high corn yields with irrigation

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Figure 2. Ample nitrogen will give corn plants dark color. Note even lower leaves are green.

Front Cover: A good corn crop capable of reaching 200 bushels per acre. Do not look for "show ears." Top yields maximize the genetic, nutrition and light resources for the plant to make full ear development.

high corn yields with irrigation

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Michigan has the lowest summer rainfall of any state east of the Mississippi River. The lack of rainfall is one of the major factors why crop yield increases during the past 15 years have not kept pace with most other states.

As shown in Table 1, drought stress (severe moisture deficiency) is a probability two years out of every five for each summer month. (There is about a 40% chance of some degree of drought stress for each month). Other sections of lower Michigan not reported in Table 1 show similar stresses. Thus, drought is likely to occur every year during some portion of the growing season. Table 2 indicates that the probability of July rainfall exceeding 5 inches is 8 percent or less.

Table 1. Meteorological Droughts for Lower Michigan[1] (Percentage of occurrence from 1931-1967).

	DROUGHT STRESS			
	Mild	Moderate	Severe	Total
		Percent		
South-west, lower[2]				
June	22	14	8	44
July	16	14	11	41
August	19	11	11	41
September	14	8	11	33
South-central, lower[3]				
June	16	11	8	35
July	16	11	11	38
August	11	14	11	36
September	14	16	5	35
South-east, lower[4]				
June	11	8	16	35
July	19	5	16	40
August	19	5	14	38
September	14	14	14	42

[1]*Data from Strommen, VanDenBrink and Kidder, MSU Research Report 78, 1969.*
[2]*Berrien, Cass, Van Buren, Kalamazoo, Allegan, Ottawa and Kent Counties.*
[3]*St. Joseph, Branch, Hillsdale, Calhoun, Jackson, Barry, Eaton, Ingham, Ionia, Clinton and Shiawassee Counties.*
[4]*Lenawee, Monroe, Washtenaw, Wayne, Livingston, Oakland, Macomb, Genesee, Lapeer and St. Clair Counties.*

Approximately 200,000 acres in Michigan are now irrigated, most of which is corn. Increased irrigation depends upon availability of water and economics. A major economic factor is obtaining high yields. This publication reports some practices that may help you obtain better yields with irrigation.

Site Selection

The irrigation systems now commonly used for corn are the self-propelled (traveler) and the center pivot. Each system can effectively irrigate from 40 to over 200 acres of land, depending on the model and irrigation system design. Fragmented and irregular-shaped fields can greatly increase costs per unit of production.

The site must have an adequate source of water. The requirements for corn range from 5 to 12 inches of irrigation water per season. Nearly 20 million gallons of water are required to apply 7 inches to a 100-acre field. Thus, it is essential that an adequate source of water be available before investing in irrigation equipment.

Table 2. Precipitation Probabilities for Lower Michigan.[1]

	RAINFALL (INCHES)				
	2.0	2.0-3.4	3.5-4.9	5.0 +	Average inches
		Percent Probability			
Southwest, lower					
June	8	47	35	10	3.5
July	27	48	17	8	2.9
August	20	45	25	10	3.2
South-central, lower					
June	5	40	40	15	3.8
July	25	50	17	8	2.9
August	25	50	19	6	3.2
Southeast, lower					
June	15	50	27	8	3.2
July	25	55	20	—	2.7
August	18	50	25	7	3.1

[1]*Misc. Pub. 1160 USDA Nov. 1969. Strommen and Horsfield. For information on counties in each area, see footnotes of Table 1.*

Check water quality from wells, since excess salts are a common problem in some areas of Michigan. A conductivity meter is generally used to measure soluble salt content. Conductivity which exceeds 200 mhos/cm $\times 10^{-5}$ is considered excessive.

The availability and cost of energy is another important consideration. In some localities, electric motors may be required because internal combustion engines are too noisy. Power line poles, trees, building sites, drainage ditches, and other features may interfere with the use of the center pivot system. For this reason, carefully design your irrigation system. An aerial photo of the farm can help you plan the layout.

