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Abstract. Terracing is the only practice that we now have that will control erosion on all land slopes under the cropping systems now being used in Iowa. Current research has proved the effectiveness of terraces in controlling erosion. Developments in terraces and terrace systems, such as making the terraces parallel, use of tile outlets, and changing the cross secion and method of construction, have eliminated most of the farmer's objection to farming with terraces. Terraces are effective and will be required, not only to protect erosive cropland, but also to decrease the sediment loads in the surface waters of the state.

Iowa is one of the leading agricultural states in the nation. This position is largely based on the extensive acreage of favorable soils which can be used to produce corn and soybeans. To protect this large acreage of productive soils from erosion, many Iowa farmers have adopted conservation measures. Demands on the land for additional production will require that effective erosion control measures be applied more extensively than in the past if the land is to continue to be protected.

Scope of Erosion Problem. The Conservation Needs Inventory made in 1963 of all lands in Iowa except urban areas and federal-owned areas points out the scope of the erosion control problem. In this inventory, the land was subdivided according to its capability as follows:

Class I	10%
Class II	45%
Class III	29%
Class IV	6%
Classes V, VI, and VII	10%

Class I land has very few limitations for any type of land use. Class II has moderate limitations for use as cropland. Class III has severe limitations for use as cropland. Class IV has very severe limitations for use as cropland and can only be cropped occasionally. Classes V, VI, & VII are not adapted for use as cropland.

These classes were further subdivided into three subclasses showing the dominant hazard to their use—erosion, wetness, or unfavorable soil conditions. Of the 26 million acres now used for cropland, over 15 million acres have a dominant water erosion hazard. Almost 11 million of these acres are not adequately treated and are feasible to treat.

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Treatment Alternatives

Treatment needs for erosion control on these 11 million acres of cropland range from cultural practices such as crop rotations to the more complex mechanical practices such as terraces. Crop rotations using meadow and small grains with row crops can be effective in controlling erosion providing percentage of close-growing crops is adequate. Contouring is also effective, particularly on gentle slopes, where it may reduce erosion by 50% over straight row farming. Contouring, however, becomes less effective as the slope increases and reduces erosion only 10% on the steepest slopes farmed. Contour strip cropping with alternate strips of meadow and grain crops will double the effectiveness of contouring. Minimum tillage or mulch tillage can also be used to reduce erosion, with its effectiveness dependent on the nature of the operations and the steepness and length of slope. To be fully effective in reducing erosion to tolerable limits, all of these more simple erosion control practices require, at least on the steeper slopes, a larger percentage of meadow crops in the rotation than is currently being used. Current cropping patterns in Iowa have greatly increased the area devoted to soybeans, a clean tilled row crop, with corresponding reductions in the acreage in meadow and small grains-close erosion resistant crops. With the cropping systems now being used, terracing, supplemented by other practices as needed, is the only practice which will effectively control erosion on all slopes.

Research on Effect of Terracing

Research by the Agricultural Research Service on field size watersheds with 12-14% slopes in the deep loess soil in Pottawattamie County near Treynor shows that soil loss by sheet erosion from contoured continuous corn watersheds is reduced from 20 tons per acre per year to less than 1 ton per acre per year when the watershed is level terraced. In addition gullies below the contoured watersheds continued to erode, while gully erosion below the terraced watershed has not been significant.

Another effect pointed out by this research is that, although total runoff for the 1964-1966 period from the contoured watersheds was about the same as from the level terraced watershed, about two-thirds of the runoff from the contoured watershed was in the form of surface storm runoff and one-third as ground water (base flow). From the terraced watershed, only about one-seventh of the total runoff was surface flow and six-sevenths was discharged as base flow.

Studies are being initiated to determine the amount of soil loss and runoff from tile outlet terraces at various locations in the state.

Very little data is available as yet, but it is anticipated that the effectiveness of the tile outlet terraces in reducing soil loss from fieldsize watersheds will be demonstrated.

Mechanics of Erosion Control by Terraces

The principal manner by which terraces reduce soil loss is by breaking up a long slope into a series of short slopes. Doubling the length of slope increases soil loss by about 1.5 times, so the effect of breaking up the slope length by terraces is very significant in reducing soil loss. In addition, all or part of the soil that does erode between terraces is retained in the terrace channel, further reducing sediment volumes actually leaving the field.

Type of Terraces. Two general types of terraces have been used in Iowa. In the deep loess soils in Western Iowa, level terraces, using the infiltration capability of the soil as an outlet, are built. Throughout the remainder of the state, the low infiltration rates of the soil does not permit the use of level terraces, and gradient terraces, requiring an outlet of some type, have been installed.

Development of Terraces in Iowa

The terraces and terrace systems which are now recommended have evolved through a long period of development in Iowa. Terraces were first used in Iowa in the early thirties. These terraces were, on the most part, built with plows or a whirlwind terracing machine, and necessarily followed a true contour very closely. This made the terraces very crooked on most fields and the spacing between any two terraces varied, causing many areas of point rows. In addition, the spacings used between terraces were very narrow. These terraces were very effective in controlling erosion, and their disadvantages were at least tolerated at that time. The point row areas and the sharp turns did not present an unsurmountable problem to the two-row equipment and the slow-speed tractors used. The rate of terrace installation increased almost annually until the mid-1950's.

