# Irrigation in Ohio: Nine Major Factors (In review)

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Ohio is often described as a water rich state. However, Ohio producers often find crop growth and yields limited by a shortage of soil moisture at critical times during the growing season. Recent drought years raised many questions about water use and management. In addition we usually see short periods of drought even in normal precipitation years. One major area of interest is the use of supplemental irrigation for food production, especially fruits and vegetables, and other high value crops.

This publication is intended to help you move in the right direction as you consider an investment in irrigation. First, ask yourself why you want to make this investment: Is it to reduce your risk of crop loss or failure because of insufficient water at critical times during the growing season? Is it to increase crop yields, or is it to provide protection against frost damage? Whatever your reason, only you can decide why you need to irrigate.

After you have answered the question "why irrigate," then evaluate all the factors that may relate to your present or proposed application. Nine major factors should be considered before you invest in an irrigation system. These are location, water supply, soil, drainage, crop, labor, management, system design, and economics.

## The Major Factors

*Location*

Your location in the state will determine the amount, timing, type, and distribution of precipitation. The annual precipitation in Ohio averages 38 inches statewide, but ranges from 42 inches on the southern border to about 32 to 34 inches along most of the northern border. Because of winds blowing over Lake Erie, the average annual precipitation reaches 44 inches in parts of northeastern Ohio, with a substantial proportion coming in the form of snow.

Long-term monthly rainfall information is important in determining the likely percentage of time that you may actually use supplemental irrigation during a given year, or over a period of years. Several sources of information are available to you. Locally, you may be able to obtain long-term monthly average rainfall records from a water pollution control center or municipal water treatment plant located in your county. If this source is not available, contact the Ohio Department of Natural Resources (ODNR), Division of Water, for long-term monthly average rainfall information. The Water Inventory Unit of the Division (Fountain Square, Columbus, OH 43224) publishes a *Monthly Water Inventory Report*, which provides a monthly summary of the precipitation status in 11 major regions of the state. The Division's website is (http://www.dnr.state.oh.us/odnr/water/). Ohio State University's Ohio Agricultural Research and Development Center (OARDC), located in Wooster, Ohio, maintains long-term weather records. For information, contact the Statistics Laboratory, OARDC, Wooster, OH 44691.

In addition to the above sources, over 50 Ohio counties have published fact sheets specifically on the county's water resources. One fact sheet in particular has a summary of the long-term monthly average precipitation. Contact your Ohio county office of Ohio State University Extension for water resources fact sheets availability in your area.

*Water Supply*

The location, quantity and quality of water that may be used for irrigation should be thoroughly investigated before you select an irrigation system. Seek professional guidance. Generally, a well yield or stream flow of 6 to 15 gallons per minute (gpm) will be required for each acre to be irrigated, depending on the crop and the soil at your location. However, for frost protection using irrigation, a flow rate of 45 to 65 gpm per acre will be required. When using a farm pond for the water source, 1 to 1.5 acre feet of water should be stored for each acre to be irrigated during a typical season.

Direct withdrawal of water from a stream is generally not a dependable source because stream flow may disappear during drought periods when irrigation water is needed most. However, if this source is an option for your application, consult with the Water Planning Unit of the ODNR Division of Water. In certain cases, a permit may be required to withdraw water from the Ohio portions of Lake Erie and the Ohio River watersheds. The Water Planning Unit also may be able to provide information on other surface water sources in your area available for public or private use.

If you are considering drilling an irrigation well, consult the ODNR Division of Water for information about the availability of an adequate ground water supply. The Water Resources Section of the Division manages a statewide database containing over 800,000 well logs. Ohio is one of only a few states that has been completely mapped for ground-water availability. The Water Resources Section can provide you with an estimate of the size, geologic make-up and yield of aquifers in your area, and possibly furnish you with information about specific wells. In addition, the county water resources fact sheets mentioned on the first page also contain specific information about ground-water resources. Water well summaries for more than 720,000 wells in Ohio are available at http://www.dnr.state.oh.us/odnr/water/maptechs/wellogs/.