Soil Texture

Corn yields without irrigation are highly correlated with the moisture-holding capacity of the soil. On sandy soils, water is lacking practically every year during some portion of the growing season. Crops on clay loams are also likely to encounter periods of moisture stress which reduce yields. Data in Table 3 illustrate the relationship of soil texture to land values and expected corn yields under good management. The soil feature that accounts for much of the differences is the available water-holding capacity. Without irrigation, there are many soils where it is not profitable to grow corn. With recent corn prices averaging $2.25 per bushel it is apparent that many fields are not making a competitive return on investment because the present average yield for Michigan is only 75 bushels per acre.

The estimated land values reported in Table 3 reflect crop productivity. The low available water holding capacity of the less expensive, droughty, sandy soils has helped to promote irrigation. Timely application of water is the equalizer in crop yields for all soil types. The expected corn yields for irrigated sands, however, are somewhat less than for other textures. This difference is due primarily to a weekly irrigation schedule which often is inadequate during hot, dry periods. A five-day irrigation schedule, however, could overcome much of this yield difference. Expected corn yeilds on loams and clay loams with irrigation may be less than for well-drained loamy sands should a heavy rain occur after an irrigation (due to poor aeration and denitrification). Because of the higher water-holding capacity, loams and clay loam soils do permit more flexibility in the watering schedule. Thus, if rains recharge all fields, irrigate the sandy soils first and follow with the finer textured soils.

The yield response from irrigating loam and clay loam soils is not as great as that for the more droughty sandy soils (Table 3). This, however, does not necessarily mean irrigation will not be economical. With less need for irrigation water, a traveler-type system can cover more acreage. Only during periods of extreme drought would such a system fall short of the evapotranspiration rate. A major concern on fine-textured soils is the slow rate of water infiltration and the danger of over-watering should heavy rains follow. These hazards can be reduced by:

1) Have the field well tiled.
2) Apply only 0.5 to 0.7 inch of water per application and less than 0.3 inch per hour.
3) Keep the available soil moisture in the effective rooting zone at less than 80 percent of the total available soil moisture-holding capacity shown in Table 3.

In evaluating the moisture-holding capacity of your soil, be sure to take into account changes in subsoil texture. Information on the available water-holding capacity for your specific soil type can be obtained form the local Soil Conservation District (SCS) office. They should be able to provide you with a detailed map of the various soil types in your field and the available water-holding capacity of each. Your County Extension office can also help you determine the available soil water-holding capacity of your soil.

Table 3. Approximate available water, estimated land value (1977) and corn yields under good management as related to soil texture.

Soil texture	*Available water/foot of depth*	*Land value*	*Estimated Yield* Without Irrigation	*Estimated Yield* With Irrigation
	inches	*$/acre*	*bu/acre*	
Sands	0.5	300	40	160
Loamy sands	1.0	500	70	170
Sandy loams	1.5	650	90	170
Loams	2.0	800	110	175
Clay Loams	2.5	1,000	125	175
		State average	75	150 (?)

Hybrid Selection

In hybrid corn trials with and without irrigation in Montcalm County (1968-1976), the average yielding hybrids gave a response of 49 bushels per acre when irrigated. The highest yielding hybrids responded with 62 bushels added yield while the lowest yielding hybrids produced only 32 additional bushels. These results demonstrate the importance of choosing high yielding hybrids to maximize returns from irrigation. Your hybrids should:

1) Be quality seed so as to give good emergence when planted in late April.

Table 4. Average growing degree days for several locations in Michigan using Base 50° F.[1]

Location	DEGREE DAYS PER MONTH May	June	July	Aug.	Sept.	Total[2]	First frost (30% probability)
Adrian	317	604	750	697	437	2,805	Oct. 4
Big Rapids	223	477	622	571	321	2,214	Sept. 23
Caro	247	538	672	615	376	2,448	Sept. 20
Coldwater	294	566	711	661	429	2,661	Oct. 1
East Lansing	242	510	651	603	358	2,364	Oct. 2
Grand Haven	219	485	659	625	398	2,386	Oct. 7
Greenville	268	541	698	641	378	2,527	Oct. 1
Kalamazoo	318	589	736	694	452	2,789	Oct. 3
Saginaw	239	519	676	617	362	2,413	Oct. 5

[1]*Data by VanDenBrink, Strommen and Kenworthy, MSU Research Report 131 (1971).*
[2]*The coefficient of variation for Southern Michigan is about 10 percent. Thus, 2 years out of 3, the totals for Adrian range between 2,596 and 3,014 degree days.*

2) Show good stalk strength at high populations.
3) Have resistance to leaf blights under high humidity.
4) Be mature by October 1, having less than 35 percent moisture in the grain.

