Bulletin No. 164 - Factors Affecting the Depth of Sowing Various Crops

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FACTORS AFFECTING THE DEPTH OF SOWING VARIOUS CROPS

By

F. S. HARRIS and H. J. MAUGHAN

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FACTORS AFFECTING THE DEPTH OF SOWING VARIOUS CROPS

By

F. S. HARRIS and H. J. MAUGUAN*

INTRODUCTION

Probably no agricultural practice varies more than the depth to which seeds are sown. Some farmers pay very little attention to depth, but simply allow the seed to be placed where the drill happens to penetrate. The percentage germination of the seed as well as the vigor of the young plants is without doubt influenced by the depth of sowing, and certainly these factors are very important in determining the yield of crops.

Long experience has shown that no single depth is best for all crops or for any given crop in all soils. Nor can a definite depth be fixed for a given soil and crop, as the moisture in the soil and probably other factors will help to determine the best depth of seeding. It seems very desirable, therefore, to learn how these various factors are interrelated.

The present paper reports studies on the effect of the percentage of soil moisture on the best depth to plant various crops. This was determined by making counts and measurements at 5-, 10-, 15-, and 20-day periods from the time of planting. The number of seeds germinated, the length of roots, the length of tops, and the height of plants above ground were obtained on each of these 5-day periods.

The germination of seeds cited in the following literature review refers to the plants appearing above the soil. Germination in the report of the experimental work in this paper, however, refers to the seeds sprouted in the soil.

*The authors wish to acknowledge their indebtedness to Mr. Grover Clyde for faithful assistance in laboratory work connected with these studies and to Mr. N. I. Butt for checking calculations.
The effect of the depth of sowing on the germination and yield of field crops has been investigated by many workers under a great variety of conditions. A summary of some results with wheat is given in Table 1.

Table 1. Summary of experiments with depth of sowing wheat made by various workers.

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Reference* No</th>
<th>No. of Years’ Work</th>
<th>Depths Sown</th>
<th>Highest Germination</th>
<th>Largest Yield</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bochkova</td>
<td>1</td>
<td>2, 4, 5, 8, 10 cm.</td>
<td>2 cm.</td>
<td>10 cm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crozier</td>
<td>3</td>
<td>1/2, 1, 2, 4, 6, 8,</td>
<td>1/2 and 1 in.</td>
<td>Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crozier</td>
<td>3</td>
<td>1/2, 1, 2, 4, 6, 8,</td>
<td>1/2 and 1 in.</td>
<td>Loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crozier</td>
<td>3</td>
<td>1/2, 1, 2, 4, 6, 8,</td>
<td>1 in.</td>
<td>Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grisdale et al.</td>
<td>4</td>
<td>1, 2, 3, 4 in.</td>
<td>2 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hays</td>
<td>7</td>
<td>1 1/2, 1 1/2, 2 1/2, 3 1/2 in</td>
<td>3 1/2 in.</td>
<td>A dry summer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MacKay</td>
<td>9</td>
<td>1, 2, 3, in.</td>
<td>1 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Merrill</td>
<td>10</td>
<td>4 1/2, 2 1/2 to 3 in.</td>
<td>1 1/2 in.</td>
<td></td>
<td></td>
<td>Clay</td>
</tr>
<tr>
<td>Morrow</td>
<td>11</td>
<td>1, 1, 2, 3 in.</td>
<td>1 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morrow and Gardner</td>
<td>12</td>
<td>1, 1, 3, 5 in.</td>
<td>1 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nelson and Osborn</td>
<td>14</td>
<td>Shallow, medium deep</td>
<td>1 in.</td>
<td>Shallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perkins and Spafford</td>
<td>15</td>
<td>1/2, 1, 1 1/2 etc., to 6 in.</td>
<td>1/2 and 1 in.</td>
<td>No yield</td>
<td>Sandy Soil</td>
<td></td>
</tr>
<tr>
<td>Perkins and Spafford</td>
<td>15</td>
<td>1/2, 1, 1 1/2 etc., to 6 in.</td>
<td>1 in.</td>
<td>Clay Loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rabomnova</td>
<td>16</td>
<td>1, 2, 4, 6, 8, 10 cm.</td>
<td>2 cm.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saunders et al.</td>
<td>17</td>
<td>1, 1, 2, 3 in.</td>
<td>2 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scovell and Curtis</td>
<td>18</td>
<td>1, 1, 2, 3 in.</td>
<td>2 in.</td>
<td>Results inconclusive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scovell et al.</td>
<td>19</td>
<td>1, 1, 2, 3, 4 in.</td>
<td>4 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ten Eyck and</td>
<td>20</td>
<td>1 1/2, 2, 2 1/2, 3 1/2, 4 in.</td>
<td>2 1/2 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoesmith</td>
<td>21</td>
<td>1, 2, 3 in.</td>
<td>1 and 2 in.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Numbers refer to paper similarly designated in “Literature Cited.”
Morrow and Gardner (13)* from six years' data on the depth of sowing oats showed that the yield decreased as the depth increased from 1 to 6 inches. Crozier (3), from sowing oats in sand, loam, and clay, obtained the best germination at 1 to 2, 1/2 to 2, and 1/2 to 2 inches, respectively. This work is confirmed by the yields from field tests of Hays (7), Grisdale et al. (4), and Saunders et al. (17). Perkins and Spafford (15) found the highest germination of oats in a sandy soil at a depth of 1 1/2 to 2 1/2 inches, while in a heavy clay loam the best depth was 1 1/2 to 2 inches.

