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# Effect of drip irrigation schedules and fertigation levels on growth parameters and yields of sweet corn

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## Abstract
A field experiment was conducted during *rabi* seasons of 2019-20 and 2020-21 to study the effect of drip irrigation schedules and fertigation levels on growth parameters and yields of sweet corn (*Zea mays* L. var. *sachharata*). The trial was laid out in split plot design with three replications, assigning total 9 combinations i.e. three irrigation schedules (0.6, 0.8 and 1.0 PEF) in main plot and three nitrogen fertigation levels (75%, 100% and 125% RDN through drip fertigation) in sub plots. The revealed that drip irrigation scheduling at 1.0 PEF enhance growth parameters and yields which ultimately resulted in higher green cob and fodder yields of *rabi* sweet corn over drip irrigation scheduling at 0.6 PEF and in fertigation levels 100% RDN through drip significantly increase growth parameters and yields of *rabi* sweet corn over 75% RDN through drip fertigation.

**Keywords:** Growth parameters, yields, drip irrigation schedule, fertigation levels, sweet corn

## Introduction
Maize is one of the most important cereal crops in the world after wheat and rice; and has great importance in the world's agricultural economy. It has many uses such as food, feed, fodder for livestock and raw material for industry. Corn oil is also famous for its non-cholesterol character. In addition, its products like corn starch, corn flakes, gluten, lactic-acid, alcohol and acetone are either directly consumed as food or used in various industries like paper, textile, foundry and fermentation. It is also known as the "queen of cereals" because of its very high yield potential than any other cereal crops. Maize seed contains 10% protein, 4% oil and 2-10% crude fibre. Maize being a C4 plant has tremendous yield potential and responds well to applied inputs. World population increasing day-by-day there is a crucial need to expand the productivity per unit area per unit time to feed the growing population of world. The total area under maize cultivation in world is 193.73 million hectares with production of 1147.62 million tons and productivity of 5924 kg $ha^{-1}$ (Anon., 2020a) [1]. United States is the largest producer of maize in the world during 2018-19. India is the seventh largest producer of maize in the world. The total area under maize cultivation in India was 9.20 million hectares, with the total production of 27.82 million tons and productivity of 3024 kg $ha^{-1}$ during the year 2018-19 (Anon., 2020a) [1]. In Gujarat, maize is grown over an area of 4.092 lakh ha with an annual production of about 8019.23 metric tons and average productivity of about 1960 kg $ha^{-1}$ (Anon., 2020b) [2].

Sweet corn is a particularly maize species which differ genetically from the field maize. Sweet corn is native of the Central America which then introduced to the rest of the world through Spanish explorers. Sweet corn differs genetically from the field maize mutation at the sugary locus. It is consumed in the immature stage of the cob. Its kernels are tender, delicious and eaten as vegetables in many cuisines worldwide. It is one of the most popular vegetables in countries like USA, Canada etc. and is becoming popular in India and other Asian countries also. The kernels of sweet corn taste much sweeter than normal corn especially at 18 to 21 days after pollination. The total sugar content in sweet corn ranges from 25-30%. In addition, fodder derived from harvest may be sold which brings additional income to the farmers. In contrast to the traditional field corn, sweet corn crop is harvested while their corn ear just attained the milky stage.

In Indian agriculture, water is becoming a scarce natural resource particularly due to changing climate. Agriculture is the largest fresh water user, consuming about 83 per cent of the total available water (Lawgali, 2008) [10]. Owing to various reasons, the demand for water for different purposes has been continuously increasing in India, but the potential water available for future use has been decreasing at a faster rate (Saleth and Dinar, 2000) [13]. The demand for water in India is expected to grow @ 2.8% Compounded Annual Growth Rate (CAGR) from 2010 to 2030, facing a supply gap of 50% by 2030. Agriculture would be the worst hit, followed by industries that are heavily dependent on water, such as food processing, beverages, textiles, metals, chemical, paper and leather. The water shortage could result in a six-per cent loss in GDP by 2050 (Nikore and Mittal, 2021) [11]. This indicates us day-after-day population will be increased and available water for agriculture will be decreased, there is a need to increase the food production by efficient use of agricultural inputs especially water and fertilizer.

