Assessing the Effect of Different Irrigation Regimes on Crop Performance of Brinjal (*Solanum melongena* L.)

ABSTRACT

This study investigated the effect of different irrigation on performance of brinjal to find the optimum IW: ETc ratio. This studywas laid out in research farm near Agrometeorological observatory, B. A. College of Agriculture, AAU, Anand (Gujarat), India during 2023-2024. The soil of the experiment field was loamy sand. The experiment utilized a Randomized Block Design to examine the influence of the IW: ETC ratio (I) on crop performance. The plot treatments consisted of five irrigation level IW: ETc ratios: I1 with a ratio of 1.00, I2 with a ratio of 0.80, I3 with a ratio of 0.60, I4 with a ratio of 0.40, and I5 following the recommended irrigation practices. Plant height, number of leaves, number of branches, leaf area index (LAI), dry weight of plant (g plant-1) were measured from three randomly selected plants from each plot at 30 days intervals after 30 DAT up to harvest. Number of fruit, fresh weight of fruit, yield were measured in each picking. The result showed that the significantly highest plant height was observed in the I1 treatment while the lowest was the I4 treatment. The highest number of leaves and branches were observed in I1  and significantly lowest was observed in I4. Fresh weight of fruit was highest in I1  and lowest in I4 . Biomass was highest in I1 (184.49 gm) and lowest 140.41gm was recorded in I4.Significantly highest Leaf area index (LAI) was recorded in I1 (3.98) and the lowest was recorded in I4 (2.60). The number of fruit per plant and fruit diameter were highest and lowest were observed in I1 and I4. No significant difference was observed in the harvest index (HI) of the brinjal crop. Fruit yield was significantly highest in I1 (55.35 t ha-1) and lowest was recorded in I4 (30.18 t ha-1).

Key word; Irrigation, IW: ETc ratio, Brinjal, Plant growth components

**Introduction**

Brinjal (*Solanum melongena* L.) is an important traditional vegetable crop in many tropical, subtropical and Mediterranean countries. Brinjal also known as aubergine, guinea squash or eggplant is an economically valuable crop grown worldwide. Brinjal belongs to the family Solanaceae. There are 3 main botanical varieties under the species melongena (Choudhary, 1976). The unripe brinjal fruit is commonly eaten as a cooked vegetable in diverse preparations and its dried shoots serve as a fuel source in rural areas. With low calorie and fat content it is primarily composed of water, protein, fiber, and carbohydrates. Brinjal is a valuable reservoir of minerals and vitamins containing a high concentration of total water-soluble sugars, free-reducing sugars and amide protein among other essential nutrients (Bajaj *et al.,* 1979). The bitterness in brinjal arise from the presence of glycoalkaloids which are widespread in plants of the Solanaceae family (Bajaj et al., 1981). It also contains β-carotene (34 mg), riboflavin (0.05 mg), thiamine (0.05 mg), niacine (0.5 mg) and ascorbic acid (0.9 mg) per 100 g of fruit. India is a hub for the diverse varieties of brinjal and it recommended for patients with diabetes, asthma, cholera, and bronchitis. (Praneetha, 2018). As per the report brinjal fruit contains moisture 92.7g, protein 1.4g, minerals 0.3g, fiber 1.3g, carbohydrate 4.0g, oxalic acid 18mg, phosphorus 47mg, iron 0.9mg, vitamin C 10mg, (Palia et al., 2021 ).

