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# Effect of different irrigation and fertigation levels on fruit quality and yield of *Summer* chilli (*Capsicum annuum* L.)

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**Abstract**
A field experiment entitled "Impact of Irrigation and Fertigation Levels on Growth, Yield and Quality of *Summer* Chilli (*Capsicum annuum* L.)" was carried out during *summer* season of 2018, in split plot design having main plot treatments as drip irrigation levels *viz*. $I_1$: at 0.7 ETc, $I_2$: at0.8 ETc,$I_3$: at 0.9 ETc, $I_4$: at 1.0 ETc, and $I_5$: at 1.1 ETc and Sub-plot treatments as fertigation levels *viz*. $F_1$= 60 per cent of RDF, $F_2$= 80 per cent of RDF and $F_3$= 100 per cent of RDF with fifteen treatment combinations, replicated thrice. Results of the study indicates that the significant differences on chilli yield and quality attributes *viz*., per cent fruit set, fruit length, girth and number of fruits per plant were observed for different drip irrigation and fertigation levels. As drip irrigation levels between 80 to 100 per cent of crop evapotranspiration were found statistically at par with each other for fruit quality and yield of chilli, irrigation level of 80 per cent of crop evapotranspiration was found optimum among the all tested treatments. Whereas, for different levels of fertigation in eleven splits had significant effect on fruit quality and yield of chilli. Fruit quality and yield of chilli was found highest in $F_3$ (fertigation with100% of RDF) treatment. Further fertigation levels with100 per cent of RDF and 80 per cent of RDF was found statistically at par with each other for the fruit quality and yield of chilli. Therefore, fertigation with 80 per cent RDF in eleven splits was found optimum. Interaction effect of different irrigation and fertigation level was found non-significant.

**Keywords:** Drip irrigation, fertigation, fruit quality, yield

## Introduction

Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network and even if the full irrigation potential is exploited, about 50 per cent of the country's cultivated area will still remain unirrigated, due to the current level of irrigation efficiency not exceeding 40 per cent. Conventional and traditional irrigation systems such as basin irrigation and wild flooding apply comparatively larger quantity of water per irrigation contributing to huge loss of water in the form of surface runoff, evaporation and deep percolation. India has to enhance the current irrigation potential of 91 m ha to 140 m ha. to achieve required food and fibre production with ever increasing population.

In view of worsening water scarcity and raising water demand, the available water resources should be very effectively utilized through water saving irrigation technologies. The need of the hour is, therefore, to maximize the production per unit of water. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to high efficiency and the direct application of water and nutrients in the vicinity of root zone, matching the crop water needs. Because of reduced water loss and uniform water application in precise quantity drip system has higher irrigation efficiency of more than 90 per cent.

Fertilizer is the costliest input after water, in agriculture. Apart from the economics consideration it is also well known that the adverse effect of injudicious use of water and fertilizer on the environment can have far reaching implications. There is, therefore, a need for technological options, which will help in sustaining the precious resources and maximizing crop production without any detrimental impact on the environment. Fertigation opened up new possibilities for controlling water and nutrient supplies to the crops. By introducing fertigation, it is possible to save the water and fertilizers about 45-50 per centand 30 per cent with increasing the productivity about 40 per cent respectively (Sivanappan and Ranghaswami, 2005) [15].

Chilli (*Capsicum annuum* L.) belongs to the *Solanaceae* family, has its unique place in the diet as a vegetable cum spice crop. Chilli is an indispensable spice due to its pungency, taste, appealing colour and flavor. It is the second largest commodity after black pepper (*Piper nigrum* L.) in the international spice trade. *Capsicum* spp. contain a range of essential nutrients and bioactive compounds which are known to exhibit antioxidant, antimicrobial, antiviral, anti-inflammatory and anticancer properties (Khan *et al.*, 2014) [7]. It is predominantly popular for its green pungent fruits, which is used for culinary purpose. The nutritive value of chilli is excellent with different types of protein, vitamin and ascorbic acid contents and has of medicinal potential of especially anti-cancerous and instant pain relief.

