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EFFICIENCY OF DRIP IRRIGATION IN CORN CULTIVATION UNDER LOW TEMPERATURE CONDITIONS IN THE STATE OF SONORA, MEXICO

Jose Luis Felix Fuentes
``Instituto Nacional de Investigación Forestales, Agrícolas y Pecuarias`` (INIFAP). Campo Experimental Norman E.Borlaug (CENEB)
Obregón, Sonora, Mexico

José Eliseo Ortiz Enríquez
``Instituto Nacional de Investigación Forestales, Agrícolas y Pecuarias`` (INIFAP). Campo Experimental Norman E.Borlaug (CENEB)
Obregón, Sonora, Mexico

Pedro Félix Valencia
``Instituto Nacional de Investigación Forestales, Agrícolas y Pecuarias`` (INIFAP). Campo Experimental Norman E.Borlaug (CENEB)
Obregón, Sonora, Mexico

Isidoro Padilla Valenzuela
``Instituto Nacional de Investigación Forestales, Agrícolas y Pecuarias`` (INIFAP). Campo Experimental Norman E.Borlaug (CENEB)
Obregón, Sonora, Mexico

Abstract: In this region, autumn-winter corn is among the crops with the highest water demand, seven irrigations in total are applied under gravity irrigation, with a net sheet of 95 cm and this limits the increase in the corn surface as happened In the 2021-22 cycle, only 8,500 hectares were planted. Due to the lack of water in the 2022-23 cycle, corn irrigation was reduced from six relief irrigations to only four relief irrigations. Commercial planting of corn under pressurized irrigation, whether drip or sprinkler irrigation, is minimal and can be a way to increase yield, water productivity and reduce the risk of frost. The work was carried out in the O-I 2022-23 cycle with a producer from the Yaqui Valley, located in Block 1414 (27.271079-109.872362), the drip irrigation system (new) was studied in the cultivation of corn in a surface of 8 ha and with the Hipopótamo hybrid on the planting date of November 15, 2023, the type of soil was clay known in the region as Barrial Profundo. Results: The corn was frozen on January 23, 2023 at temperatures of 1.45 to 1.98 °C for a period of 50 minutes, even so, the grain yield was 17,371 kg/ha, with a plant height of 3.14 m, a population of ears of 106,852/ha, the weight per ear was 192.5 grams, hectoliter weight of 68.8 kg/hl, number of rows/ear 13.6 and the weight ratio of grain and cob 80.8.19.2. The total irrigation layer applied in the cycle was 662 mm and the water productivity was 381 liters of water to produce one kilogram of corn grain.
Keywords: Increased yield, Water savings and Drip irrigation.

INTRODUCTION

The main producer of corn is the United States, Mexico is in eighth place. Corn production in the Yaqui Valley, Sonora has been part of the sequence of crops with variable surface area depending on the demand for grain, the price to the producer and the availability of water in the region's dams. The area from the 2008-09 to 2020-21 cycle has varied from 7,411 to 57,955 ha, from 2015-16 it increased (Table 1) and one of the reasons is because the wheat area has decreased in the region due to low profitability. of the same. In relation to the grain yield from the 2008-09 to 2012-13 cycle it was practically the same with 6,228 kg/ha, from 2014-15 to 2016-17 it increased by 20% and to date it has increased 50%. This is explained because producers have changed the sowing date, taking the risk of sowing late as a way to increase yield.

Autumn-winter corn demands a lot of water, around seven irrigations are applied in total under surface irrigation, with a 90 cm sheet and this limits the increase in surface area as happened in 2021-22 when only 8,500 hectares were planted. Due to this, in the 2022-23 cycle, corn irrigation was reduced from six to four relief irrigations. Even when there is a reduction in the irrigation layer, there are several risks, among which the loss in yield stands out, as well as the negative effect due to low temperatures. Frost can have a devastating impact on corn fields, as this crop is particularly sensitive to low temperatures during different stages of its growth cycle (Chinnusamy et al., 2007).

Cycle	Area (ha)	Performance
2008-09	10,763	6,040
2009-10	17,552	6,790
2010-11	12,978	5,922
2011-12	13,898	6,211
2012-13	17,897	6,178
2013-14	7,551	7,070
2014-15	7,411	7,453
2015-16	15,696	8,238
2016-17	22,928	8,649
2017-18	41,974	11,624
2018-19	49,843	12,381
2019-20	46,186	13,120
2020-21	57,955	14,150

Table 1.- Planted area and yield of corn cultivation in the Yaqui Valley, Sonora. 2008-2021.