In some cases, it may advisable to consult a hydrogeologist or local well driller. Hydrogeologists may be listed in the telephone directory in the Yellow Pages. Also, the ODNR Division of Water may be able to provide a list of hydrogeologists who provide consulting services in your area of the state. Another local source of information about the wells in your area is professional well drillers. The Division of Water maintains a list of licensed well drillers (*Ohio Directory of Drilling Contractors*) and can provide you with a list of those operating in your area. You might also consult the Yellow Pages for other information on well drilling.

When evaluating the water supply, the irrigator should be assured that the supply is adequate, of suitable quality, and plentiful enough to meet the requirements of the acreage of crops to be irrigated. Also, the supply should be economically accessible and legally available. This last requirement has become increasingly important in recent years. If you have a facility, or combination of facilities, with the capacity to withdraw 100,000 gallons or more of water per day (relates to a pump capacity of 70 gpm), then that facility must be registered with ODNR, Division of Water. This registration is required regardless of the water source (surface, ground water, or combination), unless the source is a municipality. An additional consideration related to the water supply is matching the pumping system with the yield of the water source. This is an important element of a proper system design. The Division's Water Withdrawal Facility Registration Program is located at http://www.dnr.state.oh.us/odnr/water/waterinv/wwfrprog/.

*Soil*

The soil should be capable of high production with the application of adequate amounts of crop nutrients and minerals, based on soil tests results. Also, an adequate level of soil tilth, organic matter, weed control, and other soil and crop management practices are vitally important for successful irrigation. The Ohio Agronomy Guide can provide much useful information related to crop response to fertility management and other factors for various soil textures. Remember, if water is not a primary limiting factor in your crop

production system, then an investment in irrigation may not be economical and your resources should be devoted to improving other crop management practices.

Soils vary in their ability to hold water that crop roots can use (plant available water). Soil texture and organic matter are two soil properties that help determine how much available water a given soil will hold, and the ease with which water can enter (infiltrate) the soil surface and then move through (percolate) the soil profile. Generally, water enters and moves through sandy soils very easily, but sandy soils do not have a great ability to hold water. Soils composed of a high percentage of silt- and clay-sized particles (medium- and fine-textured soils) have a far greater ability to hold water compared to sandy soils, but water does not enter nor move through these soils as easily as through sandy soils. Table 1 provides a general range of water holding capacities and infiltration rates for selected soil textures.

Table 1. Available water content (AWC) and infiltration rate values for selected soil textures.

| Soil Texture | Available Water Content (AWC) Range | Typical AWC | Infiltration Rate (bare, uncompacted soil) |
|---|---|---|---|
| | (in/ft) | (in/ft) | (in/hr) |
| Coarse sand | 0.1 - 0.4 | 0.25 | 0.5 - 1.0 |
| Sand | 0.1 – 0.4 | 0.25 | 0.5 – 1.0 |
| Fine sand | 0.6 – 0.8 | 0.75 | 0.5 - 1.0 |
| Loamy sand | 0.7 – 1.0 | 0.85 | 0.5 – 1.0 |
| Sandy loam | 1.3 - 1.6 | 1.45 | 0.5 - 1.0 |
| Loam | 1.9 - 2.2 | 2.0 | 0.25 - 0.5 |
| Silt loam | 2.3 – 2.5 | 2.4 | 0.25 – 0.5 |
| Silt | 1.9 – 2.2 | 2.0 | 0.25 – 0.5 |
| Clay loam | 2.3 - 2.5 | 2.4 | 0.10 - 0.25 |
| Silty clay loam | 2.3 – 2.5 | 2.4 | 0.10 – 0.25 |
| Silty clay | 1.8 - 2.0 | 1.9 | 0.10 - 0.25 |
| Clay | 1.7 – 1.9 | 1.8 | 0.10 - 0.25 |

Crops grown on sandy soils generally respond better to irrigation than crops grown on medium- and fine-textured soils that have a greater water holding capacity. Your county office of the USDA Natural Resources Conservation Service (NRCS) or Soil and Water Conservation District (SWCD) can provide you with information about the soils on your land, including soil texture, permeability, water-holding ability, and other soil properties. Soil properties related to irrigation will also available for all 475 Ohio soil series at the Ohio Agricultural Water Management website (http://www.ag.ohio-state.edu/~agwatmgt/).