Many of these characteristics are reported in Extension Bulletin E-431, Michigan Corn Production—Hybrids Compared.

Plant at least 90 percent of your acreage with two or three well-tested hybrids. Leave testing of new or untried hybrids to less than 10 percent of your acreage.

MSU plant breeders suggest you consider planting two different hybrids in each field. Choose as the second hybrid one that is 3 or 4 days later in maturity than the main hybrid.

This provides a longer period of pollen shed and may give better ear tip fill for the first hybrid. Do not mix seed of the two hybrids unless you are using a plateless or air-type planter. With a plate planter, use the main hybrid in 3 boxes of a 4-row planter and the second hybrid in one outside hopper. This gives a planting pattern of 6 rows of the main hybrid and 2 rows of the second. With 8-row, or more, planters, consider planting 70 to 80 percent of the rows with the main hybrid.

Pollination can be more of a problem with single (2x) hybrids because of the short pollination and silking period. To reduce stalk rot problems choose medium-early-maturing hybrids, plant early and harvest early. Stalk rot is a disease of old age—when the plant is dead or dying, it becomes susceptible. A delay in harvest increases susceptibility to stalk rot and harvest loss.

Date of Planting

The suggested planting period for lower Michigan, if the soil is ready to work, is April 15 to May 5 for sandy soils and April 25 to May 10 for other soil textures. In 1976, record-high temperatures occurred in early April followed by a period of extremely cool temperatures; nonetheless, corn planted in mid-April on sandy, well drained soils came through with excellent stands. You can replant fields in the spring, but you can do little about frosted, immature corn in the fall.

Table 5. Expected number of growing-degree days that would accumulate in a given season by Oct. 1 for various planting dates (50 percent probability).

Location	PLANTING DATE April 20	May4	May 18	June 1
Adrian	2,820	2,750	2,610	2,460
Big Rapids	2,250	2,210	2,130	1,990
Caro	2,490	2,440	2,360	2,200
East Lansing	2,400	2,350	2,260	2,120
Kalamazoo	2,850	2,780	2,630	2,470
Average change as compared to April 20		−56	−164	−314

[1]*Data from VanDenBrink, Strommen and Kenworth; MSU Research Report 131 (1971).*

Corn planted in April usually shows less vegetative (stalk) growth than late-planted corn. Ear develoment, however, is usually larger for early-planted corn. This is because the corn utilizes more solar (sun) energy when planted early. As shown in Figure 1, corn silking July 15 absorbs about 26,200 Langley energy units in 55 days, while corn silking August 15 averages only about 20,800 units. Much of the yield increase from more sun energy is due to more complete grain development near the tip of the ear.

Michigan is on the northern fringe of the corn belt. Success in corn production depends upon sufficient heat units to mature the crop. In general, a 90-day hybrid requires about 2,200 growing-degree days, 100-day hybrids about 2,350, and 110-day hybrids

2,500 degree days. Table 4 shows the degree days for several locations and Table 5 the relationship of date of planting to growing-degree days. On an average, corn planted April 20 will utilize only about 56 degree-days by May 4. However, work load or adverse weather after May 4 makes it advisable to plant early. Top-yielding hybrids that require 2,500 growing degree days outyield 2,200 degree-day hybrids by at least 15 percent.

Sprinkler irrigation can also have a cooling effect on plants which may amount to as much as 15 degrees when the temperatures are over 90 degrees however, this cooling effect with most mechanized systems would probably not last more than a few hours per irrigation.

Plant Population and Row Spacing

Most population trials for 30-inch rows suggest 26,000 plants per acre at harvest for irrigated corn. Ears averaging 0.5 pound at this population will produce 185 bushels per acre. To obtain the desired populations, overseed by about 15 percent. Some growers producing over 200 bushels strive for 28,000 plants per acre. Until you have had several years of experience with irrigation, it is not advisable to plant at such a density. If timely irrigation is difficult to maintain, or if the quantity of water is questionable, a more realistic population is about 22,000 plants per acre.

