



## **Influence of Deficit Irrigation on Biometric Parameters of Capsicum Crop under Polyhouse Conditions**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author JTR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GMK, HVHK and PS managed the analyses of the study. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/IRJPAC/2020/v21i2430375

#### Editor(s):

(1) Prof. Bengi Uslu, Ankara University, Turkey.

#### Reviewers:

(1) Lina Farah, Lebanese University, Lebanon.

(2) Entesar Mhamad Ghazal, University of Mosul, Iraq.

(3) R. Sivakumar, Tamil Nadu Agricultural University, India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/65778>

**Original Research Article**

**Received 24 October 2020**

**Accepted 28 December 2020**

**Published 31 December 2020**

### **ABSTRACT**

The influence of different deficit irrigations on capsicum crop biometric parameters and fruit yield were assessed in an experiment the variety 'Indra' was tested using completely randomized block design with three deficit irrigations (0.50, 0.75 and 1.0 ET<sub>C</sub>) and 5 replications in polyhouse and 1.0 ET<sub>C</sub> in open field conditions. The biometric parameters namely plant height, number of leaves, number of branches, number of days to flowering; number of days to harvesting, number of fruits per plant, individual fruit weight and fruit yield are measured. From the results, observed that, average of plant height (91.23 cm), number of leaves (91.3), number of branches (6.9), number of days to flowering (32.7), number of days to harvest (71), fruit number per plant (7), individual fruit

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weight (75.99 g) and yield (6466.66 t ha<sup>-1</sup>) parameters found higher in 1.0 ET<sub>c</sub> (T1), but in case of water productivity (12.4 kg ha<sup>-1</sup> mm<sup>-1</sup>) in the treatment (T2) 0.75 ET<sub>c</sub> showed superiority. From the results, it is determined that by adopting the 0.75 ET<sub>c</sub> (T2) we can save the water up to 25%.

**Aims:** The objective of this study is to evaluate the influence of deficit irrigation in biometric parameters of capsicum.

**Study Design:** Completely randomized block design.

**Place and Duration of Study:** Experiment conducted during January to May 2018 at Agriculture farm, College of Agricultural Engineering, Madakasira located in Rayalaseema region.

**Methodology:** Physical and chemical properties of field were found by using standard methods. The experiment was arranged using CRD design with three levels of irrigation and five replications. Fertigation was done with 250:150:150 kg/ha recommended doses of N:P:K to capsicum crop. Based on climatological approach (evapotranspiration basis) the quantity of water applied. All the recommended cultural practices selection of cultivars, nursery raising, land preparation, laying drip lines, fumigation, fertilizer application, transplanting, pruning, training and plant protection measures are removing affected plant parts, flowers, fruits and for thrips and aphids management are dicofol (2 ml/L) and imidacloprid (0.5 ml/l) standardized for polyhouse were followed time to time to ensure a healthy crop stand. Crop water requirement was determined by using AquaCrop model. The parameters viz., plant height, number of leaves per plant and number of branches per plant were recorded at 30, 60, 90, 120 days after transplanting and at harvest. The collected data of different parameters during the course of research were analysed as per the completely randomized design (CRD) by applying the technique of analysis of variance procedure.

**Results:** Among all the treatments, Irrigation with 100% Crop Evapotranspiration (1.0 ET<sub>c</sub>) (T1) registered the highest plant height, number of leaves, number of branches, number of days required to harvesting, number of days required to flowering, fruit number, average fruit weight and fruit yield, followed by 0.75 ET<sub>c</sub> (T2), 0.5 ET<sub>c</sub> (T3) and open field conditions. This might be due to good soil moisture distribution in drip irrigation compared to the open field. From the observed parameters it is exhibited that drip irrigation 0.75 ET<sub>c</sub> recorded as the higher water productivity (12.4 kg ha<sup>-1</sup> mm<sup>-1</sup>) followed by drip irrigation scheduled at 1.0 ET<sub>c</sub> (11.49 kg ha<sup>-1</sup> mm<sup>-1</sup>), 0.5 ET<sub>c</sub> (11.07 kg ha<sup>-1</sup> mm<sup>-1</sup>) and open field (1.38 kg ha<sup>-1</sup> mm<sup>-1</sup>) recorded very less.

