IMPORTANCE OF THE IRRIGATION OF CORN (Zea mays, L.)
DURING ITS MAXIMUM RATE OF TRANSPIRATION PERIOD

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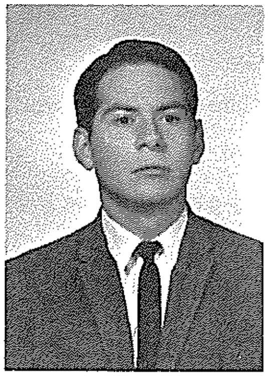
Biographical Sketch



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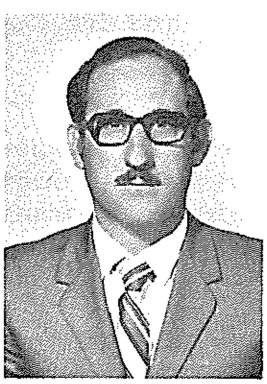

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Summary

Three different states of plant development were considered to apply irrigation during the maximum potential rate of transpiration period: Preflowering, flowering and postflowering, 70, 82 and 91 days after seeding respectively.

All the combination possibilities to apply irrigation were included. The treatments were distributed at random, replicated four times and the results were analyzed statistically.

It is presented data of soil properties, consumptive use, plant growth and grain production.

Preflowering irrigation did not affect plant growth or grain production; however, flowering and postflowering irrigation increased significantly grain production.

Apparently rainfall canceled preflowering irrigation need.

The consumptive use during the irrigation period studied was similar in all treatments, getting extreme values of 33.4 and 39.4 cms. It was obtained a linear correlation of 0.93 between grain production and water transpired from the upper 20 cms of soil, arriving to an apparent transpiration efficiency of about 2 cms per ton of grain.

Introduction

Grain production of corn can be increased avoiding water deficits during its maximum rate of growth period which corresponds in most of the cases, to its maximum rate of potential transpiration period.

In our local conditions, spring corn receives three applications of water during that period, independently of soil properties, atmospheric conditions and plant growth, and it is not known the real importance of every one of these irrigations. The objective of this research work was to find out the effectiveness of an irrigation program for the maximum rate of growth period in corn production.

Robins and Domingo (8) did not find significant difference in grain production between irrigated and not irrigated corn blocks when considering water application before flowering. The soil of the not irrigated blocks reaches 15% available moisture and the irrigated ones to a minimum of 60% available moisture. However, during and after flowering, water deficits were critical. It was observed a yield decrease of 22 to 50% by letting dry the soil once to wilting point. They arrived at the conclusion that the most critical period was flowering due to the effect on receptivity of the stigma and the reduction of corn ear size.

Howe and Rhoades (4) obtained yield of 9.94 tons/Ha with six water applications, keeping the soil moisture above 40% available moisture. The blocks receiving three irrigations from one week before flowering to one week after completion of flowering produced 9.36 tons/Ha of grain. When irrigation was reduced during that period the yield decreased significantly. Water deficit before flowering did not reduce grain production that much but delayed flowering.

Similar results had been reported by Cordner (1), Nelson (6), Hernandez and Laird (3), Rhoades and Nelson (7) and MacGillivray (5).

Haynes (2) observed that corn growth depends on soil moisture so much that there is a direct and linear relationship between dry matter produced and water transpired. Similarly Vega (9) reported that in sorghum grain production and foliage weight is related linearly to water transpired. On the other hand, root development and distribution is affected by soil moisture and in general it has been observed according to Rhoades and Nelson (7) that root explore mainly the upper levels of soil when grown in high moisture conditions.

Methods and Materials

The experiment was established in the Experimental Station of the Institute of Technology of Monterrey, in an area characterized by a calcareous soil, 3 ft. deep, underlayed by a caliche stratum, clay loam, with an apparent density of 1.3 g/ml at the surface to 1.76 g/ml at 3 ft. depth, 1 to 2% of organic matter and a changing pH from 7.2 to 8.3 (10).