The most common row spacing for irrigators is 30 inches. This spacing will outyield 38-inch rows by 5 to 8 percent. Close row spacing is especially advisable for the shorter hybrids and early planted corn. Further more, it is also more likely to suppress late germinating weeds.

Ideal planting depth varies with soil, climate, and trash conditions. For early seeding, the suggested depth is ¾ to 1 ½ inches. For late seeding, when the soil surface is dry, plant 1 ½- to 2 ½-inches deep.

Fertilizer Requirements

An item of great expense with irrigation is fertilizer which may range from a low of $30 to over $75 per acre. Nitrogen, phosphorus, and potassium are generally needed. In addition, magnesium and zinc may be needed. Nutrient needs for a crop are related to plant uptake and the portion that is removed by the crop. Nutrient removal by a 200-bushel corn crop is reported in Table 6.

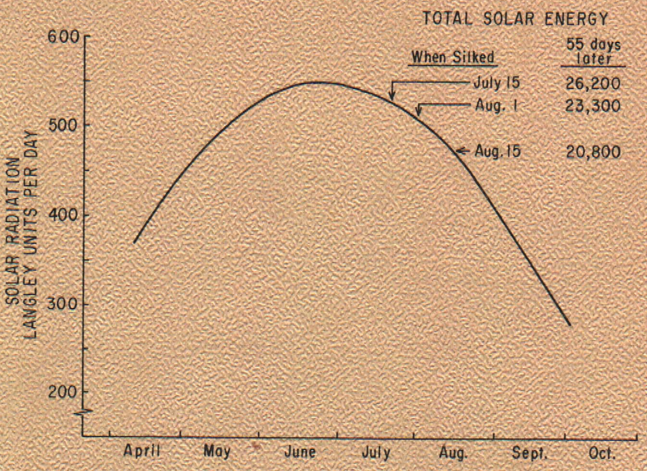

Figure 1. Average daily solar radiation and the cumulative total from silking to grain maturity for the Lansing, Michigan area. Source—North Central Regional Publication 225, Tech. Bul. 300. 1975.

Table 6. Pounds of nutrients removed by the grain and stover of a 200-bushel corn crop.

Nutrient	*QUANTITY* Grain	Stover	Total
		(lb/acre)	
Nitrogen	175	90	265
Phosphorus (as P_2O_5)	70	50	120
Potassium (as K_2O)	40	190	230
Calcium	2	40	42
Magnesium	14	20	34
Sulfur	15	11	26

For a sound fertilizer program:

1) Test soil to determine the need for lime, phosphorus, ptassium and magnesium.
2) Plow down potash (0-0-60) as indicated by soil test.
3) Place a portion or all the phosphate in bands near the seed. Consider such grades as 18-46-0, 11-46-0, 10-34-0, as they usually are the least costly per unit of phosphorus.
4) Apply the remaining nitrogen:
   a) Preplant as anhydrous ammonia, or
   b) Sidedress as anhydrous ammonia in early June, or
   c) Combination of ⅓ to ½ of the nitrogen applied early and the balance applied through the irrigation system using nitrogen solutions.

Based upon soil test results, the following quantities of phosphate and potash are recommended for a 200-bushel/acre crop:

Phosphorus						
Soil Test Bray P_1	0-19	20-39	40-59	60-79	80+	lb/acre
Phosphate (P_2O_5) Recommended	150	125	100	75	35	lb/acre

Potassium						
Soil Test K	0-60	60-119	120-169	170-209	210-270	lb/acre
Potash (K_2O) Recommended	300	250	200	150	75	lb/acre

The soil should have a pH greater than 6.0 and the magnesium above 100 pounds per acre. The need for zinc and magnesium is not common. A plant analysis will help confirm a need for these nutrients.

Nitrogen needs depend upon soil organic matter content, previous cropping history, and the amount of manure applied. (See MSU Extension Bulletin E-802) Continuously irrigated corn usually requires about 200 to 250 pounds of nitrogen per acre, Fig. 2. Many growers report that when they apply ⅓ of the fertilizer early and ⅔ through the irrigation, 200 pounds of nitrogen is ample for 175 bushels of corn. On very sandy soils, preplanting applications may require more than 250 pounds per acre.