**Conclusion:** By adopting T2 (0.75 ET<sub>c</sub>) irrigation treatment we can save the water up to 25%, by using saved water additional quantity of vegetables can be produced.

**Keywords:** Deficit irrigation; drip irrigation; capsicum and biometric parameters.

## 1. INTRODUCTION

Capsicum (*Capsicum annuum* L.) is also called bell pepper and sweet pepper, is the utmost common and extremely valuable yearly herbaceous vegetable crops [1]. Due to change in the climate, open field cultivation is not possible because of huge variation in the rainfall, humidity, temperature and wind speed etc., which affect the production of vegetables [2,3]. It is the most and important vegetable is growing after Tomato in humid and sub-humid climates [4].

The productivity on irrigated land is higher as compared to the un-irrigated land. Multiple cropping is not possible in India because the rainy season is specific in most of the regions. However, the climate supports cultivation throughout the year. Irrigation facilities make it possible to grow more than one crop in most of the areas of the country. Irrigation has helped to

bring most of the fallow land under cultivation. Irrigation has stabilized the output and yield levels. Irrigation increases the availability of water supply, which in turn increases the income of the farmers.

Deficit irrigation is one of the widely using water saving approach. Compared to full-irrigated crop deficit irrigation can be increases the water use efficiency and yield [5]. Deficit irrigation can help the reduction of cost of production, but it can also save the water and decreasing percolating of nutrients and pesticides into ground water [6]. Nevertheless, before applying such an approach for all crops, there is a necessity to know the drawbacks and benefits of deficit irrigation, particularly for water stress delicate crops like *Capsicum* species. Deficit irrigation can save the water up to 20% compared to full irrigation [7,8].

Therefore, the quantity of water that are accessible for agriculture is usually inadequate

all around the world, the information about the affiliation between irrigation managements, product quality and yield is significant to increase benefit of the available water supply. So, the present experiment was started to know the effect of deficit irrigation on growth parameters and yield parameters of capsicum crop.

## 2. MATERIALS AND METHODS

To evaluate the influence of deficit irrigation on biometric parameters of capsicum the field experiment was conducted at Agriculture Farm, College of Agricultural Engineering, Madakasira during January to May 2018 in naturally ventilated polyhouse. The location of the study area is located at latitude of 13°94' 56.89' N and longitude of 77°18' 42' E with sea level of 646 m. Capsicum crop were grown in polyhouse as well as open field conditions.

Physical and chemical properties of field were found by using standard methods. The soil of the experimental site was silt loam soil. Composite soil samples drawn from the experimental site were analyzed. The soil of the experimental site was neutral in reaction pH of 7.35 and electrical conductivity (0.43 dS/m). The water samples were analyzed for different chemical properties like pH, EC and TDS. The irrigation water contains pH is 7.21, EC is 1.367 dS/m and TDS is 882.5 mg/lit. This irrigated water is within the safe limit [9].

### 2.1 Experimental Design

The experiment was arranged using CRD design with three levels of irrigation and five replications. Fertigation was done with 250:150:150 kg/ha recommended Doses of N:P:K to capsicum crop. There were three treatments of irrigations and open field condition; i.e., T<sub>1</sub>: Irrigation with 100% Crop Evapotranspiration (1.0 ET<sub>c</sub>), T<sub>2</sub>: Irrigation with 75% Crop Evapotranspiration (0.75 ET<sub>c</sub>), T<sub>3</sub>: Irrigation with 50% Crop Evapotranspiration (0.50 ET<sub>c</sub>) and in the open field Irrigation with 100% Crop Evapotranspiration (1.0 ET<sub>c</sub>). Seedlings of 30 days age were transplanted with spacing of 50 cm X 40 cm in raised beds of 2.67 m X 4.5 m in the month of January 2018. Each block was separated by 0.5 m and raised bed width is 0.9 m to reduce lateral movement of water of the treatment. On each bed, two drip laterals were installed. Emitter covers with a distance of 30 cm. The operation time of drip irrigation system was controlled by control valve. Throughout the growing season, irrigation water was applied

using drip irrigation system according to treatment. Based on climatological approach (evapotranspiration basis) the quantity of water were applied. To supply desired quantity of water for each plot, the discharge per minute was calculated to fix the irrigation time. All the recommended cultural practices and plant protection measures standardized for polyhouse were followed time to time to ensure a healthy crop stand [3]. Crop water requirement was determined by using AquaCrop model.