India is the largest producer, consumer and exporter of chilli, which contribute to 25per cent of total world's production. In India, chilli is grown in almost all the states across the length and breadth of the country. Chilli being a long duration crop, it responds to split application of nutrients *i.e.*, nitrogen, phosphorus and potassium. It responds well to fertigation with 11 to 22 applications in terms of increased growth and yield properties besides, higher water and fertilizer use efficiencies compared to conventional methods of fertigation. Pungency and colour are two important characters liked by consumers. Some nutrients are known to play an important role in maintaining these characters. Nitrogen is an essential component of nucleic acid and has been suggested to improve the development of vegetative structures and thereby yield (Glass, 1989) [4]. Potassium is well known for its role in improving quality. Potassium improves colour, glossiness and dry matter accumulation in fruits (Subhani *et al.*, 1990) [16]. Since, chilli is a spice crop with tremendous export potential, the yield and quality are the important factors to be considered which can be achieved only through optimum nutrient application.

## Materials and Methods

The field experiment entitled "Impact of Irrigation and Fertigation Levels on Growth, Yield and Quality of *Summer* Chilli (*Capsicum annuum* L.)" was undertaken during *summer* season of year 2017-18 at Experimental farm, College of Agriculture, Badnapur, VNMKV, Parbhani.

## Experimental details

The experimental field was laid out as per plan after preparatory operations. The layout consisted of fifteen treatments arranged randomly, in split plot design with three replications in a field of 40 m x 36 m size. The gross length and width of each main plot treatment *i.e.* drip irrigation level was 7 x 36 m, divided into three sub plot treatment *i.e.* fertigation levels with each of size 7 x 12 m. Net plot size for each treatment combination was 6 x 3.6 m. A space of 1.0 m was provided between two treatments as a buffer strip to avoid lateral movement of water from treatment to treatment.

## Irrigation Scheduling

To assess the influence of infield variability irrigation levels on chilli, crop was irrigated with five drip irrigation levels as per the treatments. Irrigations were applied at an alternate day on the basis fraction of crop evapotranspiration (ETc) as per the treatments *i.e.* $I_1$: at 0.7ETc, $I_2$: at 0.8 ETc, $I_3$: at 0.9 ETc, $I_4$: at 1.0 ETc, and $I_5$: at 1.1 ETc, throughout the complete crop period of chilli.

The ETc was computed as given by equation (3.1)

$$ETc = ETr \times Kc \qquad ..... (3.1)$$

Where,
ETc = Crop evapotranspiration (mm/day)
ETr = Reference crop evapotranspiration (mm/day)
Kc = Crop coefficient

The FAO Penman-Monteith method was used to estimate ETr as given by equation (3.2)

$$ETr = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u(e_s - e_a)}{\Delta + \gamma\ (1+0.34u_2)} \qquad ....... (3.2)$$

Where,
ETr = Potential evapotranspiration (mm/day)
ssRn = Net radiation at the crop surface (MJ/m/day)
G =Soil heat flux density (MJ/m/day)
T =Mean daily air temperature at 2 m height (°C)
u2 =Wind speed at 2 m height (m/s)
es =Saturation vapours pressure (kPa)
ea = Actual vapour pressure (kPa)
es – ea = Saturation vapour pressure deficit (kPa)
Δ =Slope vapour pressure curve (kPa/°C)
γ =Psychometric constant (kPa/°C)

ETr values were computed by "Phule Jal App" developed by Gorantiwar and Palkar. It calculates the ETr values by different standard methods automatically by fetching the real time data from the weather service provider and estimate the evapotranspiration at the specified location. It has provision to fill up the input data manually also.

**Fertigation:** Water soluble 19:19:19 and Urea (46% N) was used as a source of NPK. The recommended dose of fertilizer (NPK) for chilli crop is 120:80:80 kg/ha. To assess the influence of different fertigation levels *i.e.*$F_1$ at 60 per cent, $F_2$ at 80 per cent and $F_3$ at 100 per cent of RDF fertilizers were applied in eleven splits during the critical growth stages of chilli (Establishment stage, Vegetative growth, Flowering and fruiting and Fruit maturity to harvest: 02,03,03 and 03 splits, respectively).

**Per cent of fruit set:** Number of flowers born on five randomly selected plants in each treatment was recorded. The per cent fruit set was computed by using the formula suggested by Villareal and Lai (1978) [19].

$$\text{Per cent fruit set} = \frac{\text{No. of fruits plant}^{-1}}{\text{No. of flowers plant}^{-1}} \times 100 \qquad (3.3)$$

**Length of fruit:** Fruit length (cm) of five individual fruits from the sample plants in each treatment was measured at the time of harvest and average of it was worked out.

**Circumference (Girth) of fruit:** The fruit (pod) diameter (mm) was measured by taking 5 individual fruits with a digital vernier caliper at the middle portion and conversion of the same were done to record the circumference of the pod.