Brinjal can be grown throughout the year but it thrives best during the winter season. A daily mean temperature of 13 to 21 °C is most favorable for better growth and yield of brinjal. Brinjal seeds germinate well at 25°C. The optimum temperature range for fruit set in brinjal is 18-21°C (Santhiya *et al.,* 2019). To attain a substantial crop output it is essential to ensure a sufficient water source throughout the cultivation period. The initial phase of the flowering stage is particularly susceptible to water scarcity and optimal yields are achieved through comprehensive irrigation. In general, nearly maximum yields are obtained when irrigation is applied to ensure ample water supply during both the flowering and fruit formation stages (Amiri *et al*., 2012). Crop evapotranspiration (ETc) is computed based on the crop coefficient (Kc) values concerning the evapotranspiration (ETo) as a fundamental measure (Doorenbos and Pruitt, 1975). Tyagi et al. (2000) established crop coefficients specific to wheat and maize by analyzing ETc measurements and weather data in Karnal. Precision in water application considering the accurate amount and timing is crucial for scheduling irrigations to fulfill the water use demands of crops and achieve optimal crop production. The estimation of crop water requirements (ETc) stands as a key element in the planning, design and operation of irrigation systems (Rowshon *et al*.,2013). The efficient utilization of water is crucial due to the diminishing water resources and growing food demands, whether in rainfed or irrigated agriculture. Regulated deficit irrigation proves to be a method that conserves water while still ensuring satisfactory crop yields. Models serve as valuable tools in identifying practical approaches to optimize crop growth when facing water scarcity.

**2. Materials and methods**

**2.1 Study area**

 An experimental study took place at the Agricultural Meteorology farm of B. A. College of Agriculture, AAU, Anand located at a latitude of 22°35’ N and a longitude of 72°55’ E at an altitude of 45.1 meters above mean sea level. Anand located in Gujarat, India, experiences a semi-arid climate characterized by hot and dry summers with high temperatures above 40°C during the peak months of May and June and minimum temperature 10 to 25 °C.

**2.2 Experimental design and layout**

A single factor experiment was set up in a Randomized Block Design (RBD) with four replication. The experiment consisted five treatments ratio of I1, I2, I3, I4 and I5 representing 100, 80, 60, 40% IW:ETc level and recommend irrigation practices. The experiment was conducted during October to March 2023- 24. Surface flood irrigation water quantity was measured using a 7.5 cm head Parshall flume. Subsequently a fixed depth of 50 mm of irrigation water was applied to each treatment according to the prescribed IW: ETc ratios and recommended irrigation. Daily weather data *viz*. maximum and minimum temperature, relative humidity, rainfall, pan evaporation, bright sunshine hours and wind speed were collected from an Agrometeorological observatory located near the experimental plot.

**2.3 Reference evapotranspiration (ETo)**

 Penman-Monteith method (Allen *et al*., 1998) was used for the computation of reference evapotranspiration (ETo). Each parameter was required for the calculation of ETo was calculated using a program developed in MS Excel sheet. The details of the procedure adopted for calculation are described as under.

ETo= $\frac{0.408Δ \left(R\_{n}-G\right)+λ\frac{900}{T\_{a}+273 }U\_{2}(e\_{s}-e\_{a})}{Δ+λ(1+0.34U\_{2})}$

Where,

ETo is reference evapotranspiration (mm day-1)

Rn is net radiation at the crop surface (MJ m-2 day-1)

 G is soil heat flux density (MJ m-2 day-1)

Ta is the mean daily air temperature (°C)

U2 is wind speed at 2 m height (m s-1)

es is saturation vapor pressure (k Pa)

ea is actual vapor pressure (k Pa)

es – ea is saturation vapor pressure deficit (k Pa)

Δ is the slope saturation vapor pressure curve (k Pa °C-1)

λ is psychrometric constant (k Pa °C-1)

**2.4 Crop water requirement (ETc)**

The crop evapotranspiration differs distinctly from the reference evapotranspiration (ETo) as the ground cover canopy properties and aerodynamic resistance of the crop are different from grass. The difference in evaporation and transpiration between both surfaces was combined into a single coefficient Kc. In the present study crop coefficient approach was used for the computation of crop water requirements (Doorenbos and Pruitt, 1975).