Hickman (8) concluded that 1 inch was deep enough to plant corn except during dry years. Morrow and Gardner (13) found 1 inch to give the largest yield of corn as a result of 5 years' experiments. Crozier (3) reports the best depth for the germination of corn as 4 inches in sand, 1/2 to 1 inch in loam, and 1 to 2 inches in clay.

Working with barley, Hays (6) found the best yield during a dry summer came from a 3 1/2-inch seeding. The results of Saunders et al. (17) and of Perkins and Spafford (15), however, show that a 2-inch sowing is sufficient under normal conditions. Crozier (8) reports the best germination of barley when planted from 1/2 to 1 inch deep in soil, but the favorable results from this shallow depth may be due to the fact that the seeds were watered every alternate day.

The work of Corbett (2), Crozier (3), Halsted (6), and Perkins and Spafford (15) shows that both the optimum and maximum depths for planting peas are greater than for the cereals.

As a result of one year's test on sandy soil, Perkins and Spafford (15) found little difference in germination when beans were planted from 1/2 to 6 inches deep. Halsted (5, 6), however, reports the best yields from shallow sowings.

*Numbers in parentheses refer to "Literature Cited."
As an average of 4 years' work the largest yield from sugar beets was shown by Zavitz (22) to be from seed sown 1/2 to 1 inch deep.

In Australia, Perkins and Spafford (15) showed that during a dry year sorghum grown on sandy soil gave the best germination at 1 1/2 to 2 1/2 inches, but during a favorable year the optimum depth was 1 inch. The average of their results on sand and clay soils for 2 years shows little difference in the germination of sorghum from the 1-inch to the 3 1/2-inch seedings.

The germination tests of Crozier, (3), which are supported by the field tests of Perkins and Spafford (15), show that more care

Fig. 2. Graph showing the average percentage germination of seeds with various soil moistures when planted at different depths.
must be taken when planting on a clay soil than with a sandy or loam soil. A large variation from the optimum depth does not have as deleterious an effect with a sandy soil as with a clay soil.

**WHEAT**

![Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of wheat, determined 5, 10, 15, and 20 days after planting.](image)

Fig. 3. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of wheat, determined 5, 10, 15, and 20 days after planting.
OUTLINE OF THE PRESENT EXPERIMENT

The experiment herein reported was so arranged that the effect of depth of seeding could be observed on the germination and growth of the seeds. The seed was sown in galvanized iron cans 12 inches in diameter and 12 inches deep. Ten seeds were sown in the soil of each can at each of the first 8 inches. A loam soil from the Greenville farm of the Utah Agricultural Experiment Station* was used in these tests. The water-holding capacity of this soil was about 30 per cent on a dry basis. Part of the cans were maintained at a low soil moisture content, part at a medium, and part at a high content, as shown in Figure 1.

Four cans of soil for each moisture treatment were provided,

![Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of oats, determined 5, 10, 15, and 20 days after planting.](image)

Fig. 4. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of oats, determined 5, 10, 15, and 20 days after planting.

so that data could be obtained in 5, 10, 15, and 20 days from seeding. These data were determined for each of the following crops:

- New Zealand wheat (*Triticum sativum*).
- Danish oats (*Avena sativa*).
- Australian white flint corn (*Zea mays*).
- Beardless barley (*Hordeum vulgare*).
- Common alfalfa (*Medicago sativa*).
- Canadian field peas (*Pisum arvense*).
- White wax beans (*Phaseolus sp.*).
- Sugar beets (*Beta vulgaris*).
- Feterita or sorghum (*Sorghum vulgare*).

**DISCUSSION OF RESULTS**

**Germination of Seeds**

The percentages of the seeds of the various crops that germ-
inated at different depths in the soil with the 3 moisture treatments are shown in Figure 2. The depth of sowing had no appreciable effect on the germination of oats, but with beans 1 to 3 inches gave the highest germination. All other crops germinated best when the seeds were planted 3 to 6 inches deep. This was most clearly shown with alfalfa, sugar beets, and sorghum, while with the other crops this depth was not so favorable. In general the depth of sowing had more effect on the germination of small seeds than on large ones.

Fig. 6. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of barley, determined 5, 10, 15, and 20 days after planting.