A 28 percent nitrogen solution is often applied with the irrigation water. Solid urea dissolved in water can also be used. Liquid Fertilizer is applied with an injector pump which can meter the solution into the system at any desired rate. Anhydrous ammonia cannot be applied in this manner because of precipitation problems and losses of free ammonia into the air. Proper application of nitrogen with the irrigation water gives good recovery. Liquid fertilizers are usually more expensive than anhydrous ammonia. If the difference is substantial, it may be more profitable to sidedress with anhydrous ammonia in early June.

If liquid fertilizers are used, the calculations for the gallons needed per acre are:

$$\text{gallons/acre} = \frac{\text{lbs of N/acre needed}}{\text{weight/gallon} \times \text{analysis}}$$

For example, if the situation calls for 40 pounds of nitrogen per acre and liquid 28% nitrogen solution weighing 10.6 pounds per gallon is used,

$$\text{gallons/acre} = \frac{\text{40 lbs N/acre}}{\text{10.6 lb/gallon} \times 0.28} = \text{13.5 gal/acre}$$

Gallons needed per hour is determined by multiplying the acres irrigated per hour by the gallons needed per acre. If you irrigate 0.86 acre per hour, then 0.86 acre/hr × 13.5 gal/acre = 11.6 gal/hr. Acres irrigated per hour by a traveler system is the product of feet per minute traveled × 60 minutes × width of irrigation strip (feet) divided by 43,560. For example:

$$\frac{\text{3 feet/min.} \times \text{60 minutes} \times \text{270 ft.}}{43{,}560} = \text{1.12 acres/hr.}$$

If nitrogen is applied with the irrigation water, start the first application when the corn is waist high, Fig. 3, and complete at the "early milk" stage. Generally, 20 to 50 pounds of nitrogen per acre are applied with each watering. Apply about ⅓ to ½ of the total nitrogen requirements ahead of irrigation since rainy weather could delay the need for watering. Be careful that the application is uniform. For example, when big gun sprinklers or fixed heads are used in winds over 10 mph, the distribution may be quite variable. For this reason, some growers apply ¾ of the nitrogen to the soil and ¼ with the irrigation water.

Tillage

Tillage recommendations are probably no different for irrigated than for nonirrigated corn. Soil erosion by water is generally not a problem because irrigated fields are fairly level and infiltration is usually good. Wind erosion, however, can be serious and can cause extensive damage to plants. This hazard can be reduced by leaving fields rough or plant residues on the surface.

Some growers who chisel or disk as their primary tillage practice, have noted more late weed problems. Preplant application of herbicides normally implies incorporation and can be used only on land with little or no residue. If much residue is left on the surface, use a preemergence and/or postemergence herbicide program. Trash, as may be encountered with no-till or chisel tillage practices, can interfere with seeding, Fig. 4. If this is a factor, place seed a little deeper and increase the seed rate about 10%.

In most situations, it is best to plow and then use a drag or field cultivator for preparation of the seedbed. If work schedule permits, plant immediately after plowing. In tillage trials on a loamy sand at the MSU Soils Farm, there was no significant difference in the yield for three tillage methods, as shown in Table 7. Chiseling, because of the raking problem of corn stalks, is not advised until residues are well chopped. No-till corn is not recommended where

Table 7. Effects of tillage on corn production when grown on irrigated loamy sand.

Tillage	*YIELD* 1975	1976
	bu/acre	
Spring plow	190	176
No-till	175[1]	173
Disk and Chisel	191	170

[1]No-till had to be replanted because of wireworm damage.

heavy sod exists because of possible losses caused by rodents, slugs, insects, and birds. Additional information on tillage is reported in Michigan State University Extension Bulletins E-1041 and E-1042.

Weed and Pest Control

The first 5 or 6 weeks after planting are critical for controlling weeds. After this period, the corn plants are fairly competitive, because of the high population and shading. Mechanical cultivation can be used to kill weeds. This method can also have other benefits such as reducing wind erosion or loosening the soil. Most operators, however, rely on herbicides to control weeds. Since most irrigated soils are low in organic matter and are sandy in texture, use caution with rates and materials. Chemicals such as cyanazine (Bladex), dicamba (Banvel), Linuron (Lorox), propachlor (Bexton) and Metribuzin (Sencor) are not recommended for sandy soils. Extension Bulletin E-434, "Weed Control in Field Crops," provides information about herbicides and their uses.