ETc = Kc × ETo

Where,

ETc is crop evapotranspiration/Crop water requirement (mm day-1)

ETo is reference evapotranspiration (mm day-1)

Kc is crop coefficient

**Table 1 Kc value in different growth stages**

|  |  |  |  |
| --- | --- | --- | --- |
| **Crop stages** | **Initial** | **Development** | **late** |
| **Kc value** | 0.55 | 1.20 | 0.85 |
| **Days** | 30 | 85 | 39 |

Kaswan *et al.* (2021)

**2.5 IW: ETc ratio**

 The ETc formula used to find out daily IW: ETc for irrigation application.

**2.6** **Statistical analysis**

Data on different aspects of brinjal was subjected to statistical analysis as per procedure of Randomized Block Design (Panse and Sukhatme, 1985). For accurate interpretation, the data were statistically analyzed for all of the characters. The data were analyzed in RBD by the Department of Agricultural Statistics, B. A. College of Agriculture, AAU, Anand.

**3 RESULTS AND DISCUSSION**

**3.1 Plant height**

The data on mean plant height for brinjal (*Solanum melongena*) influenced by various irrigation levels at different growth stages is presented in Table 2.

**Table 2** **Effect of different IW: ETc treatments on plant height of brinjal (cm)**

|  |  |
| --- | --- |
| **Treatments** | **Plant height (cm)** |
| **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 25.6 | 48.0 | 77.1 | 82.4 | 81.3 |
| **I2 (0.80 IW:ETc)** | 24.4 | 44.2 | 62.9 | 71.9 | 71.3 |
| **I3 (0.60 IW:ETc)** | 23.2 | 43.2 | 57.2 | 64.7 | 67.9 |
| **I4 (0.40 IW:ETc)** | 24.9 | 40.1 | 52.8 | 62.3 | 63.0 |
| **I5 (RP)** | 26.9 | 47.3 | 71.1 | 76.2 | 77.4 |
| **SE.m.±** | 0.81 | 1.71 | 4.27 | 3.53 | 3.74 |
| **CD at 5%** | NS | 5.28 | 13.16 | 10.90 | 11.54 |
| **CV %** | 6.48 | 7.68 | 13.29 | 9.88 | 10.37 |

Generally, as the irrigation level increased there was a corresponding increase in plant height at each growth stage. At 30 DAT the differences in plant height were non-significant likely due to uniform irrigation up to 30 days after transplanting. The results indicated that I1 (1.00 ETc) treatment was superior over all the treatments and recorded the highest plant height of 82.4 cm at 135 DAT and slightly decreased to 81.3 cm at harvest. Conversely, I4 (0.40 ETc) observed significantly the lowest plant height throughout most growth stages, with a final height of 63.0 cm at harvest. These findings align with Ughade and Mahadkar (2015) and Gencoglan and Gencoglan (2021).

Labdelli *et al.* (2014) reported that plant height was reduced due to water stress which can occur by slowing down cell division or indirectly by retarding the speed of growth. Kumar *et al.* (2019) also observed that plant cell elongation is usually limited when there is a lack of water because the water passage from the xylem to the nearby elongating cells is cut off. This could explain why plant height decreased with an increase in water stress.

**3.2 Number of Leaves per Plant**

Table 3 presents data on the number of leaves per plant for brinjal (*Solanum melongena*) under various irrigation levels at different growth stages. As the irrigation levels increased, the number of leaves also increased at each stage of growth. Significant differences in leaf numbers among the treatments were observed from 60 DAT onward. Treatment I1 (1.00 ETc) showed significantly the highest leaf number reaching a maximum of 97.2 leaves during 120 DAT and slightly decreasing to 96.0 at harvest. On the other hand, I4 (0.40 ETc) significantly observed the lowest leaf number throughout most growth stages with 74.7 leaves at harvest.