The best germination of beans sown in a soil with a low moisture content occurred 2 inches deeper than the best with high moisture. With most crops, however, the depth of optimum germination was about the same regardless of soil moisture.
Growth of Plants

The data on plant growth are presented in nine figures so that both the depth of seeding and the growth of the plants are shown graphically. It is necessary for a proper understanding of the figures to observe carefully the position of the surface of the soil indicated by the heavy black line marked “surface.”

Figure 3 brings out the development of the wheat seedlings at various depths with 3 moisture treatments for 10, 15 and 20 days’ growth. Planting below 5 inches had an unfavorable effect on both the length of the roots and the height of the plants. The well-developed root system of the plants from the shallow-sown seeds was no doubt an important factor in giving them a better start than those sown deeper. The ratio of roots to tops usually decreased as the soil moisture increased, this being most apparent with a high soil saturation, not only for this but for all crops.

The results with oats and corn are shown by Figures 4 and 5.
to be quite similar to those for wheat except that the depth had less effect on the total height of the plants, although the height above ground tends to decrease about as indicated by other workers.

The growth curves of barley shown in Figure 6 agree with the work of Perkins and Spafford (15) in pointing out that barley

![Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of peas, determined 5, 10, 15, and 20 days after planting.](image)

Fig. 8. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of peas, determined 5, 10, 15, and 20 days after planting.
should not be sown deeper than 2 to 3 inches in soil with low and medium and 1 inch in soil with high moisture content. The growth of tops was a little better for lower depths with high than with low moisture.

Figure 7 shows the growth of alfalfa to be quite irregular. "Damping off" was the primary cause for this variation and it was most evident with high moisture. It is shown, however, that in soils containing low or medium moisture the best growth was with shallow-sown seeds.

**BEANS**

![Diagram of beans growth](image)

Fig. 9. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of beans, determined 5, 10, 15, and 20 days after planting.

An examination of the growth of peas in Figure 8 shows some interesting relations between the depth of planting and the ratio of roots to tops. There was a much larger growth of roots as well as a larger ratio of roots to tops when the seeds were sown shallow. The deeper the seeds were sown the larger the amount of stored food used up before the plant is able to meet its needs by photosynthesis. This is probably the main reason that shallow-sown seeds usually come up better and give the comparatively larger yields indicated in the review of the literature. The op-
timum depth for the growth of peas was deeper than for the other crops, but the depth seemed to have less effect with peas.

Figure 9 shows that although the growth of the beans was not as rapid as that of the peas, the same rule applies regarding the proportion of roots and tops.

From a study of Figure 10 it is noted that increased depth of planting decreased the growth of sugar beets. The results for 15 and 20 days were considerably modified by the plants damping-off.

**BEETS**

![Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of sugar beets, determined 5, 10, 15, and 20 days after planting.](image)

Figure 10. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of sugar beets, determined 5, 10, 15, and 20 days after planting.

Figure 11 shows that the growth of sorghum was most rapid with a low soil moisture. It is also clear that the proportion of roots to tops varies inversely with the depth. Because of fungus growth a high soil moisture was fatal to most of the seedlings.

The greatest average height of the plants above ground with the different moistures is shown in Figure 12. The best growth of plants above ground usually occurred with sowing 1 inch deep, but with peas and sugar beets the 2-inch, and with barley the
3-inch, sowing produced the best growth.

Wheat, oats, corn, and peas appeared above the soil in 20 days for all the depths used. The maximum depths from which the other crops reached the surface, however, were: barley and beans, 5 inches; feterita, 3 inches; and alfalfa and sugar beets, 2 inches. This shows that the smaller seeds failed to appear in 20 days when sown more than 3 inches deep.

**FETERITA**

**LOW MOISTURE**

**MEDIUM MOISTURE**

**HIGH MOISTURE**

Fig. 11. Graph showing the effect of various soil moistures and depths of planting on the growth of roots and tops of sorghum, determined 5, 10, 15, and 20 days after planting.

**SUMMARY**

1. The proper depth for sowing seeds is an important factor in determining the yield of crops.

2. A review of the literature shows that the largest number of plants to emerge and the largest yields were usually obtained from sowing 1 to 2 inches deep.

3. Figures and tables containing the results from 17,280 determinations are presented to show the effect of the depth of
seeding on the germination and growth of wheat, oats, corn, barley, alfalfa, peas, beets, beans, and sorghum.

4. Between 1 and 8 inches the depth of sowing seemed to have little effect on the germination or sprouting of most kinds of seeds, but the highest germination usually occurred from 3 to 5 inches deep, especially for the seeds most affected by depth of sowing.

5. Deep seeding retarded the growth of small seeds and those having poor germinating power more than it did the growth of larger seeds.

6. The plants usually grew faster when the seeds were sown from 1 to 2 inches deep. This rapid growth was especially noticed with the roots, and is no doubt one of the primary reasons for a larger yield from shallow seedings.

7. In general the height of the plants above the soil decreased as the depth of seeding increased. The largest growth of the plants above ground never occurred from seeds sown deeper than 3 inches. Small seeds sown below 3 inches failed to reach the surface in 20 days.
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