With the advent of four-row, six-row and larger equipment pulled by larger and faster tractors, acceptance of these old terraces decreased. With the wider equipment, the point row areas and the narrow spaced terraces became increasingly difficult to farm.

Making Terraces Parallel. To overcome this principal objection to terraces, various methods of making the terraces parallel and thereby eliminating most of the point rows and making farming operations more efficient, were devised. The first method used was to vary the grade of the channel on a gradient terrace. By using combinations of the flattest allowable grade and the steepest allowable grade on the different terraces in the system or on different reaches of the same terrace, terraces on some fields could be made parallel. Another practice that helped was to use all possible waterways and to leave the terrace open on sharp ridges. This shortened the terraces, but made them straighter and easier to make parallel.

The second method used to make terraces parallel was by making cuts and fills along the terrace line. With larger earth moving equipment used to build terraces, this method became feasible and now is the principal method used to make terraces parallel. The necessary grade on the terrace is actually constructed by borrowing from the channel at the high spots and filling in the low spots. This method is adaptable to both gradient terraces and level terraces.

By making the terraces parallel and thereby permitting more efficient farming, terraces are more acceptable to farmers. Studies show a 5 to 34% saving in time in farming parallel terraces over farming non-parallel terrace systems. Construction of parallel terraces really got started in Iowa in the late 1950's and in 1968, 830 miles or 63% of the terraces installed in Iowa were parallel, with some areas installing almost all parallel terraces.

Tile Outlet Terraces. The next important advance in terracing was the use of tile outlets for gradient terraces. Storage for the runoff from the design rainfall (usually 2 inches) is provided in the terrace channel. The accumulated runoff water is discharged through an intake into a tile line which is sized to remove 1 inch per day. The runoff from the design storm is discharged within 2 days, preventing most damage to the crop.

There are many advantages of the tile outlet terrace. It permits more flexibility of alignment, making it easier to build the terraces parallel. Where the terrace crosses a flat-graded waterway, the terrace can be built straight across instead of turning downstream to a satisfactory outlet elevation. It permits steeper channel grades near the outlet since the water in storage will reduce the velocity and the erosive power of the water in the channel. In this case, the ease of farming will be enhanced as most of the sediment moving in the channel will be deposited in the low area around the intake, making the land flatter. With tile outlet terraces most of the open waterway outlets can be eliminated, along with the maintenance which most waterways require.

Tile outlets also reduce the total amount of soil leaving the field. Ponding the water temporarily in the terrace permits most of the sediment to be deposited in the channel, reducing the total sediment load in the tile outlet and at downstream locations.

The acceptance of tile outlet terraces by farmers has been good.

The first tile outlet terraces were built on the Howard County Farm in 1963. In 1967, the latest year for which records were available, 246 miles were constructed in the state.

Grassed Backslope Terraces. Another development in terrace design has been to improve the cross section and the manner of building the terrace. In the "grassed backslope" cross section, the backslope of the terrace is left steep, usually on a 2:1 slope. This steep backslope is seeded to grass. Most of the borrow material for this type of terrace is obtained from below the terrace with very little taken from the cannel. This cross section is a definite advantage over the ordinary broad based cross section on land slopes steeper than about 6 to 8 percent. By borrowing from the downhill side, the steepness of the land actually farmed is reduced by 3 to 4%. The conventional broad-based terrace for which the borrow is taken from the uphill side of the terrace steepens the slope actually farmed. By flattening the slope of the land actually farmed, soil losses are reduced, permitting spacings between terraces to be widened when the grassed backslope terrace is used.

The backslopes of these terraces, which are seeded to permanent grass, provide good cover for pheasants and other wildlife.

Matching Row Spacing. Another improvement in terracing is to match the terrace spacing to fit the width of the equipment. The spacing between parallel terraces is made such that a given number of trips through the field with the equipment will completely plant the area. This objective is somewhat complicated by the trend toward changing the conventional 40-inch rows to more 30-inch rows. However, on many of the slopes commonly terraced, the recommended spacing is 120 feet, which fits most multiples of 30-inch and 40-inch rows.

Terraces Reduce Sediment Problems

The primary emphasis on the use of terraces has been to prevent erosion and maintain the productivity of the lands on which they are installed. Since over 75% of Iowa land is used for cropland and 40% of this cropland is in need of treatment to control erosion by water, it follows that the greatest percentage of the sediments which appear in our streams, lakes, and reservoirs are derived from this eroding cropland. Terraces, which are essential to control erosion and protect the lands on which they are installed, are therefore one of the most important measures needed to reduce the sediment loads which fill lakes and reservoirs, clog channels, and otherwise detract from the quality of surface waters in the state. Any program aimed at materially reducing sediment in the waters of Iowa will necessarily require terracing as a foundation.

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