**Fruit weight:** Average fruit weight (g) was recorded at peak harvest by weighing five individual fruits from the sample plants in each treatment and average of it was worked out.

**Number of fruits per plants:** Total number of fruits picked from the tagged plants for each picking were recorded and presented as average number plant$^{-1}$.

**Yield:** Yield of the total fruits of the chillies harvested in different pickings (Four potential) from the sample plants in each treatment was recorded and averages was worked out to estimate yield in tonnes per hectare.

## Result and Discussion

### Irrigation scheduling

Irrigations were scheduled at an alternate day on the basis of different treatments of chilli crop evapotranspiration over the whole crop period of chilli crop. Amount of irrigation water to be given was varied according to the treatment which is based on crop evapotranspiration.

**Table 1:** Number of irrigations and gross depth of irrigation water applied for different treatments

| Treatment | Number of irrigations | Total depth of irrigation water applied (mm) |
|---|---|---|
| $I_1$ = Drip irrigation at 0.7 ETc | 55 | 417 |
| $I_2$ = Drip irrigation at 0.8 ETc | 55 | 477 |
| $I_3$=Drip irrigation at 0.9 ETc | 55 | 536 |
| $I_4$=Drip irrigation at 1.0 ETc | 55 | 596 |
| $I_5$=Drip irrigation at 1.1 ETc | 55 | 655 |

### Influence of different irrigation and fertigation levels on Fruit quality

### Per cent fruit set of chilli

Data indicates that the drip irrigation and fertigation levels significantly influenced the per cent fruit set of chilli. In main plot treatment with different drip irrigation levels, significantly highest per cent fruit set was found in treatment $I_4$ (69.10%), followed by treatments $I_3$ (67.11%)) and $I_2$ (66.85%) and these treatments were found at par with each other. Significantly lowest per cent fruit set was recorded in treatment $I_1$ (59.01%).

In the sub plot treatment, the different levels of fertigation influenced the per cent fruit set significantly. Increase in per cent fruit set was observed with increase in fertigation application. The fertigation treatment $F_3$ has recorded maximum per cent fruit set (67.30%), followed by treatment $F_2$ (65.53%) and both the treatments were found at par with each other, while the lowest per cent fruit set was recorded in treatment $F_1$(63.58%). The interaction effect of drip irrigation and fertigation levels was found non-significant on per cent fruit set of chilli.

### Fruit length of chilli

The data indicates that the drip irrigation and fertigation levels significantly influenced the fruit length of chilli. In main plot treatment with different drip irrigation levels, significantly highest fruit length was recorded under the treatment $I_4$ (9.34 cm), followed by the treatment $I_3$ (9.18 cm) and treatment $I_2$ (8.98 cm) and these treatments were found at par with each other. The fruit length was lowest under the treatment $I_1$ (7.35 cm).

In the sub plot treatment, the different levels of fertigation had showed significant effect on fruit length of chilli. Due to the effect of fertigation levels, significantly maximum fruit length was observed in treatment $F_3$ (9.23 cm), followed by treatment $F_2$ (8.92 cm) and both the treatments were found at par with each other. The fruit length was found minimum in treatment $F_1$ (8.05 cm). The interaction effect of drip irrigation and fertigation levels was noticed non-significant on the fruit length of chilli.

### Fruit girth of chilli

The data indicates that the drip irrigation and fertigation levels significantly influenced the fruit girth of chilli. In main plot treatment with different drip irrigation levels, significantly highest fruit girth was recorded under the treatment $I_4$ (5.20 cm), followed by the treatment $I_3$ (4.96 cm) and treatment $I_2$ (4.91 cm) and these treatments were found at par with each other. The fruit girth was lowest under the treatment $I_1$ (4.18 cm).

In the sub plot treatment, the different levels of fertigation had showed significant effect on fruit girth of chilli. Due to the effect of fertigation levels, significantly maximum fruit girth was observed in treatment $F_3$ (5.08 cm), followed by treatment $F_2$ (4.84 cm) and both the treatments were found at par with each other. The fruit girth was found minimum in treatment $F_1$ (4.47 cm). The interaction effect of drip irrigation and fertigation levels was noticed non-significant on the fruit girth of chilli.

### Fruit weight of chilli

The data indicates that the drip irrigation and fertigation levels significantly influenced the fruit weight of chilli. In main plot treatment with different drip irrigation levels, significantly highest fruit weight was recorded under the treatment $I_4$ (5.38 g), followed by the treatment $I_3$ (5.22 g) and treatment $I_2$ (5.14g) and these treatments were found at par with each other. The fruit weight was lowest under the treatment $I_1$ (4.65 g).

