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Texas Agricultural Extension Service

Corn Irrigation

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Corn is a water sensitive crop that generally must be irrigated adequately to maintain moderate to high soil moisture. Limiting corn irrigation can reduce yield to the extent that a different crop would be more profitable.

Yields will normally be good by planning corn acreage for irrigation well capacity at 8.5 gallons per minute (gpm) per acre where the furrow method is used; 8.0 to 8.25 gpm per acre where center pivots are equipped with spray heads or impact sprinklers; and 6.6 gpm per acre with LEPA center pivots. Practices such as alternate furrow irrigation, guiding irrigation by soil moisture measurements and in some cases stretching the frequency of seasonal irrigation can reduce the total irrigation amount needed without significantly limiting yield.

Often the greatest potential for reducing corn irrigation is during early vegetative growth stages. A high soil moisture level until eight leaves have developed usually does not contribute to yield. Deep rooting is important during this time. Plants grown in high soil moisture conditions early in the growing season tend to be more sensitive to stress during later periods of high water use when similar soil moisture levels cannot be maintained.

Irrigation Timing

Timely irrigations on corn can mean extra bushels at harvest and can limit total water application and pumping costs. Corn irrigations that are applied according to the plant's seasonal water-use pattern (Figure 1) are often more productive and lead to good irrigation water use efficiency. Irrigation during stages of growth with high water requirements normally gives corn yields a good boost, while only limited increases are obtained from irrigations during growth stages that require less water.

Corn water requirements increase rapidly after the plants have eight to ten leaves. During the following 3 to 4 weeks, which is the major vegetative growth stage, plants are likely to grow 4 to 5 feet in height. At the same time, adequate soil moisture is important for proper tassel and ear development inside the plant. Demand for water is particularly high just prior to tasseling.

Highest plant water needs of the season usually occur during silking and pollination and remain high for about 10 days when grain filling begins. During the following 6 to 7 weeks, the primary plant function is to produce grain. Moisture stress during tasseling, silking and pollination periods is normally quite costly due to delayed silking and poor pollination. Adequate soil moisture is especially important for complete pollination and for the following 10 to 14 days to achieve max-

