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Let's Examine CROP ROTATIONS

They Make Big Differences in the Crop Yields at Present Time and in the Future

By W. H. PIERRE and G. M. BROWNING

WE HAVE BEEN so involved in producing the crops the government has asked for to help win the war that we are in danger of losing sight of the need of growing good rotations for maintaining fertility and producing high yields per acre.

Iowa farmers are now growing nearly a third more acres of corn and soybeans than they did in 1941—the combined acreage of these two crops is nearly 3 1/2 million acres more than it was in 1941. With this increase in the acreage of row crops has come a decrease in the soil conserving crops—the hay and pasture.

Though this change has been necessary, it is time now to check up on just what the change means. We need to get ourselves ready for a "right face" or a "left face" if not an "about face" in our cropping system.

Soil Fertility Declining

How much has this change in our cropping system increased soil depletion on Iowa farms? The rate of depletion has been over one-half faster since 1941 than before, a careful study shows.

The growing of intertilled crops such as corn and soybeans not only uses plant food much faster, but the loss from erosion is greater, too, on rolling land. On the other hand, legume sod crops add nitrogen and organic matter to the soil which following crops can use, and legumes greatly reduce soil erosion. So when we grow fewer acres of these soil conserving crops and put into their place crops that rapidly take away plant food and increase erosion, it’s easy to see why our soil fertility has gone down rapidly since 1941.

Legumes “Core” of Rotation

The first and most important requirement of a good crop rotation is that it contains plenty of legumes. Sod crops of legume-grass combination produce much feed per acre and, in addition, they do these things:

1. Increase the yields of other crops in the rotation.
2. Help maintain soil fertility, particularly the nitrogen and organic matter.
3. Produce good soil tilth.

The number of years the land should be kept in meadow or pasture during the rotation varies with the kind of soil and the steepness of the slopes. The less the organic matter content of soils or the steeper the slope the larger should be the proportion of soil conserving crops in the rotation. In all cases, however, the legume crop is the first requirement or “core” of the rotation.

Corn Yields Increased

How much can you expect legumes in the rotation to increase the yield of corn? You can get a partial answer to this from two experiments at our Experimental Farm in Page County. In one of these experiments corn has been grown continuously for 13 years on the same plots, while plots beside them were in a 3-year rotation of corn, oats and red clover.

During the 13 years the corn grown continuously on the same land averaged 31.8 bushels per acre, while that grown in a 3-year rotation averaged 54.0 bushels—an increase of over 22 bushels an acre for rotation. Moreover, the difference in yield between the two treatments is rapidly getting greater (see the graph, p.4). In the last 5 years (1940-44) the corn grown in the rotation averaged 71.2 bushels per acre while that grown continuously averaged only 23.9 bushels per acre.

In another experiment using three different rotations, the most striking result was the large benefit obtained from sweetclover. Where sweetclover was grown in oats and turned under the following spring for corn, the yield of corn was increased an average of 26 bushels per acre (graph, p. 5). This shows the marked benefit that would be obtained each year in the yield of corn if all the small grain in Iowa were seeded down to a legume or legume-grass mixture. Many thousands of acres of...
The two pictures show how the cropping system affects the cloddiness (soil tilth). Above, in corn continuously for 10 years; below, second year of corn in a rotation of corn, corn, oats, clover. Marshall silt loam.

The runoffs were also much greater with corn.

Legumes and grasses in the rotation also reduce the loss of soil and water during the fall following the plowing of the soil. In the experiment on Marshall silt loam (table 2), land in corn following clover in the rotation lost less than one-half as much soil and only two-thirds as much water as where corn followed corn.

The reason for this difference is that sod crops improve the physical properties or tilth of the soil. This makes it possible for the soil to absorb more water so there is less water to run off and cause soil erosion.

The beneficial effect of sod on soil tilth is shown in the accompanying photographs on this page. Following continuous cropping with corn the soil turned up in large clods when plowed, whereas the corn ground that had been in clover 2 years previously had very few large clods and was in good physical condition when plowed.

Fitting Rotation to Soil

The kind of rotation that should be followed on a given farm depends on the fertility of the soil and how easily it erodes. In general the less the organic matter content of the soil and the more

Organic Matter, Nitrogen

One of the most important reasons why crop yields decrease when land is kept in grain crops such as corn and oats is that these crops lower the nitrogen and organic matter content of soils. Nitrogen is needed by plants in large quantities. With too little nitrogen, plants turn pale green and make spindly growth.