In the sub plot treatment, the different levels of fertigation had showed significant effect on fruit weight of chilli. Due to the effect of fertigation levels, significantly maximum fruit weight was observed in treatment $F_3$ (5.37 g), followed by treatment $F_2$ (5.18 g) and both the treatments were found at par with each other. The fruit weight was found minimum in treatment $F_1$ (4.85 g). The interaction effect of drip irrigation and fertigation levels was noticed non-significant on the fruit weight of chilli.

### Number of fruits per plant of chilli

The data indicates that, the drip irrigation and fertigation levels significantly influenced the number of fruits per plant of chilli. In main plot treatment with different drip irrigation levels, significantly higher number of fruits per plant was recorded under the treatment $I_4$ (107.44), followed by the treatment $I_3$ (105.52) and treatment $I_2$ (103.60) and these treatments were found at par with each other. The number of fruits per plant was lower under the treatment $I_1$ (77.72).

In the sub plot treatment, the different levels of fertigation had showed significant effect on number of fruits per plant of chilli. Due to the effect of fertigation levels, significantly higher number of fruits per plant was observed in treatment $F_3$ (106.70), followed by treatment $F_2$ (101.80) and both the treatments were found at par with each other. The number of fruits per plant was found lower in treatment $F_1$ (79.30). The interaction effect of drip irrigation and fertigation levels was noticed non-significant on the number of fruits per plant of chilli.

**Yield of chilli per ha (tonnes per ha)**

The data indicates that during the year 2018, the irrigation and fertigation levels were significantly influenced the yield of chilli per ha in the main plot treatment with different irrigation levels, significantly highest yield of chilli per ha was recorded under the treatment $I_4$ (17.02 tonnes per ha) followed by the treatment $I_3$ (16.46 tonnes per ha) and treatment $I_2$ (16.21 tonnes per ha) and these treatments were found at par with one another. The next followed treatment was $I_5$ (15.84 tonnes per ha). The yield of chilli per ha was lowest under the treatment $I_1$ (13.61 tonnes per ha).

These results are also well supported earlier byAbou-Hussein *et al*., 1984 [1] and Nesthad *et al*., 2013.

In the sub plot treatment, the fertigation with different levels of fertigation had showed significant effect on yield of chilli per ha Due to the effect of fertigation levels, significantly maximum yield per ha was observed in treatment $F_3$ (17.31 tonnes per ha) followed by treatment $F_2$ (16.27 tonnes per ha) and both the treatments were found at par with each other. The yield of chilli per ha was found minimum in treatment $F_1$ (13.91 tonnes per ha).

It might be due to optimum replenishment of water and nutrients in the effective root zone during critical periods of nutrient demand, which improve the physiological and photosynthetic activities enhancing the vegetative and productive growth of plants. The increased yield under drip irrigation might have resulted due to better water utilization (Manfrinato, 1974) [10], higher uptake of nutrients (Bafna *et al*., 1993) [3] and excellent soil-water relationship with higher oxygen concentration in the root zone (Gornet *et al*., 1973) [6].

The interaction effect of irrigation and fertigation levels was noticed non-significant on the yield of chilli per ha.

**Table 2:** Effect of different irrigation and fertigation levels on chilli fruit quality

| Treatments | Fruit set of chilli (%) | Fruit length (cm) | Fruit girth (cm) | Fruit weight (g) | Number of fruits Per plant |
|---|---|---|---|---|---|
| **A) Main Plot (Irrigation levels)** | | | | | |
| $I_1$= Drip irrigation at 0.7 ETc | 59.01 | 7.35 | 4.18 | 4.65 | 77.72 |
| $I_2$= Drip irrigation at 0.8 ETc | 66.85 | 8.98 | 4.91 | 5.14 | 103.60 |
| $I_3$= Drip irrigation at 0.9 ETc | 67.11 | 9.18 | 4.96 | 5.22 | 105.52 |
| $I_4$= Drip irrigation at 1.0 ETc | 69.10 | 9.34 | 5.20 | 5.38 | 107.44 |
| $I_5$= Drip irrigation at 1.1 ETc | 65.30 | 8.82 | 4.75 | 4.92 | 85.38 |
| S.E. ± | 0.82 | 0.12 | 0.13 | 0.134 | 1.88 |
| C.D. at (P=0.05) | 2.44 | 0.37 | 0.38 | 0.39 | 5.54 |
| **B) Sub Plot (Fertigation levels)** | | | | | |
| $F_1$= 60% of RDF | 63.58 | 8.05 | 4.47 | 4.85 | 79.30 |
| $F_2$= 80% of RDF | 65.53 | 8.92 | 4.84 | 5.18 | 101.80 |
| $F_3$= 100% of RDF | 67.30 | 9.23 | 5.08 | 5.37 | 106.70 |
| S.E. ± | 0.88 | 0.199 | 0.14 | 0.138 | 2.34 |
| C.D. at (P=0.05) | 2.60 | 0.58 | 0.42 | 0.40 | 6.92 |
| **C) Interaction (I X F)** | | | | | |
| S.E. ± | 1.97 | 0.44 | 0.32 | 0.308 | 5.26 |
| C.D. at (P=0.05) | NS | NS | NS | NS | NS |
| General Mean | 65.47 | 8.73 | 4.80 | 5.13 | 95.93 |