*Drainage*

Drainage is a most important soil and crop factor. We discuss drainage as a separate factor because while it is very important for successful irrigation, but is often neglected. Soil drainage relates to various soil properties, such as texture and structure, and topography. Subsurface and/or surface drainage should be installed before an irrigation system is purchased. Proper management of the soil water is necessary to avoid crop damage from waterlogged soil. If drainage improvements cannot be made on poorly drained agricultural soils, then crops will suffer when unexpected rainfall occurs following irrigation.

Specific information about the drainage requirements for your soil may be obtained by contacting your NRCS or SWCD office. Another local source of drainage information may be professional drainage and soil and water conservation contractors. Most SWCD and health department offices maintain a list of contractors.

*Crop*

Improvements in crop production and/or protection may be the number one reason why you are considering an investment in irrigation. Do you have a good estimate of the amount of water you need to grow a crop? The daily water-use requirements may range between 0.1 and 0.5 inches depending on the specific crop and its stage of growth. How much of this amount can you expect to fill by natural rainfall? What is the seasonal distribution of rainfall in your location? These are important questions and you may need professional help to determine the answers.

Irrigation of conventional corn and soybean production in much of Ohio may not be economically feasible, particularly on soils with good water holding capacity, such as clay or clay loam soils. However, in most cases, irrigation can be economical with crops that give greater returns per acre. These types of crops include strawberry, raspberry, blueberry, melon, potato, tomato, pickle, sweet corn, cucumber, peppers, and most other fruits and vegetables, as well as many nursery crops. Irrigation of forage crops, such as alfalfa, may also be profitable for some Ohio dairy producers. Also, irrigation might even be required as part of a contract for commercial production of crops such as seed corn and processing tomatoes. Not only can irrigation be used to supply supplemental water during the growing season, it can be used in a dry spring to facilitate seed germination, and plant emergence and establishment. The proper integration of irrigation with nutrient management may help enhance nutrient efficiency. Irrigation systems can be used with special equipment to apply crop nutrients directly with the irrigation water (fertigation). Remember to consider the full potential effect of a proper irrigation application - increased yields and better quality product - on your total crop production system. A good question to ask at this time might be “Is your infrastructure large enough to carry the increase in yields?”

Frost protection is another reason you might irrigate, and sprinkler irrigation is the most common system used in frost protection. Sprinkler irrigation is very important for strawberry, blueberry, grape and other fruit crops that may be damaged by spring frosts. If you are evaluating drip or trickle irrigation for the production of these crops, you also will need a sprinkler system for your frost protection.

*Labor*

Overhead sprinkler irrigation systems are the most commonly used type of system in Ohio. Overhead sprinkler irrigation includes solid set, hand move, linear move, water winch, reel travelers, and center pivot systems. However, micro-irrigation systems have been used successfully for several years for many of Ohio's commercial horticultural crops and home gardens. Micro-irrigation systems are gaining in popularity and application, and the types of systems used include trickle, drip, row crop tape, orchard emitter, and micro-sprinkler systems. Each specific type has different labor requirements. Studies have shown that about 1 human-hour per acre per day is required for a hand-move irrigation system. Mechanically moved systems require only 10 to 50 percent as much labor as a hand-move system. Labor requirements for micro-irrigation systems are much lower after the initial installation each year compared to sprinkler systems.

Ask yourself how much time and labor you can afford to put into running and managing an irrigation system. A reputable irrigation equipment supplier should be able to provide you with information on the labor requirements for specific types of systems.