### 2.2 Biometric Data Collection and Statistical Analysis

The observations were noted related to different crop parameters viz., plant height, number of leaves per plant, number of branches per plant as mentioned already above. The number of days required to harvesting, number of days required to flowering, fruit number, average fruit weight and fruit yield are measured recorded on 5 randomly selected plants from each treatment plot.

The collected data of different parameters during the course of research were analyzed as per the completely randomized design by applying the technique of analysis of variance procedure suggested by Gomez and Gomez [10]. The ANOVA was made at 5% level of significance to know if significant changes existed among different treatments.

## 3. RESULTS AND DISCUSSION

Among the treatments, Irrigation with 100% Crop Evapotranspiration (1.0 ET<sub>c</sub>) gave the highest plant height, number of leaves, number of branches, number of days required to harvesting, number of days required to flowering, fruit number, average fruit weight and fruit yield, followed by 0.75 ET<sub>c</sub> (T<sub>2</sub>), 0.5 ET<sub>c</sub> (T<sub>3</sub>) and open field conditions. This may be due to good soil moisture distribution in drip irrigation compared to the open field.

### 3.1 Plant Height

Plant height is significantly influenced by different irrigations at 30 DAT, 60 DAT, 90 DAT, 120 DAT and at harvest. This might be due to maximum uptake of nutrients resulting in better availability of sufficient quantity of nutrients and continuous wetting by drip irrigation. The average plant height in different treatments is shown in the Table 1. The plant height in the 0.75 ET<sub>c</sub> (T<sub>2</sub>)

drip irrigation was almost equal to the 1.0 ET<sub>C</sub> (27.79 cm) 30 and 90 DAT drip irrigation. The results obtained are compatible with the findings published by [11], which indicates that constant availability of soil moisture in the root zone is conducive to improved nutrient intake, and aeration in turn improve plant height.

### 3.2 Number of Leaves and Number of Branches

Due to various irrigation treatments at all stages of cultivation, the number of capsicum leaves varied greatly. The maximum number of leaves per plant (91.8) and number of branches (6.9) were reached in T1 at harvest among the different treatments. This may be attributed to the number of branches and the favourable weather parameters that has prevailed within the polyhouse that has favoured increased plant growth; similar findings have been achieved in pepper [4]. Maximum number of leaves and branches at higher fertigation may be attributed to better availability of sufficient quantity of nutrients especially the applied higher dosage of N responsible for cell division and cell elongation during the vegetative growth. It may be also due to increased nutrient availability through fertigation resulting in better nutrient uptake and increased photosynthetic activity leading to

bigger sized leaves. The following Table 2. shows the effect of irrigation treatment on number of leaves and number of branches in capsicum under naturally ventilated polyhouse and open field conditions.

### 3.3 Number of Days to Flowering and Number of Days to Harvest

The treatment T1 (1.0 ET<sub>C</sub>) took minimum days (33.2) for first flower appearance. However open field cultivation was taken maximum number of days (54.5) to first flower appearance. The treatment T1 (1.0 ET<sub>C</sub>) took minimum days (71) for first harvest. However open field cultivation was taken maximum number of days (95.5) to first harvest. This may be attributed to the reason that increased number of leaves produced high levels of assimilates in the photosynthetic process which hastened the appearance of flower. At higher fertigation better availability of sufficient quantity of nutrients especially the applied higher dosage of N, P and K to the plants in water soluble form may have resulted in early appearance of flowers. Related findings were found in sweet pepper [12]. The following Table 3. Effect of irrigation treatment on number of days to flowering and number of days to harvest in capsicum under naturally ventilated polyhouse and open field conditions.