## Materials and Methods

The field experiment was carried out during r*abi* seasons of 2019-20 and 2020-21 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The area is situated in southern part of Gujarat, which falls under South Saurashtra agro-climatic zone. It lies between the parallels of 20º51' N latitudes and 70º31' E longitudes with an average elevation of 83 meters above mean sea level. The soil of experimental field was clayey in texture having medium in organic carbon content (0.65 and 0.68%), medium in available nitrogen (258 and 254 kg $ha^{-1}$), medium in available phosphorus (28.65 and 30.46 kg $ha^{-1}$) and medium in available potash (196.60 and 194 kg $ha^{-1}$). The trial was laid out in Split Plot Design (SPD) with four replications assigning 9 treatment combinations of three drip irrigation schedules (0.6, 0.8 and 1.0 PEF) in main plots, three nitrogen fertigation levels (75%, 100% and125% RDN through drip fertigation) in sub plot. Sweet corn (Sugar-75) was sown according to 45x20 cm distance with the seed rate of 15 kg $ha^{-1}$. Irrigation and fertilizer application given based on the experimental treatments (RDF 120-60-0 kg N-P-K $ha^{-1}$). Other cultural operations and plant protection measures were applied as need based.

## Results and Discussion

### Effect of drip irrigation schedules

Growth parameters *viz.* plant height at 30, 60 DAS and at harvest (Table 1 and 2), number of internodes per plant (Table 3), green cob and fodder yields (Table 5) were recorded significantly higher when crop was irrigated through drip at 1.0 PEF during 2019-20, 2020-21 and on pooled data basis.

The higher growth parameters and yields were recorded in the drip irrigation scheduled at 1.0 PEF might be due to the significant reduction in plant growth with decreased frequency of irrigation seems to be resultant of water stress, which might have reduced the availability and uptake of water and nutrients. The results are in close accordance with the findings of Basava (2012) [3] and Brar *et al.* (2019) [5].

The positive effect of irrigation on plant growth and sweet corn crop might have responded well to the applied higher irrigation through drip as maize is highly responsive to nutrients and water. The fact that irrigation level increased the availability and maintaining higher soil moisture in the root zone throughout the crop period which reflected in higher relative leaf water content and subsequently in development of yield component and green cob and fodder yields. As water tension increases, the available moisture content decreases and those roots have to exert more energy to get the water from the soil particles. The higher irrigation did not cause water stress at any stage providing favorable conditions for crop growth resulting in increased green cob and fodder yields. Similar response observed by Bozkurt *et al.* (2011) [4], Basava (2012) [3], Patil *et al.* (2011) [12], Brar *et al.* (2019) [5] and Lakshmi *et al.* (2020) [9].

### Effect of fertigation

Growth parameters *viz.* plant height at 30, 60 DAS and at harvest (Table 1 and 2), stem diameter and number of internodes per plant (Table 3), green cob and fodder yields (Table 4) were recorded significantly higher when crop was fertilized with drip fertigation with 125% RDN through drip fertigation during 2019-20, 2020-21 and on pooled data basis.

Ibrahim *et al.* (2016) [8] reported that application of 80% fertilizer dose through fertigation reduced nutrient leaching from the root zone and increased its absorption by the growing plants, compared to the application of the recommended fertilizer dose of 60% through fertigation.

Nitrogen fertigation with more readily available form at more frequent intervals obviously resulted in higher availability of nitrogen in the soil solution which led to higher growth, uptake and better translocation of assimilates from source to sink thus in turn increased the yield (Fanish and Muthukrishnan, 2011) [6]. Similar results were reported by Hassan *et al.* (2010) [7], Basava (2012) [3], Brar *et al.* (2019) [5], Lakshmi *et al.* (2020) [9] and Vineela *et al.* (2021) [14].

