Effect of Subsoiling and Deep Fertilizer Placement on Yields of Corn in Iowa and Illinois


Reprinted from the AGRONOMY JOURNAL
Effect of Subsoiling and Deep Fertilizer Placement on Yields of Corn in Iowa and Illinois

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SYNOPSIS. Subsoiling to 16 and 24 inches depth did not increase corn yields in Iowa during 1955, 1956, and 1957. In Illinois, subsoiling to 12 and 18 inches depth produced a significant corn yield response at the lower depth in only 2 out of 14 experiments in 1955 and 1956. Fertilizer placed deep in the subsoiled channel was not as effective as fertilizer plowed under in the Iowa experiments.

DURING recent years considerable interest has developed in subsoiling and deep fertilizer placement in Iowa, Illinois, and surrounding states. Many have felt that compaction due to tillage machinery was creating slowly permeable layers that restricted water movement into and through the soil and thereby increased runoff and erosion. Others believed that pressure pans were restricting root development and still others believed subsoiling aided drainage.

In more recent years subsoiling has been proposed also as a means of applying fertilizer or lime into infertile and acid subsoils. It was believed that root growth in the subsoiled channels would be stimulated in this way, and yields would be increased as a result of the deep-placed fertilizer and better growing conditions.

Subsoiling has considerable appeal to farmers, but research has shown few benefits from subsoiling in the North Central United States (2, 3, 8, 10), where soils regularly freeze to considerable depth, although some benefits have
been reported in the South and Southeast (6, 7) and in
the West (4), where little or no soil freezing occurs. Dudley
(1) has summarized the research in the Great Plains and
found no evidence of general benefits from subsoiling.
Recently, workers in Indiana (9) have been working on
stabilizing loosened subsoiled channels by placing bands
of crop residues in the subsoiler slot. Studies in Kansas (5)
and Minnesota (8) show that the draft requirement for
subsoiling is high compared to other tillage operations,
making it costly.

Prior to the start of this study very few quantitative data
concerning the benefits of subsoiling were available in
Iowa and Illinois. While data in the literature from sur-
rounding states showed little benefit from subsoiling, it
was thought that perhaps larger modern machinery may
have created a compaction problem in Iowa and Illinois.
It was thus the purpose of this study to compare corn
yields on a number of locations and to measure soil bulk
density on selected sites as influenced by subsoiling.

PROCEDURE

Iowa

Subsoiling and deep fertilizer placement experiments were started
in the spring of 1955 and continued through 1958. Sites for the
experiments were chosen in areas where considerable local inter-
est existed and on soil types of major importance with wide con-
trasts in soil properties. Experiments were conducted on a total of
12 locations over 3 years and figure 1 presents the experiment
locations and soil series.

The experimental treatments were:

- No subsoiling
  - a. no fertilizer
  - b. fertilizer plowed under
- Subsoiled to 16 inches depth
  - c. no fertilizer
  - d. fertilizer plowed under
  - e. fertilizer applied with subsoiler 12 or 16 inches deep
- Subsoiled to 24 inches depth
  - f. no fertilizer
  - g. fertilizer plowed under
  - h. fertilizer applied with subsoiler 18 or 24 inches deep

The treatments will be referred to later as treatments a through
h. Two exceptions to the above treatments are indicated in the
tables. In most cases the fertilizer was concentrated superphosphate
at 80 pounds of P.Os per acre, although the rate sometimes varied.
A randomized complete block design was used with 4 or 6
replications. Plot size was 52 x 52 feet (eight 40-inch rows) by
50 feet. The subsoiling and deep fertilization were done with the
equipment shown in figure 2. Fields were subsoiled on 40-inch
intervals and corn was planted directly over the subsoiled channel.
All areas were subsoiled in the fall except on the Ida soil which
was subsoiled in early spring. In the fall of 1955 treatments were
applied at the Edina, Marshall, Galva, and Webster-Glencoe soil
locations. On the Marshall and Grundy soils the treatments were
repeated in the fall of 1956 on the same plots. Residual effects
from the 1955 subsoiling treatments were measured on the Edina
The Galva experiment was relocated in 1956. The soils were dry
for spring and fall subsoiling in 1955 but too wet for good soil
shattering in 1956.

All areas were spring-plowed and the seedbeds were prepared
in the conventional manner except on the Marshall soil, where
the corn was planted by hand-ground listing with no prior tillage
after the subsoiling, and on the Webster-Glencoe soil, which was
fall-plowed. Uniform high amounts of nitrogen (except in the
Ida experiment) and potash were applied at all locations. Row
fertilizer (100 pounds per acre of 6-24-0) was applied at time of
planting on the Grundy, Marshall, and Edina sites and care was
taken to place the corn rows directly over the subsoiled channel.
Corn stands were generally uniform at any one location and ranged
between 12,000 and 16,000 plants per acre among locations. The
stands were considered sufficient for optimum grain yields under
the moisture conditions encountered.