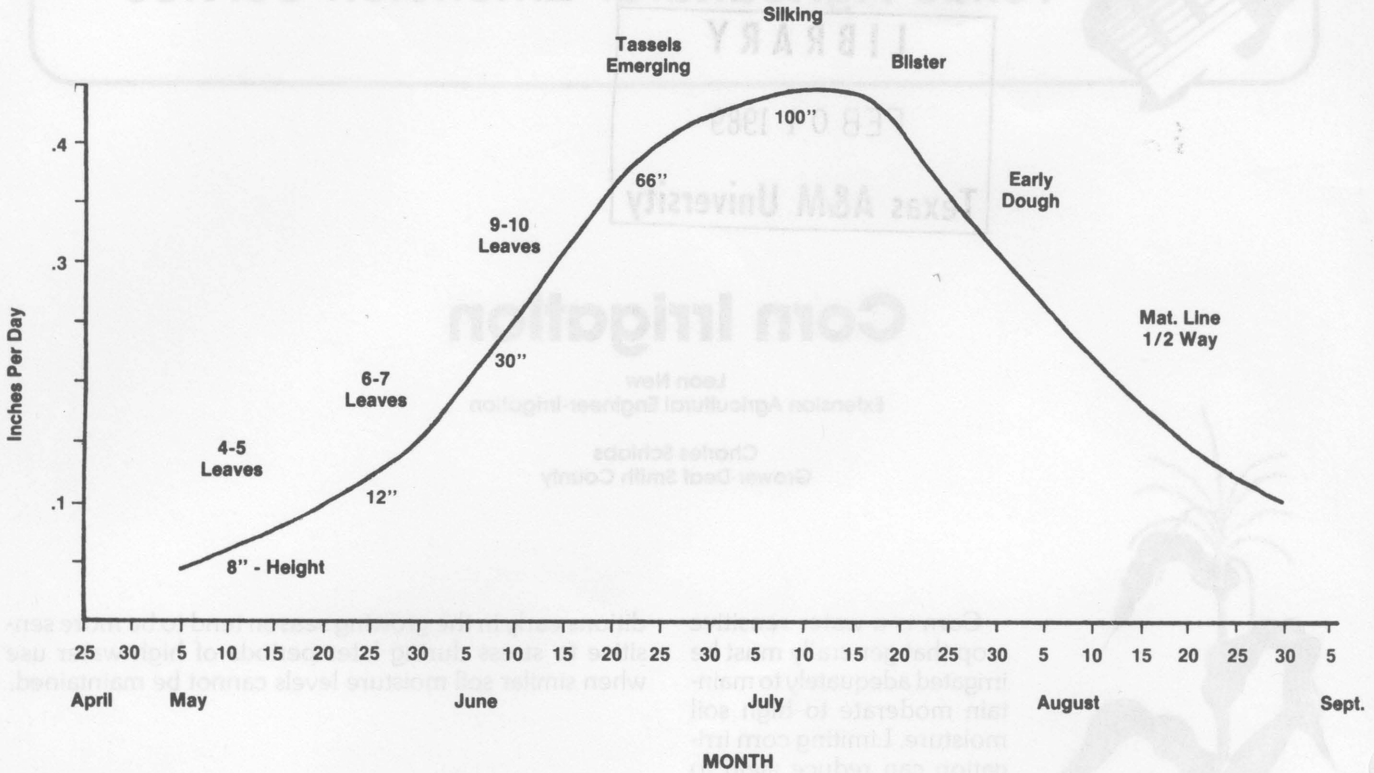

Figure 1. Typical corn daily water use in the Texas High Plains.

imum seed per ear. Water requirements are likely to be 4 to 5 inches in 10 days, and even more when temperatures are high, relative humidity is low and wind speed is up.

Water applications in alternate furrows may help wells keep pace with peak plant demands, especially on loam and other soils that do not crack appreciably when dry. Center pivot speed should not be increased unless plants are wilting badly or water volume exceeds 1000 gallons per minute for a quarter-mile machine. At least 0.5 inches should be applied by center pivots during a single irrigation.

Water requirements remain high during the early stages of grain development, often described as the blister and milk stages. During this time, grain develops and rapidly increases in weight. Adequate soil moisture must be available during the first 4 weeks of grain filling for high volume grain production. Afterward, high soil moisture levels are not as important.

By the early dough stage, water requirements normally begin to decrease. However, moisture stress while the dough is soft will limit grain fill. As grain matures, corn water needs decrease rapidly (see Figure 1).

The grain maturity line can be a guide for continuing or terminating irrigation. Corn kernels mature from the outward tip inward toward the cob. As kernel maturity progresses, a distinct yellow-white color separation is visible on each kernel and moves inward from the tip of each kernel. It is also known as the maturity line or the starch line.

To identify the maturity line, break a corn ear in half and closely inspect the exposed full kernels. Kernels exposed by the external portion of the broken ear show the maturity line more clearly. Puncture the outer and inner portion of the kernel to identify the location of mature grain.

On heavier clay and clay loam soils such as Pullman and Sherman silty clay loam and on loam soils such as Acuff and Olton, furrow irrigate until the maturity line has progressed one-third to one-half the inward distance down the kernel. Try to have a full profile of soil moisture at this stage of grain maturity. This level of soil moisture is usually adequate for the immature portion of the kernel to mature and to maintain plant quality till harvest.

On sandy soils and on fields where individual irrigations have been consistently light during the season, such as those fields with center pivots and alternate furrow irrigation, corn may need to be irrigated until the maturity line has moved one-half to two-thirds the distance down the kernel.

Formation of the black layer is a signal of full kernel maturity. The black layer becomes visible after the maturity line reaches the inward tip of the kernel, where the kernel attaches to the cob. A dark brown line first appears and later turns black. It can be located by cutting into the tip of the kernel.

Corn can no longer increase in weight after the black layer appears and reduces in moisture content during the drying period before harvest. The only benefit from irrigation after this stage is to maintain plant quality until harvest.

First Irrigation

First irrigation of corn is one of the few opportunities to limit seasonal irrigation without also limiting yield. Dates to achieve best response to the initial summer irrigation are not the same each year because of variations in rainfall, planting dates and hybrids. The irrigation rate is also a major factor influencing when to begin irrigating each year. Soil moisture sensors can aid in identifying the time to begin. Soil moisture can be significantly depleted in the first foot of soil, if good moisture remains in the second and third foot.

