University of Missouri Extension

G1641, Reviewed October 1993

Land Grading for Irrigation: Design and Construction

C. F. Cromwell and Mark Peterson
Department of Agricultural Engineering

Phillip D. Coombs
Natural Resources Conservation Service

Land grading is reshaping the surface of land to planned grades for irrigation and subsequent drainage. Land grading permits uniform and efficient application of irrigation water without excessive erosion and at the same time provides for adequate surface drainage. A plane surface (uniform row and cross slopes) is easiest to manage and maintain.

All lands to be graded for irrigation should be suitable for use as irrigated land and for the proposed methods of water application. Water supplies and the delivery system should be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Design criteria

Soils should be deep enough so that, after the needed grading work is done, an adequate, usable root zone remains over most of the field that will permit satisfactory crop production with proper conservation measures. Limited areas with shallower soils may be graded to provide adequate drainage, irrigation grades or a better field arrangement.

All grading work for drainage or irrigation should be planned as an integral part of an overall farm system to conserve soil and water resources. Boundaries, elevations and direction of slope of individual field grading jobs should be such that the requirements of all adjacent areas in the farm unit can be met. Designs for the area being graded should include plans for removing excess irrigation and storm runoff water from the fields.

Excavation and fill material required for or obtained from such structures as ditches, pads and roadways should be planned for as a part of the overall grading job and the yardage included when calculating cut-to-fill ratios. The cut-to-fill ratio will normally be between 1.30 and 1.50 to allow for losses due to compaction, hauling and undercutting.

Furrow grades

Land graded for irrigation with subsequent drainage will have a slope in the row direction between 0.1 percent and 0.5 percent on deep alluvial soils. There should be no reverse grade in the row direction. The most desirable surface is a plane. Fields graded to minimum slopes will require more maintenance of grade than steeper slopes.

Design grades on prairie claypan soils may have furrow grades up to 1.0 percent to avoid exposing large areas of subsoil in cut areas. Special residue management may be necessary to minimize erosion where furrow grades exceed 0.5 percent.

Cross slope

Cross slope (slope perpendicular to row slope) is permitted in order to reduce cut yardage or to establish the "plane of best fit." Cross slopes must be such that "breakthroughs" from both irrigation water and runoff from rainfall are held to a minimum. Recommended cross slope is shown in Table 1.

Table 1
Maximum recommended cross slope

Furrow grade	Cross slope
0.1 percent	0.3 percent
0.2 percent	0.3 percent
0.3 percent	0.3 percent
0.4 percent	0.4 percent
0.5 percent	0.5 percent

On prairie claypan soils. cross slopes up to 3 percent are permitted. Use terraces on cross slope of 2 percent or more. Where terraces are necessary on fields to be irrigated, rows should be parallel to terraces. Land forming may be necessary between terraces to eliminate reverse grade in irrigated rows.

Maximum length of runs for irrigation

Maximum length of runs for irrigation should be limited by furrow flow rates available, furrow cross-sectioned area, erosion hazard to the furrow, and water intake characteristics of the soil. Erosion hazard is a function of soil texture, crop residue and slope. A frequently used guide to maximum furrow flow rates is Q = 10/s, where s is furrow slope in percent and Q is gallons per minute per furrow.

An upper limit of 50 gpm per furrow is usually set due to furrow cross-section limitation.

Reasonable increments of length of run are fractional subdivisions of a mile due to land ownership patterns. The maximum length of run for irrigation is generally 1/4 mile.

The following table gives recommended maximum length of runs for various row slopes and soil textures. A range of run lengths is provided for some conditions. Use the shorter length of run for 2-inch irrigation applications. A longer run will result in poor water distribution through seepage and runoff. Maximum row lengths of 1/8 mile (660 feet) to 1/6 mile (880 feet), should be used on soils with high permeability or high erodibility. Soils such as Beulah Loamy Sand or Sarpy Loamy Sand have intake rates too high to be furrow irrigated. Drainage field ditches, sometimes referred to as tail ditches, should be properly designed to carry the excess flow from the furrows within reasonable time so as not to damage field crops.

Construction specifications

Land to be graded should be cleared of brush and excessive crop residue, trash or vegetative material. Grading should not be attempted when soil moisture exceeds that permitting normal tillage or plowing.

Bring the land to design grade or grades in accordance with a detailed plan showing cuts, fills and grades. Fills of more than 6 inches should be built up by spreading the soil in successive layers. Disk or chisel the field surface after scoop work is completed and before final land planing.

Finish work with a land plane will be done so the field is free from depressions that would cause ponding of water. The land plane should be operated over the field three times: once at a 45 degree angle to the direction of the rows; once at a right angle to the direction of the rows; and finally in the direction of the rows. Field checking to determine compliance with design grades should have a maximum tolerance of plus or minus 0.1 foot at any grid point, with no reverse grade.

During the first year after grading, normally cut areas swell and fill areas settle. This may require minor cuts-and-fills and additional land planing.

Table 2
Recommended maximum length of run in feet for 2- to 3-inch application

Row grade	Maximum furrow stream GPM (Q)	Length of run (feet)[1]			
		Soil texture			
		H[2]	F[3]	M[4]	S[5]
0.1 percent	50	1320	1320	1320	800 to 1320
0.25 percent	40	1320	800-1320	880	660 to 880
0.75 percent	13	660-880	660	660	
1 percent	10	660	660		

[1]The run lengths shown in the table also are applicable to border irrigation. Length of run and slope may be increased for erosion-resistant grass or grass-legume crops. Maximum cross slope should not exceed 0.1 foot per border strip width.

[2]H — Fine textured (sandy clays, silty clays and clays). Typical soils in this group are Sharkey clay, Osage clay. Carlow silty clay, and Wabash silty clay.

[3]F — Moderately fine textured (sandy clay loams, clay loams and silty clay loams). Typical soils in this group are Onawa silty clay loam, Zook silty clay loam and Colo Silty clay loam.

[4]M — Medium textured (very fine sandy loams, loams and silt loams). Typical soils in this group are Putman silt loam, Parsons silt loam, Robinsonville fine sandy loam, Dundee loam, Westerville silt loam, Nodaway silt loam and Blackoak silt loam.

[5]S — Moderately coarse textured (Sandy loams and fine sandy loams) Typical soils in this group are Bruno sandy loam and Bosket fine sandy loam.

G1641, reviewed October 1993

Related MU Extension publications

- G1504, Maintaining Grassed Waterways
  http://extension.missouri.edu/publications/DisplayPub.aspx?P=G1504

Order publications online at http://extension.missouri.edu/explore/shop/ or call toll-free 800-292-0969.

UNIVERSITY OF MISSOURI Extension

■ Issued in furtherance of the Cooperative Extension Work Acts of May 8 a
June 30, 1914, in cooperation with the United States Department of Agricultu
Director, Cooperative Extension, University of Missouri, Columbia, MO 65211
■ an equal opportunity/ADA institution ■ 573-882-7216 ■ extension.missouri.e