When legumes are brought into the rotation the crop following has a dark green color, an indication that it is getting plenty of nitrogen. Inoculated legumes do not depend on the soil for nitrogen, but absorb it from the air through the nodule bacteria on their roots. Both the roots and tops of legumes contain large amounts of nitrogen taken from the air. When these are plowed under, both oats and wheat still are not seeded to legumes in sections of Iowa.

Where corn was grown in a 4-year rotation of corn, oats, followed by clover and timothy for 2 years, the yield of corn was 32 bushels higher than when grown in a corn-oats rotation. In poor crop years the differences in yield may be smaller than those obtained in the good crop years of 1942-1944. However, the differences between the poor and good rotations will probably become greater the longer the treatments are continued.

Erosion, Runoff Decreased

Another important reason for following a good rotation which includes legume and grass sod crops is to reduce soil erosion and conserve water. Close growing crops, like legumes and grasses, protect the soil from erosion and enable it to absorb more of the rainfall. This has been well demonstrated from studies carried on at the Experimental Farm in Page County during the past 14 years. The average loss of soil from the different crops of a 3-year rotation was as follows: From corn, 18.4 tons per acre per year; from oats, 10.1 tons; and from clover sod, only 0.2 ton. (See table 2.) This shows that practically no soil was lost where red clover, alfalfa or bluegrass was grown, but large losses occurred where corn was grown.

Yields are low when corn is grown continuously. Note the increasingly higher yield from the rotation with clover. Marshall silt loam.
Legumes in rotation increase the yield of corn. Marshall silt loam. Soil Conservation Experimental Farm, Clarinda, la. (Years 1942-44.)

sloping the topography the greater should be the proportion of legume and grass sod. On soils of rolling topography, rotations should be supported by such erosion control practices as contouring or terracing. The use of these practices will reduce the proportion of sod crops needed in the rotation.

We shall discuss briefly a few examples of some standard rotations that fit different general soil conditions.

Group A—Level Soils

Since these soils are not subject to erosion, the proportion of legumes in the rotation need not be as large as on soils of rolling topography. One of the most common rotations followed on such soils is a 4-year rotation of corn—corn—oats—clover. This rotation provides for 50 percent of the land in corn or for a 1 to 2 ratio of soil conserving to intertilled crops. If soybeans are grown, part of the corn land may be used for soybeans without changing the general rotation plan.

We have had such a 4-year rotation of corn—corn—oats and clover-timothy meadow on plots at the Agronomy Farm at Ames since 1915, and good crop yields have been maintained. During the past 5 years the yield of first-year corn on these plots has averaged 63.3 bushels per acre where the soil received no other treatment during this period, and 80.5 bushels per acre where lime, manure and phosphate had been used regularly. This experiment is located on Webster soils, which are high in organic matter and quite level.

Group B—Gently Rolling

On many gently rolling soils or on only moderately productive soils the ratio of soil conserving to intertilled crops should be about 1 to 1 instead of 1 to 2 as in Group A above. This type of rotation is best illustrated by the 3-year rotation of corn—oats—clover. It is a rotation that has been followed by many farmers in some sections of the state. One objection to it is that it has only 1 year of sod. In order to overcome this objection and still maintain a ratio of soil conserving to intertilled crops of 1 to 1, a 5-year rotation of corn—corn—oats and 2 years of an alfalfa-bromegrass mixture can be used. In this rotation 40 percent of the land is in corn instead of 33 percent as in the 3-year rotation of corn—oats—clover.

Group C—Rolling to Hilly

A third group of soils are those on which about 2 acres of soil conserving crops need to be grown for each acre of intertilled crops to control erosion and maintain fertility. These are the rolling to hilly soils. A common rotation for these soils is a 4-year rotation of corn—oats and 2 years of an alfalfa-bromegrass mixture. It has only 25 percent of the land in corn and permits good control of erosion during the 2 years of sod, but it needs to be supplemented with such erosion control practices as contouring, strip cropping or terracing.

One or Two Years of Corn?

In two of the rotations that have been described, corn is grown 2 years in succession. With the Group B soils, many farmers grow 2 years of corn in succession in order to have more than 1 year of sod and still maintain a fairly high amount of corn or intertilled crops.