Moisture limited corn growth at many locations. A summary
of rainfall during the experimental period is given in table 1.

Iowa Soil Types

The soils at the experimental sites have been classified as
follows:

- Ida silt loam is an Arzonal soil developed under grass vegeta-
tion on steep slopes from coarse-textured loess. At the site used
for this experiment the soil was a uniform grayish-brown, cal-
careous, highly permeable silt loam throughout the profile. The
slope was 12%.

- Marshall silt loam is a Brunizem developed on thick loess. It
has about 8 inches of a dark brown fine silt loam surface and a
moderately permeable brown silty clay loam B horizon extending
to a depth of 24 inches. The slope was 6%.

- Galva silt loam is a Brunizem developed under grass vegetation
from loess on nearly level to gentle slopes. The soils at both
experimental sites have a dark brown silt loam surface to a
10-inch depth and a moderately permeable yellowish-brown silty
clay loam subsoil extending to a depth of about 36 inches. The
slopes at both locations ranged from 2 to 4%.

- Webster and Glencoe are Humic Gley soils developed from
Wisconsin till. The soils have a silty clay loam texture through-
out the profile. The surface soil to a depth of about 18 inches
is black, grading to an olive-gray mottled subsoil which extends
to 32 inches. The slopes ranged from 0 to 1%.

- Edina silt loam is a claypan soil which has developed on level
topography from loess under grass vegetation. It consists of 8
inches of dark grayish-brown silt loam which grades into a light
gray ashly silt loam subsoil horizon. The subsoil which begins
abruptly at about 18 inches is a dark gray mottled plastic clay
and extends to a depth of 3.5 feet.

- Grundy silt loam is a Brunizem developed on gentle slopes from
fine-textured loess under grass vegetation. It has a very dark
graysih brown silt loam surface 9 inches thick. The surface soil grades into a mottled grayish-brown and gray slowly permeable silty clay loam subsoil which reaches maximum density at a depth of about 20 inches. The subsoil is slowly permeable to a depth of 30 to 40 inches but below this depth it grades gradually into the open and friable silty parent material. The slope is about 3%.

Illinois

Experiments were established at a total of 8 locations on Ashkum, Drummer, Elliott, Martinon, and Symerton soils (figure 1) to compare (A) no subsotiling, (B) subsotiling 10 to 12 inches deep and (C) subsotiling 16 to 18 inches deep. The subsotiling was done at 40-inch intervals with a commercial cheisel-type subsotiler similar to the one shown in figure 2. The subsotiling was done in September of 1954 when the soil at all locations was relatively dry. The subsotiling on the Ashkum and Drummer soils was perpendicular to the direction of corn rows whereas on the Elliott, Martinon and Symerton soils the subsotiling was across the slope and thus generally parallel to the row direction. The treatments were arranged in a randomized block design and replicated 4 times. The plots were 50 feet wide and either 66 or 78 feet long.

All experiments were located on first- or second-year legume seedings. The experimental areas were fall plowed, usually several weeks after subsotiling, and prepared for corn planting in the conventional manner. The previous rotations had generally been 2 or 3 years of corn or soybeans followed by oats and 1 year of alfalfa. The fields had been limed and fertilized according to soil tests.

Corn yields were measured in all 8 experiments in 1955 and residual effects were measured in 1956 at the 6 sites in corn. Stand counts were uniform at any one location and varied from 12,000 to 15,000 plants per acre among locations. They were considered near optimum for the soil moisture conditions encountered.

Illinois Soil Types

The soils at the experimental sites have been classified as follows:

Ashkum silty clay loam is a Humic Gley. It is poorly drained and consists of 11 inches of black silty clay loam surface material which grades to a grayish brown mottled fine silty clay loam B horizon from 15 to 40 inches. Below 40 inches is grayish brown fine silty clay loam glacial till.

Drummer silty clay loams are Humic Gley soils. The soils at the 3 experimental sites are poorly drained and were similar in profile appearance. They have a mottled black silty clay loam extending to about 12 inches depth and grading to a gray or dark brown mottled silty clay loam B horizon at about 14 inches and extending to 36 to 38 inches. Below 38 inches the soils varied somewhat but generally are stratified with loam and silty clay loam materials.

Elliott silt loam is a Brunizem. The soils at the two sites are imperfectly drained, have 6 inches of very dark gray silt loam on the surface grading to a brown silty clay loam B horizon from 15 to 32 inches. Below 32 inches is a grayish brown silty clay loam material.

Martinon silt loam is a Brunizem. The soil at the experimental site is imperfect to low moderately well drained. The surface 9 inches of soil was very dark gray silt loam. The B horizon from 14 to 32 inches is brown to dark grayish brown mottled silty clay loam underlain by stratified silty clay loam and sandy clay loam layers to more than 60 inches.