**Table 1. Effect of irrigation treatment on plant height (cm) in capsicum under naturally ventilated polyhouse and open field conditions**

| Treatment      | Plant height in cm, DAT |         |         |         |            |
|----------------|-------------------------|---------|---------|---------|------------|
|                | 30                      | 60      | 90      | 120     | At harvest |
| T <sub>1</sub> | 28.85 a                 | 47.23 a | 57.44 a | 74.38 a | 91.23 a    |
| T <sub>2</sub> | 27.79 a                 | 42.32 b | 56.84 a | 66.37 b | 89.68 a    |
| T <sub>3</sub> | 23.46 b                 | 34.1 c  | 44.02 b | 55.18 c | 68.31 b    |
| Open           | 11.33 c                 | 11.76 d | 12.22 c | 13.28 d | 36.59 c    |
| CD at 5%       | 2.51                    | 2.32    | 2.68    | 2.93    | 3.09       |

Note: Mean values followed by the same letter within the treatments are not significantly different ( $p = .05$ ) according to the LSD test

**Table 2. Effect of irrigation treatment on number of leaves and number of branches in capsicum under naturally ventilated polyhouse and open field conditions**

| Treatment      | Number of leaves, DAT |        |        |        |            | Number of branches, DAT |       |       |       |            |
|----------------|-----------------------|--------|--------|--------|------------|-------------------------|-------|-------|-------|------------|
|                | 30                    | 60     | 90     | 120    | At harvest | 30                      | 60    | 90    | 120   | At harvest |
| T <sub>1</sub> | 26.2 a                | 44.7 a | 66.1 a | 84.5 a | 91.8 a     | 2.8 a                   | 5.4 a | 6.3 a | 6.7 a | 6.9 a      |
| T <sub>2</sub> | 23.6 b                | 43 a   | 62.3 b | 78.3 b | 87.1 a     | 2.4 a                   | 5.1 a | 6.1 a | 6.3 a | 6.6 a      |
| T <sub>3</sub> | 20.8 c                | 32.9 b | 45.2 c | 63.3 c | 72.9 b     | 1.5 b                   | 3 b   | 4.7 b | 5.4 b | 5.9 b      |
| Open           | 12.6                  | 16.7   | 22.4   | 28.5   | 43.7 c     | 0.8 c                   | 1.6 c | 2 c   | 2.1 c | 2.9 c      |
| CD at 5%       | 2.3                   | 2.46   | 2.71   | 3.56   | 4.68       | 0.56                    | 0.66  | 0.45  | 0.51  | 0.59       |

Note: Mean values followed by the same letter within the treatments are not significantly different ( $p = .05$ ) according to the LSD test

**Table 3. Effect of irrigation treatment on number of days to flowering and number of days to harvest in capsicum under naturally ventilated polyhouse and open field conditions**

| S. No | Treatment      | Number of days to flowering, DAT | Number of days to harvest, DAT |
|-------|----------------|----------------------------------|--------------------------------|
| 1     | T <sub>1</sub> | 33.2 a                           | 71 a                           |
| 2     | T <sub>2</sub> | 33.7 a                           | 71.5 a                         |
| 3     | T <sub>3</sub> | 40.5 b                           | 73.6 b                         |
| 4     | Open           | 54.5 c                           | 95.5 c                         |
| 5     | CD             | 1.54                             | 1.61                           |

Note: Mean values followed by the same letter within the treatments are not significantly different ( $p = .05$ ) according to the LSD test

**Table 4. Effect of irrigation treatment on fruit number per plant and individual fruit weight in capsicum under naturally ventilated polyhouse and open field conditions**

| S. No | Treatment      | Fruit number per plant | Individual fruit weight (g) |
|-------|----------------|------------------------|-----------------------------|
| 1     | T <sub>1</sub> | 7 a                    | 75.99 a                     |
| 2     | T <sub>2</sub> | 6.4 a                  | 60.41 b                     |
| 3     | T <sub>3</sub> | 3 b                    | 38.77 c                     |
| 4     | Open           | 1.5                    | 26.66                       |
| 5     | CD             | 0.81                   | 6.95                        |

Note: Mean values followed by the same letter within the treatments are not significantly different ( $p = .05$ ) according to the LSD test

**Table 5. Effect of Irrigation treatments on yield of capsicum under naturally ventilated polyhouse and open filed conditions**

| Treatment      | Yield (kg ha <sup>-1</sup> ) |
|----------------|------------------------------|
| T <sub>1</sub> | 6466.66                      |
| T <sub>2</sub> | 5233.33                      |
| T <sub>3</sub> | 3116.66                      |
| Open           | 850.00                       |

