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WATER MANAGEMENT (DRAINAGE)

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Economic Factors of Drainage Related to Corn Production

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Since the late 1800s, U.S. farmers have been using drainage methods to allow cultivation of poorly drained soils, once believed to be unproductive and unhealthy. Today, proper drainage is still recognized as a key to maximum crop yields.

Nationally, 25 percent of all cropland is classed as "wet" soil. And corn is grown on a surprisingly large portion of that land, thanks to drainage improvements.

Increasing the productivity of a poorly drained soil by installing drainage improvements, however, does not necessarily guarantee increased corn production profits. A farmer has to compare potential benefits with the expected costs of a drainage investment to know if it's going to be profitable or not.

The purpose of this publication is to help you, the corn producer, make such a comparison. Discussed are the likely effects of drainage improvements, the yield value of those improvements, the factors determining the economics of drainage, and how to calculate returns to a drainage investment.

AGRONOMIC EFFECTS OF DRAINAGE

Research dealing with the effects of soil drainage on corn yield levels, yield variation and date of planting is limited and results are frequently site-specific. Therefore, although the following studies indicate the likely benefits from drainage improvements, local experience and yield records should be used to verify these results.

Effects on Yield Level and Variability

Drainage improvements on poorly drained soils often result in substantially higher corn yields. Long-term experiments in north central Ohio on Toledo silty clay, a very poorly drained soil, have compared surface drainage only, tile drainage only, and a combination of surface and tile drainage on replicated plots (1). Average yields over 13 years were 92, 116 and 121 bushels per acre for the surface only, tile only and surface plus tile drainage systems, respectively, versus 60 bushels per acre on the undrained plots (Table 1).

Table 1. Corn Yields with Various Drainage Systems on Toledo Silty Clay Soil in North Central Ohio, 13 Years of Record.

	Drainage system			
Crop	None	Surface only	Tile only	Surface and tile
	bushels/acre			
Corn	60	92	116	121

These same Ohio studies show that drainage improvements also tend to lessen variability in yields. Over the 13 years, there was 18 percent yield variation from year-to-year on the tile-drained and combination tile-and surface-drained plots compared to a 33 percent variation on the surface-drained plots and 46 percent on the undrained plots.

A 3-year experiment in southwest Ohio on Clermont silt loam, a "fragipan" soil, found that shallow (18 inches deep) subsurface drains together with good surface drainage can significantly improve corn yields. In fact, drainage improvements are essential to obtaining high yields with no-till practices on this poorly drained soil (2). In this experiment, average yields were 158 bushels per acre within 10 feet of the subsurface drains but only 140 bushels at a distance of 40 feet from the drains.

Drainage improvements are also likely to accentuate the yield benefits of irrigation on soils with low water-holding capacity in the root zone. A 5-year experiment in south central Illinois on the Cisne soil association, a claypan soil, showed that corn yields increased 1 5 bushels per acre in response to drainage improvements alone and 38 bushels per acre in response to irrigation alone (3). But where irrigation was applied to drainage-improved claypan, yields increased 78 bushels per acre-nearly double the no-treatment plot yields (Table 2)!

Table 2. Corn Yields with Drainage Improvements and Irrigation on a Claypan Soil in

South Central Illinois.

Drainage system	Irrigation treatment: None	Irrigation treatment: Sprinkler
	bushels/acre	
None	80	18
Surface and subsurface	95	156

Effects of Timeliness of Planting

Frequently, because of excess soil moisture planting must be delayed, which can significantly reduce corn yields. For example, long-term Ohio studies indicate that the optimum corn planting date is May 7 for Wooster and one day earlier each 10 miles south of Wooster which means April 23 for Portsmouth, Ohio. Date-of-planting studies at Columbus. Ohio. found that average yields decrease 0.2 percent per day for corn planted between April 8 to May 7, 0.6 percent per day when planted from May 7 to May 29, and 1.8 percent per day for May 29 to June 23. Similar North Carolina data suggest decreases of 0.87 percent per day for corn planted April 20 to May 30 and 1.86 percent per day after May 30 in that state.

Drainage improvements can speed up the drying rate for poorly drained soils, adding perhaps 2- 3 field working days in May during wet years in Ohio. This would permit 4-9 calendar days earlier planting, since only about one-third of the month is suitable for field work in wet years.

PREDICTING YIELD RESPONSE TO DRAINAGE IMPROVEMENTS

Corn yield response to soil water stress can be predicted if one knows (a) the planting date and (b) the effects of both excessive and deficient soil moisture. The prediction (often called a yield index) is based on a stress-day index, certain crop susceptibility factors and soil water conditions. Yield indexes have, in turn, been used to predict the average annual net profit from corn production (4).