**Table 1:** Effect of drip irrigation schedules and nitrogen fertigation levels on plant height of sweet corn (at 30 DAS and 60 DAS)

| | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | At 30 DAS | | | At 60 DAS | | |
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation schedules (I)** | | | | | | |
| I1: Drip irrigation 0.6 PEF | 35.39 | 40.97 | 38.18 | 131.89 | 123.60 | 127.75 |
| I2: Drip irrigation 0.8 PEF | 40.93 | 47.49 | 44.21 | 142.25 | 137.96 | 140.10 |
| I3: Drip irrigation 1.0 PEF | 42.69 | 48.07 | 45.38 | 149.56 | 144.30 | 146.93 |
| S.Em. ± | 1.10 | 1.48 | 0.92 | 2.66 | 3.75 | 2.30 |
| C.D. at 5% | 3.82 | 5.13 | 2.85 | 9.21 | 12.97 | 7.08 |
| C.V. % | 9.64 | 11.28 | 10.63 | 6.53 | 9.60 | 8.15 |
| **Nitrogen fertigation levels (N)** | | | | | | |
| N1: 75% RDN | 35.50 | 41.86 | 38.68 | 129.73 | 124.02 | 126.87 |
| N2: 100% RDN | 40.48 | 46.36 | 43.42 | 145.41 | 138.88 | 142.14 |
| N3: 125% RDN | 43.04 | 48.30 | 45.67 | 148.56 | 142.97 | 145.76 |
| S.Em. ± | 1.09 | 1.18 | 0.81 | 2.35 | 3.35 | 2.05 |
| C.D. at 5% | 3.25 | 3.52 | 2.31 | 6.99 | 9.96 | 5.87 |
| C.V. % | 9.55 | 9.01 | 9.27 | 5.77 | 8.58 | 7.26 |
| **Interaction (IxN)** | | | | | | |
| S.Em. ± | 0.06 | 0.07 | 0.05 | 4.08 | 5.81 | 3.55 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS |

**Table 2:** Effect of drip irrigation schedules and nitrogen fertigation levels on plant height of sweet corn (at harvest)

| Treatments | Plant height (cm) At harvest | | |
|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation schedules (I)** | | | |
| I1: Drip irrigation 0.6 PEF | 160.35 | 157.49 | 158.92 |
| I2: Drip irrigation 0.8 PEF | 178.59 | 174.54 | 176.56 |
| I3: Drip irrigation 1.0 PEF | 184.03 | 176.55 | 180.29 |
| S.Em. ± | 4.42 | 4.48 | 3.15 |
| C.D. at 5% | 15.29 | 15.50 | 9.70 |
| C.V. % | 8.78 | 9.15 | 8.97 |
| **Nitrogen fertigation levels (N)** | | | |
| N1: 75% RDN | 163.41 | 156.01 | 159.71 |
| N2: 100% RDN | 176.70 | 173.31 | 175.00 |
| N3: 125% RDN | 182.86 | 179.27 | 181.07 |
| S.Em. ± | 3.29 | 3.99 | 2.59 |
| C.D. at 5% | 9.78 | 11.87 | 7.42 |
| C.V. % | 6.54 | 8.16 | 7.37 |
| **Interaction (I x N)** | | | |
| S.Em. ± | 5.70 | 6.92 | 4.48 |
| C.D. at 5% | NS | NS | NS |

**Table 3:** Effect of drip irrigation schedules and nitrogen fertigation levels on stem diameter and number of internodes per plant of sweet corn

| | Stem diameter at harvest (cm) | | | Number of internodes per plant | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation schedules (I)** | | | | | | |
| I1: Drip irrigation 0.6 PEF | 2.07 | 2.10 | 2.08 | 6.29 | 6.55 | 6.42 |
| I2: Drip irrigation 0.8 PEF | 2.17 | 2.16 | 2.17 | 7.37 | 7.39 | 7.38 |
| I3: Drip irrigation 1.0 PEF | 2.21 | 2.23 | 2.22 | 7.59 | 7.66 | 7.63 |
| S.Em. ± | 0.06 | 0.06 | 0.04 | 0.21 | 0.22 | 0.15 |
| C.D. (P=0.05) | NS | NS | NS | 0.71 | 0.78 | 0.47 |
| C.V. (%) | 9.49 | 9.85 | 9.67 | 10.05 | 10.82 | 10.45 |
| **Nitrogen fertigation levels (N)** | | | | | | |
| N1: 75% RDN | 2.08 | 2.07 | 2.07 | 6.46 | 6.49 | 6.47 |
| N2: 100% RDN | 2.16 | 2.20 | 2.18 | 7.17 | 7.44 | 7.30 |
| N3: 12% RDN | 2.21 | 2.22 | 2.22 | 7.63 | 7.67 | 7.65 |
| S.Em. ± | 0.04 | 0.04 | 0.03 | 0.18 | 0.19 | 0.13 |
| C.D. at 5% | 0.11 | 0.12 | 0.08 | 0.52 | 0.55 | 0.37 |
| C.V. % | 5.92 | 6.62 | 6.28 | 8.56 | 8.95 | 8.76 |
| **Interaction (I x N)** | | | | | | |
| S.Em. ± | 0.06 | 0.07 | 0.05 | 0.30 | 0.32 | 0.22 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS |

