	61.75
Schmier	33.48	36.76	54.88	68.73
Average	51.00	48.70	50.70	58.90

Difference required for significance—5% level—5.15
Difference required for significance—1% level—6.93

seed. If green manure or other organic material is continually being added to the soil it is more likely to produce a friable soil which will hold moisture and work down into a satisfactory seed bed. Fall plowing and other weed control measures are necessary in preceding crops to assist in controlling weeds in the beet crop. If a field is prepared for planting a beet crop, and w^eeds make it necessary to work the field again before planting, the chances of having enough moisture left to produce a good stand of beets are poor. The best planting equipment and techniques known can not compensate for a haphazard job of seed bed preparation. These experiments have shown that there is a correlation between the type of equipment used, the firmness of the soil after using various tools, the moisture held in the seed zone and the emergence of seedlings.