*Management*

Your management time will increase with the application of irrigation. Regardless of the type of system, successful irrigation requires good planning and high-level management. Accurate decisions concerning the timing and amount of irrigation are very important. These decisions may make the difference between

a successful and unsuccessful crop production year. Extra responsibilities associated with the application of an irrigation system include: monitoring the soil water status in the field, scheduling water applications, adjusting water application rates as crop water requirements change throughout the season, following weather patterns and precipitation forecasts, coordinating irrigation with the timing of other cultural operations (cultivating, spraying, harvesting, etc.), and simply making sure that the water was turned on and off at the appropriate times. Irrigation alters the environment in your field, and may necessitate changes in some of your standard cultural practices. For example, higher humidity may increase the potential for certain disease pressures; water applications may increase the potential for nitrogen leaching, thus requiring split applications of nitrogen fertilizer. How does the extra responsibility of irrigation management fit into your present crop production schedule?

*System Design*

By the time you get to the actual design process, you should have a very good idea of how your location and potential water supply might impact your decision. Also, you should now be aware of how conducive your soil and its drainage properties are to your selected crop under irrigated conditions. What kind of system will fit your production needs, and labor and management constraints? Profitable and efficient irrigation requires knowledge of all of the factors mentioned above and proper engineering of the entire system. For best results, each system should be "tailored" to fit the particular need.

Most irrigation equipment suppliers will provide the necessary engineering services and cost estimates upon request. In addition, there are a number of consulting engineers who can provide the appropriate engineering services. Consult the Yellow Pages for irrigation equipment suppliers and consulting engineers in your area.

The equipment supplier's availability and quality of sales and repair service are important items that relate to system design and selection, as well as management. A neighboring farmer who has had experience with irrigation may be a good source of information regarding the selection of an irrigation equipment supplier.

*Economics*

The costs of irrigation will vary considerably depending on many factors, including many of those discussed above. Table 2 provides an assessment of capital investment and labor costs for several general types of sprinkler irrigation systems. This information is provided as relative values, in relation to a center-pivot system. For example, if the investment cost for a self-propelled center-pivot system was $4,000, an estimate of the cost for a hand-move system with giant sprinklers might be $2,000, one-half the cost of the center-pivot system. It is very important that you collect all possible information regarding your proposed application, and work with your system designer to estimate the costs for the system that best meets your needs.

Table 2. Relative costs of sprinkler irrigation equipment.

| Type of System | Relative Investment Cost* | Relative Labor Cost | Practical Hours of Operation per Day |
|---|---|---|---|
| Hand-move laterals (standard sprinklers) | 0.4 | 5.0 | 16 |
| Hand-move laterals (giant sprinklers) | 0.5 | 4.0 | 12 - 16 |
| End-pull laterals (tractor tow) | 0.5 | 1.4 | 16 |
| Boom-type sprinklers (trailer-mounted) | 0.6 | 3.7 | 12 - 16 |
| Side-roll laterals (powered-wheel move) | 0.7 | 1.7 | 18 - 20 |
| Self-propelled (center-pivot) | 1.0 | 1.0 | 24 |
| Solid set | 3.0 - 5.0 | 1.0 | 24 |

*Based on a 65-ha field, 63 *L*/s from pump, and 80 percent application efficiency. *Source:* Berge and Groskopp (1964); Schwab et al., 1993.

**Summary**

This publication is intended to help you initiate a proper evaluation of an irrigation system for your crop production system. The nine factors described above are only the beginning of your investigation into irrigation, but these are major items that you should consider before going further. Other items that should be considered include environmental aspects, financial resources, lease versus purchase, dealer availability and service, and the impact on your present production system. Table 3 provides a summary of many of the factors discussed above with the general type of irrigation system of interest. **It pays to do your homework!**

Table 3. Comparison of sprinkler irrigation systems and micro-irrigation systems in relation to site and situation factors.