The crop was corn of the variety Nuevo Leon VS-1, which is about 8 ft. high, and has 140 day cycle.

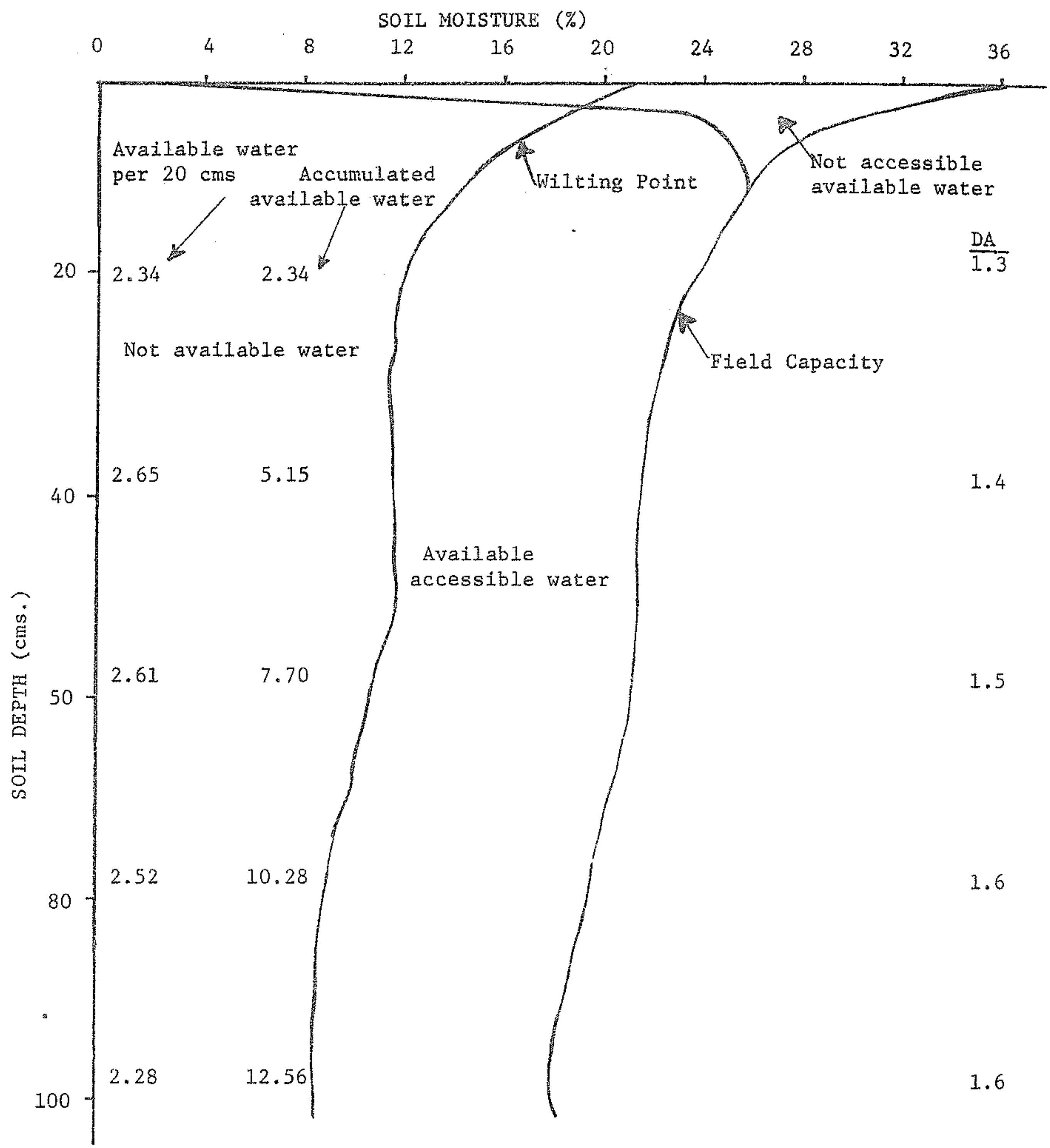
The treatments included consisted of applying irrigations at three different growth states: a) Preflowering (P), b) Flowering (F), and c) Postflowering (E) or 70, 82 and 91 days after seeding time. There were included all the combinations possible, that is 8 different treatments. Before the critical period studied, the field received 3 applications of water at seeding time and 14 and 56 days after respectively.