Source: Local Plant Health Board of the Yaqui Valley, Sonora.

According to Arbues Oses. (2011), "frost can cause damage to corn through the freezing of water in plant tissues, causing physical damage to cells and tissues, and can also affect the plant's ability to maintain essential metabolic processes. ". This can result in a decrease in corn production and a significant loss in crop yield. (Mondragón, 2005). To mitigate the damage caused by low temperatures in corn cultivation, irrigation plays a fundamental role. According to Florez et al. (2007), adequate irrigation can help protect corn plants against frost by raising the temperature of the soil and surrounding air, which prevents or reduces frost damage. Overhead irrigation, in particular, can be effective in providing latent heat as water freezes, releasing heat and protecting plants from freeze damage.

Commercial planting of corn under drip or sprinkler irrigation is minimal and can be a way to increase yield, increase water productivity and reduce the risk of frost. The objective of this work was to study the application of irrigation using the drip irrigation system in the cultivation of corn in a commercial scheme in the Yaqui Valley, Sonora.

MATERIALS AND METHODS

The work was carried out in the O-I 2022-23 cycle with a producer from the Yaqui Valley, Sonora, in Block 1414, coordinates 27.271079-109.872362. A soil analysis was carried out, the soil has a clay texture, the saturation point of 53%, the hydraulic conductivity of 4.71 cm/h, nitrogen (N) with 48.3 kg/ha and phosphorus (P) with 33.6 kg/ha. ha. The planting area was 8 ha. The previous crop was wheat, the land preparation was a double step of harrow, it was fertilized with a mixture of urea (N) and P of 350 kg/ha to give a dose of 109-78-00 of NPK, later it was incorporated with dredge. The irrigation system was new, beds were laid out and irrigation tape was placed at the same time at a depth of 10 cm. The irrigation tapes were placed 1.50 m apart with a 40 cm separation between drippers and above the bed two rows of corn were planted 70 cm apart (Figures 1 and 2). For sowing, the soil was not covered, it was carried out directly in wet conditions with a precision seeder on November 15, 2022, depositing 9 seeds per linear meter at 6 cm depth to give a population of 119,988 seeds per ha, the hybrid was Hippopotamus de the Asgrow company.

Figures 1 and 2. Sowing bed, installation of the irrigation tape and application of pre-sowing irrigation.

P For the application of irrigation, Watermark sensors were installed to monitor soil humidity, also checking the soil humidity with a shovel to form a humidity bulb since there was a year of low temperatures and it was necessary to apply more water to protect the soil. plant. To control weeds, two mechanical weedings and an application of herbicide for bindweed (Convolvulus arvensis, L.) were carried out. For pests, an application was made for the fall armyworm (Spodoptera frugiperda). All plant fertilization was carried out as ferti-irrigation, UAN-32 and phosphoric acid were used to complete the dose of 450-100-00 N-P-K. The collection was manual, 4 repetitions were harvested throughout the entire plot, the useful plot was 3 beds by 3 m long. (13.5 m^2).

RESULTS AND DISCUSSION

Corn was frozen on January 23, 2023 (Figure 4) at temperatures of 1.45 to 1.98 °C for a period of 50 minutes (Figure 3), at the four to five leaf stage (V4 to V5) however, the grain yield was 17,371 kg/ha (Table 2), high yield for the region. The damage to the plant was on the leaves, cuts were made at the base of the stem and the growing point was observed to be healthy, but it took a month for the plant to recover. Barrales et al., (2002) mentions that the flowering and grain filling stage is the stage in which the plant is most sensitive to frost damage, impacting its productivity.

According to Straschnoy et al., (2006) they define that frost occurs when the temperature of the earth or objects on the surface reaches 0 °C at a height of 1.5 m. Martin, and Muñoz, (2017) establish that soil moisture can also influence its radiation potential, which increases the heat capacity of wet soil. This explains the decrease in frost damage in irrigated fields, compared with those not watered. Barrales et al., (2002) mention that corn is one of the crops that shows the least tolerance to cold and that death occurs at temperatures below 0°C. Water management was key to reducing frost since the 2022-23 cycle was very cold, a humidity bulb was maintained across the width of the bed, so a greater amount of water was applied than in previous experiences.