The stress-day crop susceptibility and soil water condition factors have been incorporated into a drainage simulation procedure that describes 63 percent of the variation in yields over a 12-year period in North Carolina (5). Using this procedure, the relative yield indexes from nine simulations for the Toledo silty clay soil were calculated and are shown in Figure 1 (6). Similar analyses could be made to evaluate planned drainage systems (Figure 2)

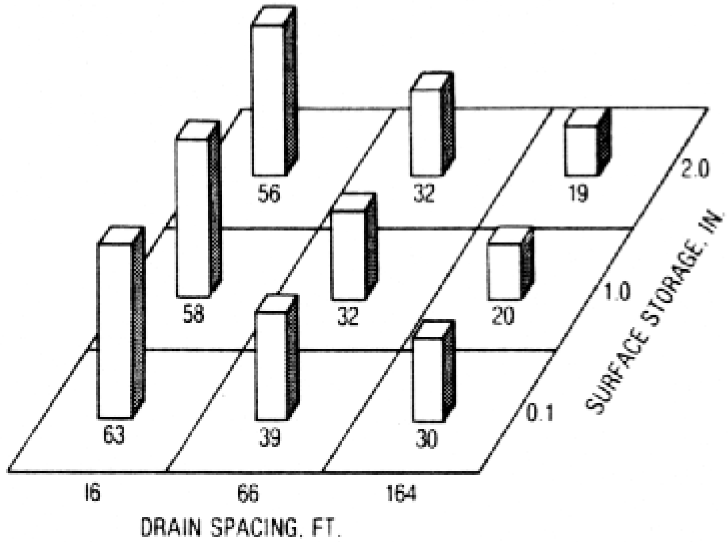

Figure 1. Relative corn yield index on Toledo silty clay soil as affected by surface storage volume and subsurface drain spacing. Columbus, Ohio. weather l949-1970.

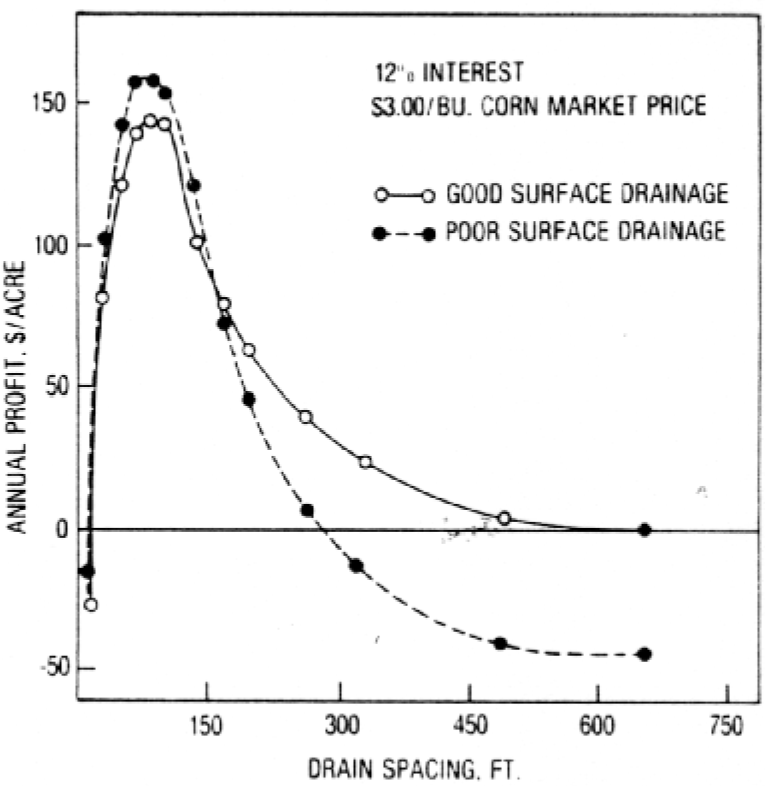

Figure 2. Predicted average annual net profit from production of corn on a Rains sandy loam sail as affected by drain spacing and surface drainage in North Carolina.

ECONOMIC FACTORS OF DRAINAGE

A number of factors play key,roles in assessing the economic potential of drainage investments. Those that must be considered in making an economic analysis include: current productivity of the land, increased yields possible from drainage improvements, cost of those improvements, market price of the crop(s) grown, taxes and the producer's financial position. In addition, since drainage improvements can last for up to 50 years, any economic analysis should compare costs to benefits over their expected life.

Items not included in this discussion of economic factors are: modifications in runoff and erosion rates, and changes in runoff water quality. Although surface runoff and erosion are important and must be dealt with, the dollar costs and returns to reducing them is very difficult to measure.

DETERMINING RETURNS TO DRAINAGE

Simplistically, returns to drainage are merely the added net income from crops as a result of the drainage improvements *minus* the cost of those improvements. Involved in figuring the added net income, costs and rate of return on investment, however, are such factors as: number of years to depreciate the investment, amount qualifying as a soil and water conservation expense, amount qualifying for investment tax credit, maintenance cost, marginal income tax rate, increase in fair market value of property due to drainage, and length of the evaluation period.

This section briefly explains and gives examples of two drainage investment analysis procedures. One makes an *approximate ("ball park") estimate* of returns to drainage improvements, which is a good first step and requires only pencil and paper. The other provides a *detailed analysis*, which you should have if serious about proceeding with improvements but which can be a complicated computational process.