The experimental design was random block, included 4 replicates and the effective experimental unit was 3 rows of 25 ft. long.

The water retention characteristics of the soil are indicated in Figure 1.

The effects of the variable studied were determined by grain production and height of the plants and related to water evapotranspired, rainfall and air moisture and temperature.

Figure 1. Field Capacity, Wilting Point, Not Accessible Available Water, Available Accessible Water, Not Available Water and Apparent Density of the Soil.



Experimental Results

Grain production. The grain weights were calculated on 15% moisture bases. The effects of the treatments are expressed in the following table:

Table 1. Grain production in relation to the application of water at different states of growth.

Treatment	Grain Production Tons/Ha	Relative Grain Production %
P + F + E	5.57	121
P + F + O	5.12	112
O + F + E	5.40	118
P + O + E	5.32	116
P + O + O	4.42	96
O + F + O	5.19	113
O + O + E	5.11	111
O + O + O	4.59	100

P = Preflowering
F = Flowering
E = Postflowering
O = Without irrigation

D.M.S. 0.05 = 0.60 to 0.68 Tons/Ha

Plant height. To determine the irrigations effects on plant height, five plants at random were measured up to the tassel. It was found no significant difference between treatments and plant height oscillated between 10.3 to 10.6 ft.

Water evapotranspired. It was determined by soil sampling before and after irrigation and considering rainfall. The corresponding values during the total growth period were the following:

Table 2. Water applied expressed in centimeters considered to be evapotranspired and total rainfall occurred.

Treatment	Days After Seeding Time							Rainfall cms	Total
	14	56	70	82	91	118	Total a	Total b	a + b
P + F + E	2.0	4.96	3.31	4.54	2.60	3.49	20.90	16.96	37.86
P + F + O	2.0	4.96	3.31	4.54	-	6.03	20.84	16.96	37.80
O + F + E	2.0	4.96	-	6.41	2.42	3.54	19.33	16.96	36.29
P + O + E	2.0	4.96	3.31	-	2.43	4.73	22.43	16.96	39.39
P + O + O	2.0	4.96	3.31	-	-	6.13	16.40	16.96	33.36
O + F + O	2.0	4.96	-	6.41	-	6.57	19.94	16.96	36.90
O + O + E	2.0	4.96	-	-	7.54	5.93	20.43	16.96	37.39
O + O + O	2.0	4.96	-	-	-	9.78	16.74	16.96	33.70

P = Preflowering
F = Flowering
E = Postflowering
O = Without irrigation

No statistical analysis was possible since soil sampling was made only in one replicate.

Total irrigation varied from 16.40 to 22.43 cms and total rainfall was 16.96 cms. Rainfall occurred in 31 days during the 118 days of the growth period; however, only in 13 days occurred rainfall higher than 0.5 cms. The distribution of water applied artificially or received naturally is indicated in Figure 2.