The major insects that attack corn are the European corn borer, aphids, and corn rootworm. "No-till" tillage has resulted in other pest problems. Corn rootworm is presently the major problem, especially where corn follows corn. This sequence is common where pivot irrigation systems are installed. Control of corn rootworm is reported in Extension Bulletin E-736.

Major diseases of corn are leaf blights, smut, and stalk-rotting fungi. They are more of a problem because of the higher humidity, weaker stalks, and the intense environmental conditions. Resistant hybrids are the most common control measure for these problems.

Rotations

Of the field crops grown in Michigan, corn is probably the most profitable for irrigating because the corn plant responds markedly to management. For this reason, once an irrigation system is installed, the farm operator is likely to grow continuous corn. There are benefits from growing corn in rotation. For example, a corn-soybean rotation often shows a yield increase of about 5% in corn production. Likewise, corn in an alfalfa rotation shows about the same response. These increases are probably due to less nematode, leaf and root disease, and insect problems. Rotations with alfalfa reduce nitrogen and insect control costs and help improve subsoil percolation. The data in Table 10 illustrate how alfalfa in a rotation can relate to corn production costs. These benefits have to be considered when selecting the type of irrigation system. Nonetheless, it may still be more profitable to grow continuous corn.

Watering Schedule

Knowledge of the available moisture-holding capacity of a soil and the evapotranspiration from a field is used to determine the need for irrigation. Evapotranspiration (ET) is the sum of the loss of water through direct evaporation (E) from the soil surface and the loss of water from the leaf surface of plants thorugh transpiration (T). Under normal Michigan conditions, the average daily loss for corn is about .14 inch in June, .19 inch in July, and .16 inch in August, Fig. 5. Under extremely high temperatures and dry and windy weather conditions, the loss can exceed .30 inch per day.

The ET increases with rise in air temperature, light intensity, wind velocity and a decrease in humidity. These losses can be related to evaporation of water from a large open pan. In general, when there is good plant cover, the ET is about 80% of the loss of water from an open pan. Thus, if the loss from an open pan is .30 inch, the ET is about .24 inch. During irrigation, the rate of evaporation can also be high and may amount to over 10% of the applied water. This loss is less when irrigating in late evening and during the night.

Available soil moisture is the water held in the soil for crop growth—measured as the difference between field capacity and wilting point. Start irrigating when available soil moisture content of the upper two feet drops to 50 to 65%. Soil moisture meters are available, but often good instruments are

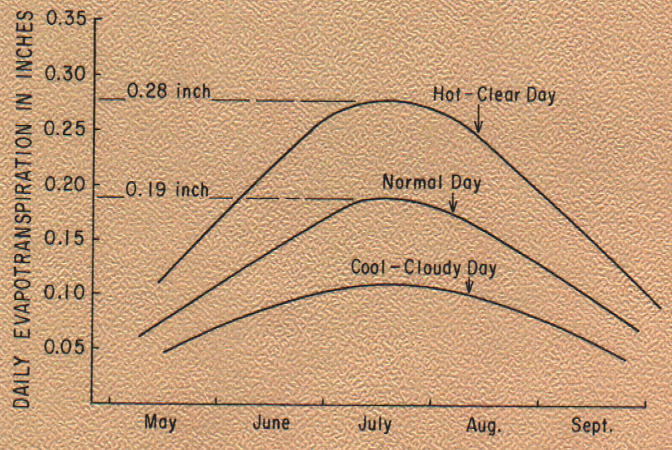

Figure 5. Estimated daily evapotranspiration for corn growing at East Lansing, MI, as related to weather conditions.