**Table 3 Effect of different IW: ETc treatments on number of leaves plant -1of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Number of leaves plant -1** |
| **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 36.2 | 62.0 | 82.2 | 97.2 | 96.0 |
| **I2 (0.80 IW:ETc)** | 35.2 | 56.9 | 71.2 | 83.0 | 80.7 |
| **I3 (0.60 IW:ETc)** | 34.9 | 53.8 | 66.0 | 82.0 | 78.7 |
| **I4 (0.40 IW:ETc)** | 34.7 | 49.2 | 59.5 | 75.5 | 74.7 |
| **I5 (RP)** | 38.8 | 58.1 | 80.7 | 93.0 | 93.7 |
| **SE.m.±** | 1.02 | 2.38 | 4.64 | 4.42 | 4.81 |
| **CD at 5%** | NS | 7.33 | 14.30 | 13.62 | 14.83 |
| **CV %** | 5.68 | 8.48 | 12.90 | 10.26 | 11.35 |

This result aligns with the findings of Ughade and Mahadkar (2015) which showed that the highest number of leaves per plant was observed with the 1.00 ETc irrigation treatments in brinjal. Similarly, Fawzy *et al*. (2019) found that applying irrigation water at 100% ETo resulted in the highest significant number of leaves per plant in tomato.

**3.3 Number of Branches per Plant**

The number of branches per plant for different irrigation treatments at various growth stages to until harvest, is presented in Table 4. I1 consistently observed significantly the highest number of branches per plant with reach a maximum of 15.2 branches at 105 DAT and decreasing to 12.8 at harvest. Conversely, I4 recorded significantly the lowest number of branches throughout the growth stages with 9.2 branches at harvest. Abdelhady *et al*. (2017) also reported a similar result for tomato.

 **Table 4 Effect of different IW: ETc treatments on number of branches plant -1 of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Number of branches plant-1** |
| **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 7.1 | 12.0 | 14.3 | 15.2 | 12.8 |
| **I2 (0.80 IW:ETc)** | 7.0 | 10.4 | 12.5 | 13.0 | 11.0 |
| **I3 (0.60 IW:ETc)** | 6.9 | 10.1 | 11.5 | 11.5 | 9.9 |
| **I4 (0.40 IW:ETc)** | 6.7 | 9.4 | 10.4 | 10.7 | 9.2 |
| **I5 (RP)** | 7.5 | 11.1 | 13.6 | 14.2 | 11.3 |
| **SE.m.±** | 0.27 | 0.46 | 0.77 | 0.86 | 0.74 |
| **CD at 5%** | NS | 1.42 | 2.37 | 2.64 | 2.26 |
| **CV %** | 7.68 | 8.68 | 12.28 | 13.21 | 13.50 |

**3.4 Fresh Weight of Fruit (g)**

The impact of varying irrigation levels on the average fresh weight of fruit is presented in Table 5. The irrigation treatments (I1 to I5) showed significant variations in fruit weight over time. The data shows that significantly highest fresh weight of fruit per plant was recorded in the treatment I1 (54.5 g), and lowest fresh weight was recorded in the treatment I4 (37.7 g). Treatment I2 recorded 48.6 g fruit plant-1 which was at par with the treatment I3. This is consistent with findings from other studies such as those by Diaz-Perez and Eaton (2015) and Dermirel *et al.* (2014) which reported that reduced irrigation levels lead to lower fruit yield and weight.

**Table 5 Effect of different IW: ETc treatments on fresh weight of fruit plant -1 of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Fresh weight of fruit plant-1 (g)** |
| **70 DAT** | **100 DAT** | **130 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 51.0 | 51.7 | 52.1 | 54.5 |
| **I2 (0.80 IW:ETc)** | 48.5 | 48.5 | 44.2 | 47.3 |
| **I3 (0.60 IW:ETc)** | 47.0 | 46.4 | 41.6 | 44.5 |
| **I4 (0.40 IW:ETc)** | 45.0 | 37.7 | 38.0 | 41.2 |
| **I5 (RP)** | 55.5 | 52.9 | 47.4 | 51.1 |
| **SE.m.±** | 2.06 | 2.81 | 2.65 | 2.58 |
| **CD at 5%** | 6.36 | 8.66 | 8.18 | 7.94 |
| **CV %** | 8.35 | 11.84 | 11.87 | 10.78 |