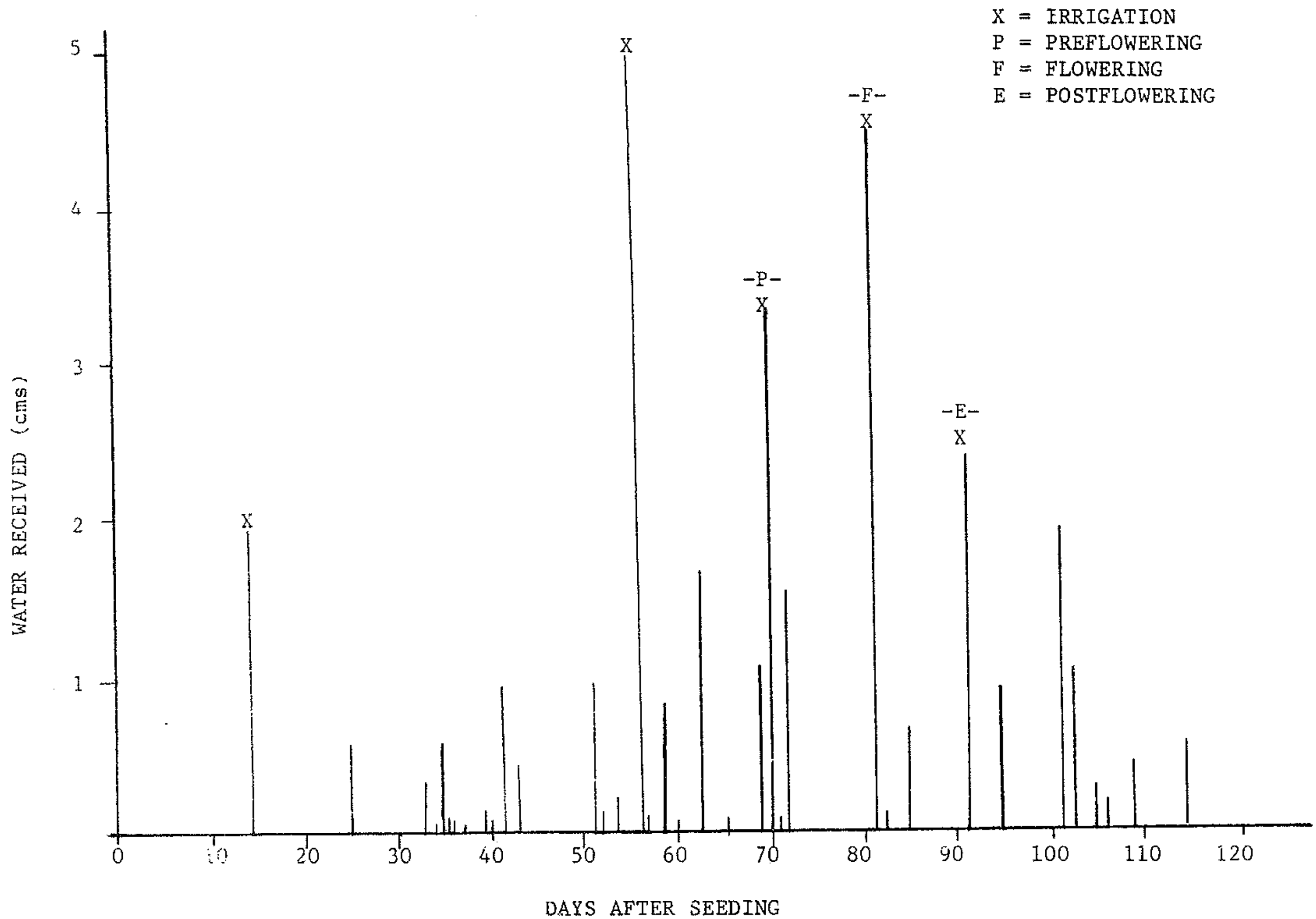


Figure 2. Rainfall and Irrigation Water Captured by the Soil During the Total Growth Period of Corn.

Discussion

Although soil water deficit never was lower than 60% of the available moisture, corn response to irrigation during the most intense transpiration period was significant. The referred influence on grain production is indicated in the following table:

Table 3. Grain production as related to irrigation during most intense transpiration period.