**Table 4:** Effect of drip irrigation schedules and fertigation levels on green cob and fodder yield of sweet corn

| | Green cob yield (kg $ha^{-1}$) | | | Green fodder yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Drip irrigation schedules (I)** | | | | | | |
| I1: Drip irrigation 0.6 PEF | 7198 | 7582 | 7390 | 24356 | 28271 | 26312 |
| I2: Drip irrigation 0.8 PEF | 8332 | 8794 | 8563 | 28793 | 33294 | 31043 |
| I3: Drip irrigation 1.0 PEF | 8382 | 8835 | 8609 | 28892 | 33481 | 31187 |
| S.Em. ± | 272 | 299 | 202 | 1002 | 1098 | 743 |
| C.D. at 5% | 941 | 1035 | 623 | 3468 | 3799 | 2290 |
| C.V. % | 11.82 | 12.33 | 12.09 | 12.70 | 12.00 | 12.34 |
| **Nitrogen fertigation levels (N)** | | | | | | |
| N1: 75% RDN | 7481 | 7728 | 7605 | 25829 | 28303 | 27065 |
| N2: 100% RDN | 8193 | 8675 | 8434 | 28078 | 33365 | 30722 |
| N3: 125% RDN | 8237 | 8808 | 8523 | 28135 | 33378 | 30757 |
| S.Em. ± | 188 | 198 | 137 | 697 | 820 | 538 |
| C.D. at 5% | 559 | 589 | 392 | 2072 | 2436 | 1544 |
| C.V. % | 8.18 | 8.17 | 8.18 | 8.83 | 8.97 | 8.93 |
| **Interaction (I x N)** | | | | | | |
| S.Em. ± | 326 | 343 | 236 | 1208 | 1420 | 932 |
| C.D. at 5% | 968 | 1020 | 679 | 3588 | 4219 | 2673 |

## Interaction effect

The interaction effect between drip irrigation schedules and nitrogen fertigation levels (I X N) on green cob and fodder yields (Table 5 and 6) was found significant during 2019-20, 2020-21 and in pooled results.

**Table 5:** Interaction effect between drip irrigation schedules and nitrogen fertigation levels on green cob yield of sweet corn

| Drip irrigation Nitrogen schedules fertigation | 2019-20 | | | 2020-21 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | I1 | I2 | I3 | I1 | I2 | I3 | I1 | I2 | I3 |
| N1 | 6704 | 7256 | 8480 | 7064 | 7827 | 8294 | 6884 | 7542 | 8389 |
| N2 | 7679 | 8770 | 8132 | 7654 | 8733 | 9637 | 7666 | 8752 | 8884 |
| N3 | 7212 | 8969 | 8531 | 8027 | 9821 | 8575 | 7620 | 9396 | 8553 |
| S.Em. ± | | | 326 | S.Em. ± | | 343 | S.Em. ± | | 237 |
| C.D. (P=0.05) | | | 968 | C.D. (P=0.05) | | 1020 | C.D. (P=0.05) | | 679 |

Application of irrigation through drip at 0.8 PEF and fertilized the crop with 125% RDN through drip fertigation (I2N3) produced significantly maximum green cob yield of 8969 kg ha$^{-1}$during 2019-20 which was remained statistically at par with treatment combination I2N2, I3N3, I3N1 and I3N2during 2019-20. Application of irrigation at 0.6 PEF through drip and fertilized the crop with 75% RDN through fertigation (I1N1) recorded significantly minimum cob yield of 6704 kg ha$^{-1}$during 2019-20.