| Site & Situation Factors | Sprinkler Systems | | | Microirrigation Systems |
|---|---|---|---|---|
| | Intermittent Mechanical-Move | Continuous Mechanical-Move | Solid-Set and Permanent | Emitters and Porous Tubes |
| Infiltration rate | All | Medium to high | All | All |
| Topography | Level to rolling | Level to rolling | Level to rolling | All |
| Crops | Generally shorter Crops | All but trees and vineyards | All | High value required |
| Water supply | Small streams nearly continuous | Small streams nearly continuous | Small streams | Small streams, continuous and clean |
| Water quality | Salty water may harm plants | Salty walter may harm plants | Salty water may Harm plants | All–can potentially use high salt waters |
| Efficiency | Average 70-80% | Average 80% | Average 70-80% | Average 80-90% |
| Labor requirement | Moderate, some training | Low, some training | Low to seasonal high, little training | Low to high, some training |
| Capital requirement | Moderate | Moderate | High | High |
| Energy requirement | Moderate to high | Moderate to high | Moderate | Low to moderate |
| Management skill | Moderate | Moderate to high | Moderate | High |
| Machinery operations | Medium field length, small interference | Some interference circular fields | Some interference | May have considerable interference |
| Duration of use | Short to medium | Short to medium | Long term | Long term, but durability unknown |
| Weather | Poor in windy conditions | Better in windy conditions than other sprinklers | Windy conditions Reduce performance, good for cooling | All |
| Chemical application | Good | Good | Good | Very good |

*Source:* Fangmeier and Biggs (1986); Schwab et al., 1993.

Sources of Information

Throughout this publication are a number of references to sources of additional information. Most counties in Ohio have several local sources of additional information, such as: county offices of Ohio State University Extension, Soil and Water Conservation Districts, and the USDA Natural Resources Conservation Service. In addition, the many services and programs of the ODNR Division of Water can be seen at http://www.dnr.state.oh.us/odnr/water/programs/. As part of the revision of this fact sheet all of the cited information sources will be updated. If you have questions about other sources of educational or technical assistance, please contact the author.

**Information Inventory**

To aid you with further evaluation and planning for an irrigation system and in working with your irrigation system designer and/or consultant, the following check list was developed. You might consider making photocopies of this checklist to evaluate different sites and options. Most of the information in the checklist will be required for your system design. Try to provide any information that you have available. Your designer should be knowledgeable about helping you obtain the information that you do not know.

In addition to the information in the checklist, a sketch of the field site showing topographic details (contours, elevations, high and low spots, etc.), field boundaries, structural improvements (utility lines, roads, fences, buildings, water source location, etc.), and physical features that may be important in the design. Make a copy of the grid sheet to sketch your field conditions. If you have several field sites, provide information specific to each site, and the relation of these sites to each other. To aid your designer, other information about your farm operation schedules and management may also be important.

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Irrigation Information Inventory Checklist

Name: _____ Date: _____
Address:
_____

Field Identification: _____ Acreage in this field to be irrigated: _____

Precipitation and wind conditions: _____

Water source (circle): River/Stream Pond Spring Well Reservoir Other _____

Water analysis (physical/chemical): _____

Amount of water available _____
Gallons per minute _____ How long can water be pumped at the rate listed? _____

Type of power available (circle): Gasoline Natural Gas Propane Diesel Water Electric (cycle, voltage, phase) _____ Type of power desired: _____

Highest elevation in the field above the possible pump location: _____
Suction lift to pump (under 15 feet if possible): _____

Type of soil (sandy, sandy loam, loam, silty clay, clay, etc.): _____
Depth of restrictive soil layers: _____

Drainage installed? _____ Needed: _____ System specs:
_____

Crop(s) to be irrigated: _____
Rotation with other crops:
_____
Existing planting or proposed planting: _____
Beginning and ending of crop season:
_____
Growth stage critical for water:
_____
Crop water requirement (inches per day or week, specify) _____

Using single plant rows or beds with multiple plant rows? List which one: _____
If multiple rows on a bed, how many? _____
Distance between single rows or beds (spacing) _____ (feet)
Row or bed width _____ (feet)
Distance between plants along a row _____ (inches)
Distance between plant rows on a bed _____ (inches or feet)

Labor and management time available to operate system:
Labor (hours per day): _____ Number of persons:_____ Management time (hours per day): _____
Days during average week that labor and/or management is not available:
_____
Hours per day that system can be operated: _____

System automation desired (circle): Fully automated No automation Somewhere in between

List on an additional sheet other information that might be useful.