**Table 6. Effect of Irrigation treatments on Water productivity of capsicum under naturally ventilated polyhouse and open field**

| Treatment      | Total irrigation water applied (mm) | Yield (kg ha <sup>-1</sup> ) | Water productivity (kg ha <sup>-1</sup> mm <sup>-1</sup> ) |
|----------------|-------------------------------------|------------------------------|--|
| T <sub>1</sub> | 562.6                               | 6466.66                      | 11.49  |
| T <sub>2</sub> | 421.9                               | 5233.33                      | 12.4   |
| T <sub>3</sub> | 281.3                               | 3116.66                      | 11.07  |
| Open Field     | 612                                 | 850                          | 1.38   |

### 3.4 Number of Fruits per Plant and Individual Fruit Weight

From the Table 4 number of fruits and average weight of fruits are significantly differed due to different treatments. Among all treatments, T<sub>1</sub> recorded maximum number of fruits (7) and individual fruit weight (75.99 gm/plant). The fruit weight plays a key role in accumulative the whole yield in capsicum. The treatment T<sub>1</sub> (1.0 ET<sub>C</sub>) recorded highest individual fruit weight (75.99 g). The increase in fruit weight might be

due to better utilization of photosynthates. Similar findings are recorded [12,13].

### 3.5 Yield (kg/ha)

The treatment T<sub>1</sub>, which received 100 per cent of drip irrigation along with 100 per cent recommended dosage of water-soluble fertilizer showed maximum fruit yield per hectare (6466.66 kg ha<sup>-1</sup>). While the lowest fruit yield per hectare (850 kg ha<sup>-1</sup>). The higher level of irrigation and fertilizer application, which made plants to respond in production of early flowering,

fruit set again, helped in obtaining the highest fruit yield per hectare. Parallel results are observed with [11,14] for Capsicum crop. To compare polyhouse capsicum crop yield with open field, capsicum plants cannot survive during the off-season due to severe hot weather conditions in the open field. Table 5 shows the effect of irrigation treatments on yield of capsicum under naturally ventilated polyhouse and open filed conditions.

### 3.6 Water Productivity

Table 6 describes the data concerning capsicum water productivity as affected by various irrigation schedules. The water productivity of capsicum was seen to vary between various treatments for deficit irrigation.

From the observed parameters it is exhibited that drip irrigation 0.75 ET<sub>C</sub> noted as the higher in water productivity (12.4 kg ha<sup>-1</sup> mm<sup>-1</sup>) followed by drip irrigation scheduled at 1.0 ET<sub>C</sub> (11.49 kg ha<sup>-1</sup> mm<sup>-1</sup>), 0.5 ET<sub>C</sub> (11.07 kg ha<sup>-1</sup> mm<sup>-1</sup>) and open field (1.38 kg ha<sup>-1</sup> mm<sup>-1</sup>) recorded very less. While the fruit yield is best at the stage of drip irrigation of 1.0 ET<sub>C</sub>, the productivity of water performed in comparison with lows of drip-irrigation schedules is lower (11.49 kg ha<sup>-1</sup> mm<sup>-1</sup>). The water productivity steadily declines as the degree of irrigation increases. Related findings [9] have been obtained and published.

### 4. CONCLUSION

Now a day's cultivation of high value crops under polyhouse is getting momentum in India. From the study, irrigation water of 562.6 mm applied for T1, which results in superior in all average biometric parameters like plant height (74.38 cm), number of leaves (91.8), number of branches (6.9), number of days to first flowering (33.2 days), number of days to harvesting (71), number of fruits per plant (7), individual fruit weight (75.99 g) and fruit yield (6466.66 kg ha<sup>-1</sup>) but, statistically T1 is on par with the T2.

But in case of water productivity (12.4 kg ha<sup>-1</sup> mm<sup>-1</sup>) observed in the T2 (0.75 ET<sub>C</sub>). By adopting T2 (0.75 ET<sub>C</sub>) treatment we can save the water up to 25%, by using saved water additional quantity of vegetables can be produced.

### ACKNOWLEDGEMENT

The authors greatly acknowledge the Acharya N G Ranga Agricultural University for the technical and financial support for the research.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
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