During the year 2020-21, application of irrigation through drip at 0.8 PEF and fertilized the crop with 125% RDN through drip fertigation (I2N3) produced significantly maximum green cob yield of 9821 kg ha$^{-1}$and which was remained statistically at par with treatment combination I3N2. Significantly minimum cob yield of 7064 kg ha$^{-1}$ was recorded with the application of irrigation at 0.6 PEF through drip and fertilizing the crop with 75% RDN through drip fertigation (I1N1).

Application of irrigation through drip at 0.8 PEF and fertilized the crop with 125% RDN through drip fertigation (I2N3) produced significantly maximum green cob yield of 9396 kg ha$^{-1}$ on pooled data basis and which was remained statistically at par with treatment combination I2N2 and I3N2. Significantly lowest green cob yield of 6884 kg ha$^{-1}$ was recorded with application of irrigation at 0.6 PEF through drip and application of 75% RDN through drip fertigation (I1N1).

**Table 6:** Interaction effect between drip irrigation schedules and fertigation levels on green fodder yield of sweet corn

| Drip irrigation Nitrogen schedules fertigation | 2019-20 | | | 2020-21 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | I1 | I2 | I3 | I1 | I2 | I3 | I1 | I2 | I3 |
| N1 | 22174 | 28868 | 26443 | 27692 | 29224 | 27992 | 24935 | 29045 | 27218 |
| N2 | 26017 | 31017 | 27204 | 28178 | 36897 | 35021 | 27097 | 33957 | 31110 |
| N3 | 24875 | 26496 | 33036 | 28942 | 33761 | 37432 | 26908 | 30128 | 35234 |
| S.Em. ± | | | 1208 | S.Em. ± | | 1420 | S.Em. ± | | 932 |
| C.D. at 5% | | | 3588 | C.D. at 5% | | 4219 | C.D. at 5% | | 2673 |

Significantly maximum green fodder yield of 33036 kg ha$^{-1}$ during 2019-20 (Table 6) was recorded with irrigating the crop through drip at 1.0 PEF and fertilizing with the 125% RDN through drip fertigation (I3N3) and it was found on par with I2N2 (drip irrigation at 0.8 PEF with drip fertigation of 100% RDN). The treatment combination I1N1 recorded significantly lower fodder yield of 22174 kg ha$^{-1}$.

Application of drip irrigation at 1.0 PEF and fertilizing the crop with 125% RDN through drip fertigation recorded significantly maximum green fodder yield of 37432 kg ha$^{-1}$ (Table 6) and it was found at par with treatment combination I2N2, I2N3 and I3N2 during 2020-21. Significantly lower green fodder yield was found with application of drip irrigation at 0.6 PEF with fertigation of 75% RDN (27692 kg ha$^{-1}$) being at par with I1N2, I1N3, I2N1 and I3N1.

Significantly maximum green fodder yield of 35234 kg ha$^{-1}$ on pooled data basis was recorded with irrigating the crop through drip at 1.0 PEF and fertilizing the crop with the 125% RDN through drip fertigation (I3N3) and it was found on par with treatment combination I2N2 (drip irrigation at 0.8 PEF with fertigation of 100% RDN) on pooled results basis (Table 6).

Treatment combination I1N1 recorded significantly lower green fodder yield of 24935 kg ha$^{-1}$ but it was found on par with I1N2, I1N2 and I3N1.

This might be due to frequent supply of nutrients in the active rooting area of the crop. Frequent application of water and nutrients in drip fertigation remained in direct contact with root system with negligible losses through leaching Brar *et al.* (2019) [5]. Similar results was reported by Basava (2012) [3] and Ibrahim *et al.* (2016) [8].

## Conclusion

Based on the results of two year experimentation, it can be concluded that for getting higher green cob yield, net realization and sustaining soil fertility sweet corn crop should be applied two common surface irrigation (first immediately after sowing and second 7 days after first irrigation) followed by irrigation scheduled through drip at 0.8 PEF (operating pressure- 1.2 kg cm$^2$ and lateral spacing - 90 cm) at an alternate day and crop should be fertilized with 100% RDN, out of which, 50% RDN as basal and remaining 50% RDN in five equal splits at 10 days through fertigation started from 30 DAS.

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