Flood or furrow irrigation is an option in most parts of the world if water is available in a timely manner. This allows increasing the heat capacity of the soil and its thermal conductivity (Gracia et al., 2017). During January and February, frequent irrigation was applied 2 to 3 times a week, then in March and April the irrigation was more spaced, in May and June again frequent irrigation due to the high temperatures, the irrigation layer applied throughout the cycle was 66.2 cm and a productivity of 382 liters of water to produce one kg of corn grain. Table 2 shows a comparison of the irrigation schedule of gravity irrigation and sprinkler irrigation in corn cultivation. In the 2018-19 cycle, Ortiz et al obtained a yield of 18,126 tons per ha under drip irrigation in corn without frost problems with an irrigation sheet of 41.22 cm and a water productivity of 229 liters of water, so There is potential for yield and water savings using drip irrigation. The plant height was 3.14

m, the number of ears/ha was 106,852, the ear weight was 192.5 grams, the hectoliter weight was 68.8, the number of rows was 13.6, and the weight of 1000 grains was 432.5 grams.

Gravity irrigation schedule				
Irrigation (Number)	**Interval (days)**	**Days after sowing**	**Net sheet mm**	**Raw sheet mm**
1	0	-20	141	235
2	84	64	44.5	74.2
3	34	98	73.7	122.8
4	23	121	86.1	143.4
5	30	141	96.9	161.5
Total			442.2	736.9
Sprinkler irrigation schedule for corn				
Irrigation (Number)	**Interval (days)**	**Days after sowing**	**Net sheet mm**	**Raw sheet mm**
1	0	-20	141	165.1
2	50	30	15.6	18.3
3	38	68	36.4	42.8
4	20	88	42.9	50.4
5	19	107	49.8	58.5
6	13	120	52.6	61.9
7	12	132	56.9	66.9
8	13	145	61.1	71.9
Total			456.2	535.8

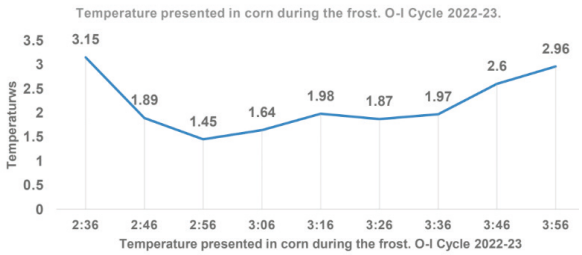
Table 2. Comparative analysis of gravity and sprinkler irrigation in corn cultivation

Repetition	**Grain yield in kg/ha at 14% humidity**	**Plant height in m**	**Number of ears/ha**	**Average weight per cob in grams**
1	18,336	3.22	107,407	230
2	19,091	3.07	112,593	152
3	16,026	3.12	103,704	193
4	16,030	3.15	103,704	195
Average	**17,371**	**3.14**	**106,852**	**192.5**

Table 3: Corn yield under drip irrigation. Yaqui Valley, Son. O-I 2022-23.

Repetition	**Test weight**	**Weight of 1000 grains in gr**	**Number of rows/cob**	**Grain:cob ratio**
1	68.0	425	13.8	79.8: 20.2
2	65.5	460	14.0	79.2: 20.8
3	71.0	420	13.2	82.2: 17.8
4	70.5	425	13.4	81.8: 18.2
Average	**68.8**	**432.5**	**13.6**	**80.8: 19.2**

Table 4: Variables in corn under drip irrigation. Yaqui Valley, Son. O-I Cycle 2022-23.



Figures 3. Temperatures during the frost in the corn plot

Figure 4. Corn plot with symptoms of frost

CONCLUSIONS

The highest corn grain yield was 17,371 kg/ha under drip irrigation.

-The corn was frozen in the V4 to V5 stage at temperatures of 1.45 to 1.98 °C which remained for 50 minutes.

- The irrigation layer applied throughout the cycle was 66.2 cm or 6.62 thousand m3/ha, or 662 mm/ha

- Water productivity was 382 liters of water per kg of corn grain.

- The plant height was 3.14 m, the number of ears/ha was 101,852, the weight/ear was 192.5 grams, the hectoliter weight was 68.8, the weight of 1000 grains was 432.5 gr, the number of rows/ear was 13.6 and the cob grain ratio of 80.8:19.2.

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