Symerton silt loam is a Brunizem, moderately well drained, has 8 inches of very dark gray brown silt loam which grades to a yellowish brown clay loam B horizon from 12 to 30 inches. Below 30 inches is a bright loam stratified material.

RESULTS

The effects of subsotiling treatments to 16 and 24 inches depth and a no subsotiling treatment on corn yields in Iowa are given in table 2. These values represent the mean of treatments a and b for no subsotiling, treatments c and d for the 16-inch subsotiling, and treatments f and g for the 24-inch subsotiling, without and with plowed-under fertlizer in each case.

In none of the 11 experiments did subsotiling produce a significant yield increase. A reduction of 9.7 bushels per acre for subsotiling at a 24-inch soil depth was significant on the Edina soil in 1956. Likewise, subsotiling to a depth of 24 inches decreased corn yields on the Grundy soil by 6.4 bushels per acre in 1957. In several other experiments the trend was toward lower yields from subsotiling although they were not significant at the 5% level.

During August and September of 1956 bulk density samples were taken on the Webster–Glencoe and Marshall experiments that had been subsotiled in the fall of 1955. The samples were taken with the equipment shown in figure 3 in the corn row which was planted over the subsotiled channel. The effects of subsotiling on bulk density of the
Marshall soil are given in figure 4 and for the Webster-Glencoe soil in figure 5.

On the Marshall soil the differences in bulk density between the check and the 16-inch subsoiling were significantly different in the 6- to 9-, 9- to 12-, and 12- to 15-inch layers. The differences between the check and the 24-inch subsoiling were not significant at the 5% level. Differences in bulk density between subsoiling and no subsoiling were not significant at any depth on the Webster-Glencoe soil. In both soils the bulk density values are in the range where little or no increase in plant growth would be expected from a loosening of the soil. In the two soils studied no compacted horizon within the surface 15 inches was found to exist and visual observations indicated that compacted layers did not occur within the top 2 feet of soil on these 2 soils or in any of the other soils studied.

The effects of subsoiling 12 and 18 inches deep in the fall of 1954 on corn yields at 8 locations in Illinois in 1955 and at 6 of the same locations in 1956 are shown in table 3. In one location in 1955 on Symerton silt loam a significant yield increase of 5.8 bushels per acre was obtained from the 18-inch subsoiling although the increase due to 12-inch subsoiling was less than 2 bushels per acre and not significant. While a significant yield increase at only 1 location was obtained in 1955 on the sloping Elliott, Martinton, and Symerton soils the average increases due to subsoiling 12 and 18 inches deep were 0.7 and 7.2 bushels per acre, respectively. Mean yield increases on the nearly level Drummer and Ashkum soils were even smaller and not significant, averaging 3 bushels per acre.

Corn yields were significantly increased due to the residual effects of subsoiling at only 1 of the 6 locations in 1956 and this occurred only when the subsoiling was done at an 18-inch depth. There were increases or decreases at other locations and depths but none was significant.

The responses to fertilizer and the comparisons of fertilizer plowed under with fertilizer placed in bands 16 or 24 inches deep are given in table 4. The table shows only those experiments in which a statistically significant response to fertilizer or placement occurred.

The experiments on the Ida soil in 1955 and the Webster-Glencoe soil in 1956, 1957, and 1958 showed a significant response to fertilizer. On the Ida soil there was no significant difference in the effects of plowed-under and deep-placed fertilizer. In 1956 on the Webster-Glencoe location the yield reduction caused by the 16-inch-deep placement of phosphorus as compared to plowed-under phosphorus was significant at the 5% level and in 1957 and 1958 it was significant at the 10% level. In all years at the Webster-Glencoe locations the mean yields were lower when the phosphorus was placed at the 24-inch depth as compared to the plowed-under phosphorus but the differences were not significant.
Table 3—Effect of subsoiling 12 and 18 inches deep in the fall of 1955 at various locations in Will and Kankakee Counties in Illinois on corn yields in 1956 and 1957.

<table>
<thead>
<tr>
<th>Location No.</th>
<th>Soil type</th>
<th>1955 subsoiling</th>
<th>1956 subsoiling</th>
<th>Bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None 12 18 inches</td>
<td>None 12 18 inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ashurst silty clay loam</td>
<td>73.8 76.7 83.5</td>
<td>109.7 102.9 98.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Drummer silty clay loam</td>
<td>76.7 74.3 74.4</td>
<td>82.9 66.5 64.3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Drummer silty clay loam</td>
<td>83.6 84.4 76.7</td>
<td>106.1 99.3 97.2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Drummer silty clay loam</td>
<td>87.9 78.0 75.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Elliot silty clay loam</td>
<td>83.0 72.3 90.7</td>
<td>82.4 90.9 90.4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Elliot silt loam</td>
<td>86.1 73.2 88.4</td>
<td>76.9 74.2 67.0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mattison silt loam</td>
<td>76.8 74.3 90.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Symerton silt loam</td>
<td>96.3 96.2 102.7*</td>
<td>77.1 75.2 80.6</td>
<td></td>
</tr>
</tbody>
</table>

* Yield increase over no subsoiling treatment significant at 5% level.