Field tests on Pullman silty clay loam soil that compared corn yield when the first furrow irrigation was delayed 1 week after normal irrigation began showed significant reductions in 5 out of 11 years. In these 5 years, yield ranged from 715 pounds (13 bushels) to 1540 pounds (28 bushels) less. In the other 6 years, yield was not significantly influenced by the irrigation being applied week later.

Where the first irrigation was delayed 2 weeks from normal, yield was significantly less in 10 of 11 years. Yield reductions ranged from 885 pounds (16 bushels) to 2285 pounds (41 bushels) per acre. For all 11 years, yield averaged 480 pounds (9 bushels) per acre less when the first irrigation was delayed 1 week and 1250 pounds (22 bushels) when the first irrigation was delayed 2 weeks (Table 1). Following either 1 or 2 weeks delay of the first irrigation, subsequent applications were made approximately 2 weeks apart.

Corn plant height is usually less when the first irrigation is delayed, depending upon rainfall. Field tests showed that height is often 10 inches less when the first irrigation is 1 week later and about 20 inches less when the inital application is made 2 weeks later (Figure 2). Plants will respond to subsequent irrigations. Moisture stress during vegetative growth limits leaf area and dry matter causing plants to develop fewer seed on each ear.

Table 1. Corn yield reductions per acre when the first seasonal irrigation is one and two weeks after the first normal application (1977-1987). Deaf Smith County, Texas.

Year	Comparative first irrigation	One week delay			Two week delay		
	Date	Pounds	Bushels	Date	Pounds	Bushels	Date
1987	June 18	1060	19	June 26	1400	25	July 1
1986	June 30	160	3	July 6	2285	41	July 13
1985	June 25	1540	28	July 3	1155	21	July 8
1984	June 23	0	0	June 30	1275	23	July 16
1983	June 27	990	18	July 4	1440	26	July 10
1982	June 17	0	0	June 24	885	16	July 17
1981	June 13	715	13	June 20	1180	21	June 26
1980	June 24	740	13	July 1	955	17	July 7
1979	June 23	0	0	July 1	232	4	July 14
1978	June 22	75	1	June 29	1850	33	July 5
1977	June 12	0	0	July 3	1095	20	July 3
11-Year average		480	9		1250	22	

Bushels to nearest whole number.
Actual irrigation dates selected to best utilize rainfall.

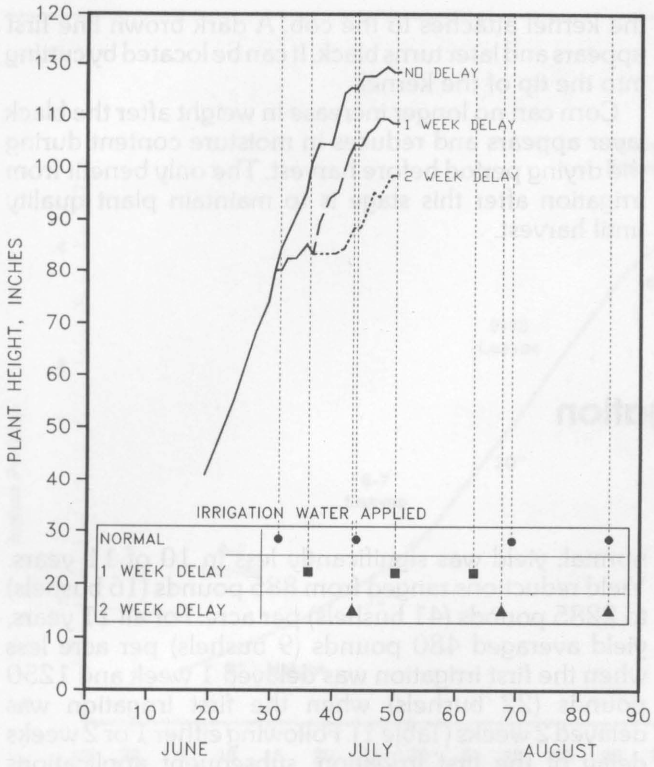

Figure 2. Typical corn plant height as influenced by timing of first furrow irrigation (1986). Deaf Smith County, Texas.