Irrigation	Treatments Compared	Increment Ton/Ha
Preflowering	P + F + E vs. F + E	0.17
	P + F vs. F	-0.07
	P + F vs. E	-0.21
	P vs O	-0.17
Flowering	P + F + E vs. P + E	0.25
	P + F vs. P	0.70 +
	F + E vs. E	0.29
	F vs. O	0.60 +
Postflowering	P + F + E vs. P + F	0.45
	F + E vs. F	0.21
	P + E vs. P	0.90
	E vs. O	0.52
Preflowering and flowering	P + F + E vs. E	0.46
	P + F vs. O	0.53
Preflowering and postflowering	P + F + E vs. F	0.38
	P + E vs. O	0.73 +
Flowering and postflowering	P + F + E vs. P	1.15 +
	F + E vs. O	0.81 +
Preflowering, flowering and postflowering	P + F + E vs. O	0.98 +

+Significantly different at 5% error level.

P = Preflowering
F = Flowering
E = Postflowering
O = Without irrigation

Preflowering irrigation. (P) It was not necessary since the differences observed never were significant, this is explained because soil available moisture deficit was 18%, rainfall occurred 6 days (3.98 cms), mean temperature was 26.1° C and when not applied in combination with the other two irrigations its effect is masked by the corresponding to the other irrigation.

Flowering irrigation. (F) This irrigation was considered important for grain production especially when preflowering irrigation was not applied and relatively less determinant of production when postflowering irrigation was excluded. This is probably a consequence of the strong influence of the postflowering irrigation on grain production and related to high air moisture influence period (Mean of 71.8%) and moderate temperature during the corresponding influence period (27.3°C).

Postflowering irrigation. (E) Highly determinant of grain production when flowering irrigation was not applied (900 Kgs/Ha) and preflowering irrigation occurred. When these two irrigations were excluded its influence is less (520 Kgs/Ha), since yield was limited by flowering irrigation, phenomena also observed by Howes and Rhoades (4) and Robins and Domingo (8).

According to the experimental results the highest yields were obtained when flowering and postflowering irrigations were applied.

Consumptive Use.

To study the relationship between water evapotranspired and grain production, water loss as vapor was separated in two fractions: water lost immediately after irrigation or after a rainfall, normally during the following 48 hours, called in this study as Not Accessible Available Moisture and water lost later named Accessible Available Moisture. The corresponding values are indicated in Table 4.

Table 4. Consumptive use, not accessible available moisture, accessible available moisture and water efficiency of corn when receiving preflowering, flowering or postflowering irrigations.

	C.U. cms a	Not Acc. Available Moisture cms	Acc. Available Moisture cms b	Grain Production Ton/Ha	Water Efficiency cms/Ton a	b
P + F + E	37.86	6.54	31.32	5.57	6.8	5.6
P + F + 0	37.80	5.45	32.35	5.12	7.4	6.3
0 + F + E	36.29	5.45	30.84	5.40	6.7	5.7
P + 0 + E	39.39	5.45	33.94	5.32	7.4	6.4
P + 0 + 0	33.36	4.36	29.00	4.42	7.5	6.6
0 + F + 0	36.90	4.36	32.54	5.19	7.1	6.3
0 + 0 + E	37.39	4.36	33.03	5.11	7.3	6.5
0 + 0 + 0	33.70	3.27	30.43	4.59	7.3	6.6

Highest efficiencies were observed when flowering and postflowering irrigations were applied, and practically constant efficiency is obtained in the rest of the treatments. From these two irrigations postflowering was especially important.

In order to explain the results from another point of view, it was determined the accessible available moisture consumed from the different depths of soil and related to grain production, finding an apparent relationship between water coming from the upper 20 cms of soil and grain production given by the regression = 3.85 + 0.51 X and a correlation of r = 0.93. This supports the idea that yield was determined mainly by the accessible available moisture lost by the crop mostly by transpiration from the upper layer of soil, observation referred for sorghum in the same soils by Vega (9).

Conclusions

Apparently the postflowering irrigation was the most important for an efficient grain production, followed by the flowering irrigation.

Grain production relates directly to consumptive use considering total evapotranspired water or only that accessible available moisture lost as vapor, probably most by transpiration.

From the total water evapotranspired that accessible available moisture coming from the upper 20 cms of soil relates directly to grain production with a slope value of 0.51 Tons/cms or 1.96 cms/Ton supporting that this is the most effective water.

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