The disadvantage of this system is that the growing of 2 years of corn in succession is conducive to soil erosion. Moreover, the question has often been raised as to the comparative yields of first and second-year corn. Tests at the Agronomy Farm at Ames and at the Soil Conservation Experimental Farm in Page County help answer this question. The results obtained are shown in table 3.

In all experiments the first-year corn outyielded the second-year corn. During the favorable crop years of 1943 and 1944 the first-year corn averaged 20.8 bushels or 30.2 percent higher than second-year corn at Clarinda and 11.7 bushels or 13.5 percent higher at Ames. The long time averages which include a number of dry or unfavorable seasons give values of 6.1 to 8.5 bushels in favor of first-year corn, or an average of about 16 percent. The reason for these differences is that the beneficial effect of the legume sod in making nitrogen available and improving soil tilth (physical condition of the soil) only partially carries over into the second year.

Use of Cover Crops

The shortcomings of a rotation with 2 years of corn or intertilled crops in succession can be partly overcome by seeding a legume...
cover crop in the first-year corn. Not only will the cover crop protect the soil from erosion but it will supply nitrogen for the second-year corn.

Rye and vetch or sweetclover on land supplied with lime, and rye and vetch on unlimed or acid areas have been successful as cover crops when broadcast with a cultivator attachment or endgate seeder either before or after the last cultivation of corn, or when seeded in standing corn with a one-horse grain drill about Aug. 15. In about 1 year out of 5, on an average, good stands will not be obtained at the time of last cultivation because of July or early August droughts or because of grasshopper or chinch bug injury. Seedings of rye and vetch made between Aug. 15 and Oct. 1 seldom fail, but those made about Aug. 15 make the most growth. Seeding of sweet-clover should be made by Sept. 1.

Use Alfalfa-Bromegrass

During recent years the experience of many farmers and the results of experimental work have emphasized the value of alfalfa and brome grass grown together as a perennial hay and pasture crop. An alfalfa-brome grass meadow or pasture produces a large yield of high quality feed on adapted land and is very effective in controlling erosion. So we may expect an increase in the acreage of this important crop combination in the next 10 years.

You may wonder, "How can I best fit this valuable crop regularly into my rotation and at the same time grow the desired acreage of intertilled crops?" Hilly and steep fields should, of course, be in grass-legume pastures or meadows as much of the time as possible in order to protect the land from erosion. The problem is with the less rolling land, or the land that is in regular rotation. There is a strong tendency to keep the alfalfa-brome grass meadow or pasture 3 to 4 years, or as long as it is producing well. The result is that the other cropland on the farm is kept in corn or non-legume crops for several years in succession—a situation that reduces yields and encourages erosion.

On level or gently rolling soils it would be much better to keep each field in meadow or pasture not more than 2 or 3 years, and thus maintain the productivity of all fields on the farm. This can be done on many farms by using a 5-year rotation, previously described, of corn—corn—ots and alfalfa-brome grass for 2 years. This rotation provides for 40 percent corn or intertilled crop and 40 percent of perennial meadow.

If you want to avoid 2 years of corn in succession on rolling land, this rotation can be readily changed to a 6-year rotation of corn—ots (with sweetclover crop for green manure)—corn—ots and 2 years of meadow. In this rotation, the two corn crops do not occur in succession, and a legume crop precedes each corn crop. At the same time 33 percent of the land is in corn.

In some tests reported by the Wisconsin Agricultural Experiment Station the best hay is made when the day is real hot and the hay dries rapidly. In fact, artificially dried hay is the best source of carotene for livestock.

Hay which is never exposed to sunlight contains practically no vitamin A, says G. Bohstedt of the University of Wisconsin. On the other hand, too long exposure will bleach out the carotene.

<table>
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<th>TABLE 1. THE EFFECT OF CROP ROTATION ON LOSSES OF SOIL ORGANIC MATTER.</th>
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<tr>
<td>2-year rotation (Corn—oats)</td>
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<td>3-year rotation (Corn—oats—clover)</td>
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<td>Modified 4-year rotation (Corn—oats—legume hay—wheat)*</td>
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* Kept in alfalfa for 5 years out of 20.

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<tr>
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* Does not include 1936 and 1937 when stands of clover were not obtained.

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<th>TABLE 3. A COMPARISON OF THE YIELD OF CORN THE FIRST AND SECOND YEAR AFTER SEEDED TO LEGUME.</th>
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