Computer programs are now available that greatly "uncomplicate" that process, assuring accurate calculations and the flexibility of considering a multitude of alternatives. But remember that computer output is no better than the input ("garbage in, garbage out"). You still need to carefully think through your input assumptions to be certain that they're valid.

Regardless of the procedure used, consider the following to help insure the accuracy of your input figures:

* Seek assistance in identifying drainage improvement needs and alternatives from your local Extension Service, Soil Conservation Service and/or Soil and Water Conservation District.

* Obtain design assistance from the SOS, SWCD, local land improvement contractor and state-published drainage guide.

* Secure firm estimates of the costs of selected drainage improvements in consultation with the above information sources.

* Plan on hiring engineering assistance for complex jobs.

* Utilize your records and experience on fields with and without drainage improvements to estimate likely increased crop yields and subsequent added net income. (For ball-park estimates, consider the research results presented in Tables 1 and 2.)

Approximate-Analysis Example

Table 3 gives an example of how one might approximate the rate of return on a subsurface drainage investment for corn production. The assumptions made for this example are: (a) $500 per acre for installation of tile system in an undrained field, (b) a corn yield increase of 44 bushels per acre from that now subsurface-drained field, (c) an expected 20-year economic life for the improvement, (d) 16 percent interest on the average investment, (e) 0.2 percent of the investment per year for maintenance, and (f) an estimated corn market price of $2.50 per bushel.

Table 3. Example Approximate-Analysis Calculations of Benefits and Costs of Installing Tile Drainage.

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Benefits
  Yield increase x price
    (44 bushel/acre x $2.50/bushel)  = $110.00

Cost ($500/acre investment)
  Interest (16%)
        ($500/2) x 0.16              =   40.00
       Depreciation (20-year life)
        $500/20                      =   25.00
       Maintenance (0.2% of investment)
        $500 x 0.002                 =    1.00
                                       ---------
                    Annual cost/acre    $66.00

  Benefit-cost ratio    =  110 : 66  =  1.67: 1
  Benefits minus costs  =  110 - 66  =  $44.00
  Rate of return        =   44/500   =  9%
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The table shows that the average annual benefit from the extra 44 bushels of corn is $110 per acre, whereas the approximate annual cost is $66 per acre. That means a benefit-cost ratio of 110/66 or 1.67 to 1. The annual added net income exceeding costs by $44 per acre represents a 9 percent return on the investment (excluding taxes or land value increase).

Detailed-Analysis Example

Although detailed analyses can be performed by hand, they are best handled by computer. The one reviewed here was "solved" on a programmable calculator. A description of the procedure is in Ohio State University Cooperative Extension Service Agricultural Engineering Soil and Water Leaflet No. 29, "Returns to Drainage." Similar computer programs have been developed by various other universities and commercial companies. Check with your state Extension Service as to what is available.

The assumptions for this detailed drainage analysis are the same as used in the approximate analysis, with these additions: (a) the producer wants to depreciate the investment in 5 years, (b) he has the 25 percent marginal tax rate, and (c) the improvement will increase the land value $375 per acre (from $1500 to $1875). Under these conditions, the $109 benefit per acre ($110 - $1 maintenance) gives an after-tax rate of return on the investment of 21 percent.

The detailed analysis shows that returns will have equaled costs by the fifth year, being $156.75 the first year, $106.75 the second year, $106.75 the third year, $106.75 the fourth year, $106.75 the fifth year, $81 .75 for each of years 6 through 19, and $363.00 for year 20.

The analysis also reveals that returns for the first year include a $50 investment tax credit, that returns for the first 5 years include $25 annually from depreciation tax savings, and that the twentieth year includes a $281 .25 return to drainage from assumed sale of the land. If we had not assumed an increase in land value due to drainage, year 20 would return $81.75, and the after-tax return on investment would be 19 instead of 21 percent.

SUMMARY

Since drainage improvements are long-term investments, it's important to look at the effect of variation in net returns per acre on the after-tax rate of return. In our detailed example, we found that a $109 added net return per acre gave a 21 percent after-tax return on the investment. Table 4 shows that, if the added income was $80 per acre, return on investment would be 15 percent; if $60 per acre, 11 percent return; and if $40, 7 percent.

Table 4. After-Tax Rate of Return for a $500-per-Acre Drainage Improvement Investment with $40 to $140 Net Return per Acre and 0% to 100% Financing.*

Net return per acre	Percentage of cost financed 0%	80%	100%
	percent return		
$40	7	5	4
60	11	11	11
80	15	19	22
100	19	28	>75
120	23	41	>75
140	26	56	>75

*Assume 5-year depreciation. 20-year life, 25% marginal tax rate. 25% increase in $1500 land value resulting from drainage improvement, zero inflation and financing for 6 years at 16% interest

When financing is to be considered, some computational procedures may give misleading results. For instance, when added net income per acre goes from $40 to $140, Table 4 shows that percent return goes from 7 to 26 if there is no financing. However, when 100 percent of the cost is financed, the return is 4 percent at $40 net income per acre and exceeds 75 percent at $100 net per acre! In order to avoid unrealistic results like these due to the computational procedure, we recommend that 80 percent of the investment cost be the maximum amount considered as financed.

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