Last Irrigation

Stopping irrigation before the grain maturity line has progressed sufficiently can significantly limit corn yield. Adequate moisture is essential to maintain potential grain weight until the kernels are mature. The grain maturity line and soil moisture sensors can aid in making an accurate decision. Dates of the last irrigation will vary considerably depending on rainfall, soil type and hybrid cultivar.

Field tests on Pullman silty clay loam soil showed considerable yield increase from an additional furrow irrigation in 8 of 11 years. Increases ranged from 435 pounds (8 bushels) per acre to 1915 pounds (34 bushels) per acre as shown in Table 2. There was no yield difference in 3 of the 11 years. Previous seasonal irrigations were generally at 2 week intervals to maintain adequate soil moisture.

Irrigation Quantity and Frequency

Corn typically can respond efficiently to 22 to 26 inches of seasonal irrigation. A preplant application is often beneficial in addition to this, especially where the acreage planted stretches the quantity of irrigation water available. Prewater can contribute to timely planting, enhance seed germination and store water in the soil root zone for use by the plants during high water use growth stages when irrigation capacity may be less than daily plant use.

Irrigation frequency is determined to a great extent by the irrigation method. Where center pivots are used, the frequency is often each 3 to 5 days, and 1 to 2 inches of water is applied. With furrow irrigation, the quantity of water applied for a single irrigation cannot be as precisely controlled. Individual applications are greater with furrow irrigation, often 4 to 6 inches, and therefore can be less frequent. Irrigating alternate furrows will usually allow a reduction in the amount of single and seasonal irrigation. However, especially during peak water use, periodic applications should be more frequent. The use of alternate furrows is less effective when soil cracks, land slopes very little, or this slope permits the water to move too fast.

In field tests on Pullman silty clay loam soil, half-mile long rows 40 inches wide were furrow irrigated to provide corn yield data from a range of 18 to 28 inches of seasonal irrigation. Irrigations were applied at the following intervals: 2 weeks, 3 weeks and according to soil moisture determined by gypsum block soil moisture sensors (Table 3). Tests also included irrigating every furrow and alternate furrows each 10 days.

At least one, and probably two, additional irrigations are required when applications are at 10-day intervals according to these field tests. Total summer irrigation in every furrow averaged 6.7 inches (or 31 percent) more than when soil moisture sensors were used to guide irrigation, and corresponding yield averaged 515 pounds (9 bushels) or only 5 percent more per acre. Irrigating in every furrow each 10 days averaged 3.7 inches (or 15 percent) more water applied than on 2 week frequency, and yield was 535 pounds (10 bushels) or 6 percent more. Irrigation in every furrow each 10 days averged 7.4 inches (or 35 percent) more water applied than irrigating alternate furrows each 10 days, whereas yield averaged 610 pounds (11 bushels) or only 6 percent more per acre. Average seasonal rainfall for these tests ranged from 0.7″ in April to 4.4″ in August, with an average total of 15.6″ for April-September in 1979-1987.

Corn yield per acre-inch of seasonal irrigation is an excellent measure for evaluating irrigation management practices. A reasonable goal is 450 to 500 pounds of corn per acre-inch of irrigation. Farmers can compare the cost of irrigating and the value of the average yield per acre-inch for three or more crop seasons to determine the most profitable management. Yield per acre-inch of irrigation will be greater when rainfall is high and less when it is low. An accumulation of yield and irrigation information provides a more accurate evaluation. When irrigation systems such as furrow and center pivot are compared, preplant and watering-up application amounts must be included in order to obtain accurate comparisons.

Irrigation and Plant Population

Corn plants have the ability to partially compensate in production for lower plant population by producing more kernels per ear. Each plant will produce more where the population is less. Populations of 24,000 to 30,000 plants per acre are generally required to achieve maximum yield with adequate irrigation, depending on the corn hybrid. Populations of 18,000 to 22,000 plants per acre may provide greater total yield where irrigation

Table 2. Corn yield increases from an additional last furrow irrigation (1976-1987). Deaf Smith County, Texas.