Table 8. **Practical interpretation chart of soil moisture for various soil textures and conditions. (From the National Engineering Handbook, SCS, USDA, Section 15, Chapter 1).**

Available moisture in soil	*FEEL OR APPEARANCE OF SOIL*			
	Coarse-textured soils	*Moderately coarse textured soils*	*Medium-textured soils*	*Fine and very fine textured soils*
0 percent	Dry, loose, and single-grained; flows through fingers	Dry and loose; flows through fingers	Powdery dry; in some places slightly crusted but breaks down easily into powder	Hard, baked and cracked; has loose crumbs on surface in some places
50 percent or less	Appears to be dry; does not form a ball under pressure[1]	Appears to be dry; does not form a ball under pressure[1]	Somewhat crumbly but holds together under pressure[1]	Somewhat pliable; balls under pressure[1]
50 to 75 percent	Appears to be dry; does not form a ball under pressure[1]	Balls under pressure but seldom holds together	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure	Forms a ball; ribbons out between thumb and forefinger
75 percent to field capacity	Sticks together slightly; may form a very weak ball under pressure	Forms weak ball that breaks easily; does not slick	Forms ball; very pliable; slicks readily if relatively high in clay	Ribbons out between fingers easily; has a slick feeling
At field capacity (100 percent)	On squeezing, no free water appears on soil, but wet outline of ball is left on hand	Same as for coarse-textured soils at field capacity	Same as for coarse-textured soils at field capacity	Same as for coarse-textured on soils at field capacity
Above field capacity	Free water appears when soil is bounced in hand	Free water is released with kneading	Free water can be squeezed out	Puddles; free water forms on surface

[1]*Ball is formed by squeezing a handful of soil very firmly.*

too sophisticated for most field operators. The "feel" method may work for many. The physical properties reported in Table 8 should help in estimating soil moisture conditions.

Using 36 inches as the effective root zone for corn and knowing the soil moisture-holding capacity, you can estimate the irrigation schedule needed to maintain adequate levels of available water. This is illustrated in Table 9. The days of carrying capacity assume a depletion of 75% of the available moisture and a uniform soil texture in the profile. Most soil profiles, however, consist of two or three textured layers. The soil water holding capacity can be obtained from your District SCS Office. The available moisture should be maintained above 25%. Start irrigation well in advance of this level.

Table 9 gives the days of carrying capacity for sands as only 4 or 5 days. For soils of such low carrying capacity, only about 1 inch of water is recommended per irrigation, otherwise, there could be leaching losses. For these situations, the pivot system is preferred because a complete revolution can be made in 8 to 48 hours, depending on the drive mechanism.

Table 9. Available moisture content of soils and their crop carrying capacity.

Soil texture	*Available water*		*Evapo-transpiration*	*Days carrying capacity*
	inch/foot	*36 inches of soil*	*inch/day*	*(75% drawn down)*
Sand	0.5	1.5	0.20	5.6
			0.30	3.8
Loamy sand	1.0	3.0	0.20	11.2
			0.30	7.5
Sandy loam	1.5	4.5	0.20	16.9
			0.30	11.2
Loam	2.0	6.0	0.20	22.5
			0.30	15.0

The moisture-holding capacity for loamy sands and sandy loams is more typical for most irrigated fields. A weekly watering schedule is usually needed. The total water required from irrigation and rainfall should total about 16 inches for the months of June, July, and August.

Rainfall can disrupt an irrigation schedule. Generally, for each ¼ inch of rain, irrigation may be delayed one day. This, of course, assumes the irrigation is on schedule. If a rain completely recharges the soil profile, the irrigation schedule will depend on how fast the fields can be irrigated, the moisture-holding capacity of the soil, and weather conditions. The important point is to start early enough that areas covered at the end of the cycle do not fall below the 25% level of available water. The schedule also increases efficiency in the use of water.

Adequate soil moisture should be maintained by rainfall and irrigation until plants have reached physiological maturity. Usually, irrigation can be

Table 10. Estimated costs to grow corn on loamy sand with and without irrigation (1977).[1]