**Table 3:** Effect of different irrigation and fertigation levels on yield of chilli (tonnes per ha)

| Treatments | Yield of chilli (tonnes / ha) |
|---|---|
| **A) Main Plot (Irrigation levels)** | |
| $I_1$= Drip irrigation at 0.7 ETc | 13.61 |
| $I_2$= Drip irrigation at 0.8 ETc | 16.21 |
| $I_3$= Drip irrigation at 0.9 ETc | 16.46 |
| $I_4$= Drip irrigation at 1.0 ETc | 17.02 |
| $I_5$= Drip irrigation at 1.1 ETc | 15.84 |
| S.E. ± | 0.37 |
| C.D. at (P=0.05) | 1.09 |
| **B) Sub Plot (Fertigation levels)** | |
| $F_1$= 60% of RDF | 13.91 |
| $F_2$= 80% of RDF | 16.27 |
| $F_3$= 100% of RDF | 17.31 |
| S.E. ± | 0.69 |
| C.D. at (P=0.05) | 2.04 |
| **C) Interaction (I X F)** | |
| S.E. ± | 1.55 |
| C.D. at (P=0.05) | NS |
| General Mean | 15.83 |

**Conclusion**

Significant differences on chilli yield and quality attributes *viz.*, per cent fruit set, fruit length, girth and number of fruits per plant were observed for different drip irrigation and fertigation levels. Among drip irrigation levels the fruit quality attributes obtained under drip irrigation at 1.0 ETc were recorded significantly higher for per cent fruit set (69.10) fruit length (9.34 cm), fruit girth (5.20 cm), fruit weight (5.38 g) and number of fruit per plant (107.44) over rest of the irrigation levels. However, it was found at par with drip irrigation level at 0.9 ETc (Per cent fruit set 67.11, fruit length 9.18 cm, fruit girth 4.96 cm, fruit weight 5.22 g and number of fruit per plant 105.52) and drip irrigation level at 0.8 ETc (Per cent fruit set 66.85, fruit length 8.98 cm, fruit girth 4.91 cm, fruit weight 5.14 g and number of fruit per plant 103.60). Lowest Per cent fruit set (59.01), fruit length (7.35 cm), fruit girth (4.18 cm), fruit weight (4.65 g) and number of fruit per plant (77.72) were recorded in drip irrigation level at 0.7 ETc. Thus, drip irrigation level at 0.8 of crop evapotranspiration was found to be optimum.

Whereas, for different fertigation levels, fertigation with 100 per cent of RDF and 80 per cent of RDF found statistically at par with each other for the fruit quality attributes of chilli. Fertigation with 100 per cent RDF recorded significantly higher Per cent fruit set (67.30), fruit length (9.23 cm), fruit girth (5.08 cm), fruit weight (5.37 g) and number of fruit per plant (106.70) and was found statistically at par with fertigation with 80 per cent RDF (Per cent fruit set 65.53, fruit length 8.92cm, fruit girth 4.84 cm, fruit weight 5.18 g and number of fruit per plant 101.80). Therefore, fertigation with 80 per cent RDF was said to be good enough. Interaction effect of different drip irrigation and fertigation level was found non-significant on fruit quality attributes of chilli.

Yield of chilli was found highest in $F_3$ (fertigation with 100% of RDF) treatment. Further fertigation levels with100 per cent of RDF and 80 per cent of RDF was found statistically at par with each other for the above growth parameters at various stages of crop growth and yield of chilli. Therefore, fertigation with 80 per cent RDF in eleven splits was found optimum. Interaction effect of different irrigation and fertigation level was found non-significant.

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