Year	Last irrigation date on comparative plots	Last irrigation on test plots: Date	Lbs/ac	Bu/ac	August rainfall
1987	July 31	Aug 20	555	10	7.7"
1986	July 29	Aug 26	0	0	8.1"
1985	Aug 12	Aug 26	825	15	7"
1984	July 30	Aug 31	435	8	6.4"
1983	Aug 23	Sept 6	760	14	6"
1982	Aug 14	Aug 28	1,620	29	1.3"
1981	July 25	Aug 8	0	0	1.8"
1980	Aug 6	Aug 30	0	0	4.6"
1979	Aug 14	Aug 28	1,105	20	2.5"
1978	Aug 4	Aug 18	1,915	34	2.5"
1976	Aug 15	Aug 28	1,080	19	4.5"
		AVERAGE	755	13	4.2"

(Data not available for 1977.)

Table 3. Averge corn yield for various furrow irrigation frequencies and amounts (1979-1987). Deaf Smith County, Texas.

	Irrigation*		Yield at 15.5% grain moisture		
Frequency	Number	Inches	Bushels	Pounds	Lbs/ac-inch
10-day every row	5.9	28.4	182	10,180	359
Soil moisture	4.0	21.7	173	9,665	446
2-week	4.7	24.7	172	9,645	390
10-day alt. row	5.8	21.0	171	9,570	456
3-week	3.2	18.0	150	8,375	464

*Does not include prewater.

Table 4. Average corn plant response from irrigation with high and low population (1979-1987). Deaf Smith County, Texas.

Plant Population	Irrigation*			Production @ 15.5% grain moisture			
	Interval	Number	Inches	Bu/ac	Lbs/ac	Diff. lbs/ac	Lbs/plant
30,880	10-day, alt. furrow	5.8	21.6	169	9,445	260	.31
21,250	10-day, alt.	5.8	21.6	164	9,185		.43
30,725	3-week	3.2	18.7	147	8,220	205	.27
21,440	3-week	3.2	18.7	150	8,425		.39
30,800	Average	4.5	20.2	158	8,835	30	.29
21,345	Average	4.5	20.2	157	8,805		.41

*Does not include prewater.

and thus production potential are more limited. Moisture stress during the 2 weeks before and 1 week after pollination can cause a greater number of barren plants where populations are high.

Field tests on Pullman silty clay loam soil where half-mile long rows 40 inches wide were furrow irrigated provide yield variations for higher and lower plant populations. Where irrigation was more normal using alternate furrow applications on 10-day intervals, production from an average plant population of 30,880 plants per acre averaged 260 pounds (5 bushels) more (i.e., 3 percent increase) than where the plant population averaged 21,250, as shown in Table 4. Production averaged 0.31 pounds per plant in the higher population and 0.43 pounds per plant in the lower plant population. Yield was greater 6 of 9 years from the highest plant population.

For the 3-week irrigation intervals, where irrigation and thus soil moisture were less adequate, production from an average plant population of 21,440 plants per acre was 200 pounds (4 bushels) per acre more than that from a population that averaged 30,725 (Table 4). In this case, production from individual plants averaged 0.27 pounds with the higher population and 0.39 pounds from the lower. Yield was greater from the lower plant population 7 of 9 years where irrigations were on 3-week irrigation intervals. Each plant population was irrigated the same.

Summary

Corn is more sensitive to plant water stress than most other field crops and therefore must be adequately irrigated in order to produce optimum yields. The greatest potential for limiting irrigation is during early vegetative growth. The effects of plant water stress are normally slow to develop in the spring because rainfall is often greater than later in the season, and roots grow deeper into the soil root zone that provides near adequate plant requirements. However, only a few days of afternoon plant wilting can be allowed. Highest plant water needs of the season occur during a 4-week period that is 2 weeks before and 2 weeks after pollination. Stopping irrigation before grain has sufficiently progressed to maturity can be costly. In managing irrigation at this time, it is critical to correctly decide when to stop. Yield per acre-inch of irrigation is an excellent measure for evaluation of any corn irrigation procedure. It should be evaluated annually. Plan irrigations with the plant's water use pattern in mind, along with the ability of the irrigation wells and water distribution equipment to supply the requirement. Where irrigation is planned to be less than fully adequate, lower plant populations may minimize yield reduction and reduce seed costs. Actual irrigation quantities are highly influenced by irrigation application and distribution efficiencies.

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