**3.5 Dry Weight of Plant (g plant-1)**

The results in Table 6 indicated that different irrigation levels significantly affected the dry weight of plants at various growth stages and at harvest. The significantly highest dry weight of plant was recorded under treatment I1 (1.0 IW: ETc) of 184.4 g plant-1 and significantly lowest dry weight of plant was observed under I4 treatment of 140.4 g plant-1. Treatment I2 was at par with the treatment I3. Similar finding was supporting by Abdalla *et al,* (2018) they concluded that irrigation treatment significantly effect on dry weight of brinjal.

**Table 6 Effect of different IW: ETc treatments on dry weight plant-1 of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Dry weight of plant (g plant-1)** |
| **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 21.9 | 50.4 | 129.7 | 184.4 | 167.8 |
| **I2 (0.80 IW:ETc)** | 19.9 | 47.7 | 110.8 | 153.7 | 138.4 |
| **I3 (0.60 IW:ETc)** | 19.1 | 45.1 | 107.8 | 146.2 | 130.9 |
| **I4 (0.40 IW:ETc)** | 19.3 | 43.4 | 102.6 | 140.4 | 120.1 |
| **I5 (RP)** | 20.4 | 49.4 | 120.7 | 176.0 | 151.7 |
| **SE.m.±** | 0.63 | 1.60 | 5.72 | 8.48 | 9.00 |
| **CD at 5%** | NS | 4.94 | 17.62 | 26.13 | 27.75 |
| **CV %** | 6.24 | 6.78 | 10.00 | 10.59 | 12.70 |

**3.6 Leaf Area Index**

The variation in leaf area index (LAI) for different irrigation treatments has been observed over time from 30 DAT to harvest. The LAI values for each irrigation level were presented in Fig. 1. The LAI was relatively low during the early vegetative growth period up to 45 DAT across all treatments. The canopy developed gradually increase with the progress of the crop age in all treatments. That corresponds to the period of maximum canopy development. The result shows that significantly the highest LAI was recorded under treatment I1 of 3.98. . Treatment I4 recorded the significantly lowest LAI 2.6. This observation aligns with findings from Karaca and Buyuktas (2021) and Colak *et al.* (2015).

**Fig. 1 Effect of different IW: ETc treatments on leaf area index of brinjal**

**3.7 Number of Fruit per Plant**

**Table 7 Effect of different IW: ETc treatments on the number of fruits per plant of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Number of fruit per plant** |
| **70 DAT** | **100 DAT** | **130 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 5.8 | 12.1 | 20.7 | 19.5 |
| **I2 (0.80 IW:ETc)** | 5.2 | 10.0 | 17.1 | 16.7 |
| **I3 (0.60 IW:ETc)** | 5.2 | 10.3 | 16.0 | 15.7 |
| **I4 (0.40 IW:ETc)** | 5.4 | 9.7 | 14.3 | 14.5 |
| **I5 (RP)** | 6.0 | 11.6 | 19.3 | 18.7 |
| **SE.m.±** | 0.19 | 0.51 | 3.43 | 0.99 |
| **CD at 5%** | 0.58 | 1.59 | 1.11 | 3.07 |
| **CV %** | 6.84 | 9.57 | 12.70 | 11.67 |

The number of fruits per plant was observed under different irrigation treatments over several DAT and at harvest as shown in Table 7. The treatment I­1 was superior over all the treatments and observed the significantly highest number of fruits per plant reaching up to 20.7 fruits per plant. In contrast the I4 resulted significantly lowest number of fruits per plant with values as low as 14.3 fruits. These results align with the findings of Rehman *et al.* (2019) who reported that the growth and yield characteristics of brinjal cultivars varied significantly in response to water stress.