Table 4—Effect of plowed-under and deep-placed fertilizer on yields of corn and oats in Iowa.

<table>
<thead>
<tr>
<th>Experiment location No.</th>
<th>Fertilizer placement</th>
<th>Bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Ida silt loam</td>
<td>April 1955</td>
<td>21.0 36.8 - 37.6</td>
</tr>
<tr>
<td>2  Webster-Grinnell clay loam</td>
<td>Oct. 1956 Corn</td>
<td>94.4 68.9 68.5 66.5</td>
</tr>
<tr>
<td>3  Webster-Grinnell clay loam</td>
<td>Oct. 1957 Corn</td>
<td>62.0 82.9 70.0 78.3</td>
</tr>
<tr>
<td>4  Webster-Grinnell clay loam</td>
<td>Oct. 1958 Oats</td>
<td>50.0 75.5 61.7 60.5</td>
</tr>
</tbody>
</table>

* The deep-placed fertilizer on the Ida silt loam was applied in April 1955 in the bottom of a subsoiled slot. That on the Webster soil was distributed in a band from the bottom to 4 inches above the bottom of the subsoiled slot in October 1955. In both experiments the fertilizer was placed at 40-inch intervals immediately below where the corn rows were placed. The fertilizer on the Ida soil was 50-100-60 and on the Webster soil was 60-120-60. In all cases the comparison between fertilizer and no fertilizer was significant at the 5% or 1% level.

Discussion

In this study the treatment plots were randomized without protection from runoff between plots. However, rainfall was below normal with few excessive storms at any of the locations. Observations indicated that runoff was negligible. Thus conditions for measuring differences in yields due to differences in runoff were not present in these experiments. On the Webster–Glencoe and Edina soils in Iowa and the Ashkum and Drummer soils in Illinois, where drainage is sometimes desirable, rainfall was low enough so that excess soil moisture was not a problem. Moisture deficiencies frequently occurred, in all experiments in 1955 and 1956 and in some locations in 1957 (see table 1). Thus, if the subsoiling encouraged deeper root penetration into moist soil it likely would have been reflected in increased yields. If, however, the loosened subsoiled slot remained open from the time of treatment application in the fall until the time of seedbed preparation in the spring, evaporation of moisture from deeper layers may have caused the decreased yields obtained after subsoiling. A small amount of mixing of less fertile subsoil with more fertile surface soil also occurred.

In experiments in other sections of the country where subsoiling has improved crop yields, pressure or natural compacted zones have been observed and root restriction due to the compacted zone was usually noticed. Thus no such compacted soil horizons limiting vertical root extension were observed in these experiments. Thus, from the bulk density and profile characteristics of the soils studied yield increases from subsoiling probably should not be expected. However, at the time of initiation of these experiments considerable local interest was expressed and many farmers were using subsoiling equipment on the same soil types as studied in these experiments.

In only 2 of the 7 experimental locations did phosphorus or phosphorus plus nitrogen produce a significant increase in corn yields over the no fertilizer treatments. In both cases the plowed-under fertilizer was more effective than the deep-placed fertilizer. The Ida experiment in 1955 was conducted under severe drouth conditions, and the Webster–Glencoe experiment in 1956, 1957, and 1958 under moderate to good moisture conditions. Thus some range in soil moisture conditions was sampled.

Summary

Subsoiling to 16 and 24 inches depth did not produce significant yield increases in 12 experiments on 7 important soil types in Iowa in 1955 through 1958. In 2 cases subsoiling to 24 inches depth decreased corn yields significantly. In Illinois in 1955, corn yields were increased significantly by subsoiling to 18 inches depth in 1 out of 8 experiments on 5 soil types. The residual effect of subsoiling increased yields at 1 of the 6 locations in 1956. Measurements at two locations in Iowa generally showed small and unimportant decreases in soil bulk density due to subsoiling.

Significant responses to fertilizer were obtained at two locations in Iowa. On an Ida soil under drouth conditions, phosphorus plus nitrogen produced insignificantly greater yield increases when plowed under than when placed in the subsoiled channel 20 inches deep. On a Webster–Glencoe soil, plowed-under phosphorus produced greater corn yields the first and second years and greater oat yields the third year after application than phosphorus placed 16 or 24 inches deep in the subsoiled channel.

Literature Cited

6. RANNEY, W. A. Effects of deep breaking studied; increased yield as obtained in dry years. Mississippi Farm Res. 17:1. 1954.