			NO IRRIGATION		WITH IRRIGATION	
Item	*Explanation*	*Price/Unit*	*After Corn*	*After Alfalfa*	*After Corn*	*After Alfalfa*
Seed	18,000 28,000	$42.00	$ 9.50	$ 9.50	$14.70	$14.70
Fertilizer						
N	70-10-220-140 lb[2]	.15	10.50	1.50	33.00	21.00
P_2O_5	25-25-75-75 lb	.15	3.75	3.75	11.25	11.25
K_2O	50-75-150-200 lb	.08	4.00	6.00	12.00	16.00
Lime	400 and 800 lb	10/T	2.00	2.00	4.00	4.00
Herbicides						
Atrazine (AAtrex)	1.5 lb	2.00	3.00	3.00	3.00	3.00
Alachlor (Lasso)	2 qts.	13.80	6.90	6.90	6.90	6.90
Insecticide After Corn			6.00	—	6.00	—
Supplies and Misc.			4.00	4.00	10.00	10.00
Field Operations Custom Rates						
Spread dry fert.	1 time	2.00	2.00	2.00	2.00	2.00
Plow	1	9.00	9.00	9.00	9.00	9.00
Fitting	1	3.00	3.00	3.00	3.00	3.00
Planting	1	5.00	5.00	5.00	5.00	5.00
Apply anhydrous	1	3.00	—	—	3.00	3.00
Spray herbicide	1	3.00	3.00	3.00	3.00	3.00
Cultivate	No	2.50	—	—	—	—
Harvesting			12.00	12.00	16.00	16.00
Trucking		.15	9.00	9.30	22.80	23.40
Drying		.15	9.00	9.30	22.80	23.40
Stalk chopping	1		4.00	4.00	5.00	5.00
Irrigation 6X @ 1.33 inches/irrigation (8" total)						
Fuel-electricity		2.50/inch	—	—	20.00	20.00
Depreciation		32.00	—	—	32.00	32.00
Labor	1 hr.	4.00	—	—	4.00	4.00
Land rent		40	40.00	40.00	40.00	40.00
Interest on capital			4.00	4.00	34.00	34.00
Insurance			3.00	3.00	6.00	6.00
Total cost per acre			152.65	140.25	328.45	315.65
Crop yield bu/A			60.00	62.00	165.00	170.00
Corrected for land loss — 5%			60.00	62.00	157.00	162.00
Cost per bushel			2.54	2.26	2.09	1.95

[1]*The authors express their appreciation to Gerald Schwab, Department of Agricultural Economics and E. A. Netherton, Extension Field Crop Agent for their help.*

[2]*Pounds of nitrogen per acre for each of the four cropping situations.*

discontinued when the grain is in the full dent stage and moisture is above 50% of the soil moisture holding capacity. Corn is mature when the kernel moisture reaches 35%. At this stage, the "black layer" forms at the base of the kernel. Normally, this takes place about mid-September. Stopping irrigation too early can prevent nutrient translocation and completion of kernel development. Plants under drought stress late in the season are also more likely to lodge because of poor stalk development. Be prepared to apply one watering in September if needed.

With extensive acreage or inadequate water supply, start early enough so that all your acreage gets adequate water during the critical tasseling-pollination-silking period. The greatest benefit from irrigation is prior to tasseling and through silking. Two or three timely applications during this period should result in 140-150 bushel per acre corn.

Production Costs

We will not compare costs for various irrigation systems here. Economic returns have been variable during the past several years because there have been great changes in equipment, energy and nitrogen costs, and in land values. Corn prices have also ranged from $2.00 to $3.00 per bushel. Thus, cost and return estimates can become quickly outdated. Those illustrated in Table 10 attempt to relate to economic conditions found in the 1976-77 season. Operators should have low production costs because many are based on custom operator charges. The estimates are based on yields of 150-160 bushel per acre. Under top management practices, yields should average 170-180 bushels per acre.

Summary

1) Make certain you have adequate water sources for irrigation.
2) Select the irrigation system that best fits your cropping sequence, field design, and labor resources.
3) Have your soil tested and strive for balanced fertility. Consider applying some nitrogen in the irrigation water.
4) Select high-yielding hybrids that will mature 10 days or more before frost.
5) Plant all fields by May 10 and place seed about one inch deep.

Figure 3. Corn should be waist high by July 4. At this stage, the crop starts using large amounts of nutrients and water.

Figure 4. Irrigated corn with good yields can return over 5 tons of stover per acre. When returned to the soil, the residue greatly increases soil microbial activity and improves the soil organic matter.

6) Practice minimum tillage to reduce soil compaction.

7) Strive for a plant population of 24,000 to 28,000 plants at harvest.

8) Control insects and weeds.

9) Start irrigation when available soil moisture is about 50 to 65% of the available soil moisture-holding capacity and complete the cycle before moisture drops to 25%.

10) Do not stop irrigating until plants have reached physiological maturity ("black layer" stage).

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