**3.8 Fruit Diameter of Brinjal (cm)**

The result presented in Table 8 indicated that the application of irrigation significantly influenced the fruit diameter at different irrigation levels. The data showed that I1 recorded significantly highest fruit diameter during 115 DAT of 5.45 cm which was at par with the treatment I5. Treatment I2 recorded 4.89 during 115 DAT which at par with treatment I3. Significantly lowest fruit diameter was observed under I4 treatment 3.94 cm. The findings of this study are supported by AlSelwey (2021) and Uddina *et al.* (2016).

**Table 8 Effect of different IW : ETc treatments on fruit diameter of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Fruit diameter (cm)**  |
| **70 DAT** | **100 DAT** | **130 DAT** | **At harvest** |
| **I1 (1.00 IW:ETc)** | 4.94 | 5.19 | 5.01 | 5.17 |
| **I2 (0.80 IW:ETc)** | 4.85 | 4.87 | 4.41 | 4.60 |
| **I3 (0.60 IW:ETc)** | 4.60 | 4.74 | 4.25 | 4.15 |
| **I4 (0.40 IW:ETc)** | 4.36 | 4.13 | 3.94 | 4.15 |
| **I5 (RP)** | 5.06 | 5.17 | 4.98 | 5.03 |
| **SE.m.±** | 0.13 | 0.21 | 0.22 | 0.23 |
| **CD at 5%** | 0.40 | 0.64 | 0.67 | 0.71 |
| **CV %** | 5.45 | 8.59 | 9.66 | 9.94 |

**3.9 Harvest Index (HI) of Brinjal**

The data on the harvest index presented in Fig.2 found that there were no significant differences among the treatments for harvest index. Fig. 2 shows that the harvest index in treatment I1 was 50.39 and slightly decreased to 47.95 in treatment I4 indicating no significant difference between these treatments. The result support with the findings of Koundinya *et al.* (2017) who reported a harvest index for different genotypes of brinjal ranging from 43.0 to 62.0.

**Fig. 2 Effect of different IW: ETc treatments on harvest index (HI) of brinjal**

**3.10 Yield**

Different irrigation levels significantly influenced the yield of the crop presented in Table 9. The maximum yield (55.35 t ha-1) was recorded under treatment I1 (1.00 ETc) which was significantly superior over other irrigation treatments and at par with the treatment I5 (as per recommended irrigation). Treatment I5 recorded 54.88 t ha-1 yield. Treatment I2 (0.80 ETc) produced 42.74 t ha-1 yield, which was statistically at par with irrigation level I3 (0.60 ETc) producing the yield (38.14 t ha-1). The irrigation level I4 (0.40 ETc) significantly recorded the lowest yield of 30.18t ha-1 demonstrating a significant decrease in yield with reduced irrigation levels.

**Table 9 Effect of different IW: ETc treatments on total fruit yield of brinjal**

|  |  |
| --- | --- |
| **Treatments** | **Yield** |
| **t ha-1** |
| **I1 (1.00 IW:ETc)** | 55.3 |
| **I2 (0.80 IW:ETc)** | 42.7 |
| **I3 (0.60 IW:ETc)** | 38.1 |
| **I4 (0.40 IW:ETc)** | 30.1 |
| **I5 (RP)** | 54.8 |
| **SE.m.±** | 2.6 |
| **CD at 5%** | 12.17 |
| **CV %** | 12.18 |

**Conclusion**

The findings indicate that higher irrigation levels significantly enhance plant height, number of leaves, number of branch per plant and overall biomass. Optimal irrigation (I1: 1.00 IW: ETc) consistently resulted in superior plant growth, higher fresh weights of fruit, LAI, number of fruit per plant and the highest yield demonstrating the crucial role of adequate water supply in brinjal cultivation. Reduced irrigation levels (I4: 0.40 IW: ETc) led to significantly lower plant performance and yield. The I1 treatment (1.00 IW: ETc) emerged as the most effective irrigation strategy, balancing water usage and maximizing yield. These findings provide valuable guidelines for irrigation scheduling in brinjal cultivation, emphasizing the need for optimal water management to achieve higher yields and efficient resource utilization.

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