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# Response of Different Levels of Fertigation on Capsicum (*Capsicum annum* var. *grossum* L.) Grown under Soilless Media

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## Abstract

The present investigation was conducted in the academic year 2021-2023 at the polyhouse, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India. The experiment was laid out in RBD (Randomized Block Design) with five replications and six treatments viz. $T_1$: control, $T_2$: 40% Fertigation, $T_3$: 60% Fertigation, $T_4$: 80% Fertigation, $T_5$: 100% Fertigation, $T_6$: 120% Fertigation. The study revealed that the growth stage wise application of different levels of fertigation increased the all parameters of capsicum. The maximum plant height (148.77 cm), plant diameter (52.43 cm), leaf length (18.05 cm), leaf diameter (9.10 cm), days to first flowering (46.72), days to first picking (74.32), harvest duration (68.83) were found maximum with the application of 120% fertigation. The average fruit weight (70.47g), number of fruits per plant (13.29), fruit length (72.98 mm), fruit diameter (58.50 mm), fruit yield per plant (1208.49 g), fruit yield per hectare (33.50 tonnes) were found maximum with the application of 100% fertigation. The same treatment also produces the highest net returns of Rs. (1383963.99) along with benefit : cost ratio (2.21). These findings suggested that optimum production of capsicum can be attained with application of 100% fertigation.

***Key words*:** Capsicum, Fertigation, Growth, Polyhouse, Quality, Soilless media, Yield

Sweet pepper (*Capsicum annum* var. *grossum* L.) belongs to the genus Capsicum and the family Solanaceae. It originated in Central and South America [1]. It is considered one of the best vegetable sources of human health beneficial components [2]. Capsicum is grown on a large scale because of its unique taste, nutritive value, attractive color and flavor [3]. Sweet peppers are low in energy but high in nutrients, particularly in terms of Vitamin A (180 IU), Vitamin C (283 mg), Vitamin E and Vitamin $B_1$ [4]. It offers a host of other good sources like folate, riboflavin, thiamin and niacin and minerals like potassium (263.7 mg), magnesium (14.9 mg), calcium (13 Mg), phosphorous (28.3 mg) [5]. Moreover, it is one of the most prominent crops which offers medicinal value in pharmaceutical industries by providing a high amount of antioxidants, capsanthin and capsaicin as the main active substance [6]. For successful cultivation of Capsicum, poly houses and polytunnels are the most suitable structures [7]. Sweet pepper is one of the important horticultural crops which usually grown in greenhouses where the microclimate can be precisely monitored and controlled [8]. Cultivation inside the greenhouses can be a profitable venture as it enhances the quantity with quality and also ensures an off-season production [9]. The main aim of greenhouse technology is to protect the plants from the natural vagaries of weather, to provide superior quality of fruit, improved shelf life and also substantially reduction from the use of insecticides or pesticides [3]. Fertigation is the best innovative approach for the cultivation of capsicum [3]. It is the technique of supplying dissolved fertilizers to the crop through drip system [10]. This system provides a numerous advantages like higher production, improved fruit quality, efficient use of resources, environmental safety and flexibility in field operations, reduces weeds and successful crop cultivation on fields with undulating topography [11]. This approach also improves the quantity of crops with better quality and also makes control on soil or water-borne diseases [12]. It offers precise control on fertilizer application like uptake of nutrients can be adjusted accordingly to the requirement of the plants [3]. Soilless culture is commonly used in horticultural crops cultivation inside the greenhouse [13]. It is an artificial method of providing a reservoir of nutrients and water to plants [14]. Many inexpensive soilless media like vermicompost, coconut coir can be used because it has air and water retention capacity [1]. It contributes to the improvement of plant growth, earliness, yield and increases crop quality, which results in higher competitiveness and economic incomes [15]. Replacing soil with soilless media is to combat issue related to plant protection, soil-related plant diseases and environmental regulations against groundwater pollution with nitrate pesticides [14].

## MATERIALS AND METHODS

The experimental study was conducted in partially ventilated Poly-house of Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India, during 2021 and 2022. It is located at height of 246 meter above mean sea level latitude between 30˚ 27˚ and 30˚46’ N and 76˚ - 04’ and 76˚-38’ E

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longitude. Nursery of Capsicum variety 'Indra' was sown in the plug trays on 7th December, 2021. Afterwards these plug trays were maintained using standard procedures for the production of seedlings. After 8 weeks, uniform pepper seedlings were transplanted on 15th January, 2022 into polybags which was filled with soilless media which composed of coco peat, vermicompost and Neem cake in the ratio 3:2:1. Seedlings were transplanted at spacing of 60 cm row to row and 60 cm plant to plant and each row containing 30 plants. The recommended dose of NPK (125:62.5:30 kg $ha^{-1}$) fertilizers applied as per the treatments imposed. Fertigation was done on alternative days by drip irrigation. All the recommended cultural practices were adhered on time to assure a good crop stand. The Experimental plots were visited regularly in the morning and evening hours for observing the crop and forthcoming problems with them. The experiment was set up in randomized block design with five replications comprising of six treatments combination i.e. $T_1$: Control (No RDF), $T_2$: 40% RDF of NPK, $T_3$: 60% RDF of NPK, $T_4$: 80% RDF of NPK, $T_5$: 100% RDF of NPK and $T_6$: 120% RDF of NPK. Observations were recorded from randomly selected fifteen labeled plants in each treatment and then their average was computed. Parameters i.e. plant height (cm), plant diameter (cm), leaf length (cm), leaf diameter (cm) were taken at 30, 60, 90 and at harvest days after transplanting was recorded with the help of measuring scale. Days to first flowering and days to First picking were counted from the date of transplanting to the stage when plants showed initiation of the flower buds and turns into developed green fruit. The harvest duration was calculated from the date of initial picking until the date of final picking. Fruit length (mm) and diameter (mm) was measured with vernier caliper. The Fruits from each treatment were taken at fully developed green stage and weighted with the help of electronic weighing machine and was expressed in the gram. Cumulative number of fruits harvested from each plot was worked out by counting the fruit in various pickings till the end of the crop season. The weight of the fresh fully developed fruits was taken at each picking, added and average value was worked out as fruit yield per plant and hectare which expressed in grams and tonnes. According to the experiment design, the attribute data were statistically analyzed and the treatments means were evaluated at a significance level of 5% [15].

## RESULTS AND DISCUSSION

*Effect on growth parameters*

Growth parameters are considered as important trait in capsicum crop. The observations on various growth parameters of plant height, plant diameter, leaf length and leaf breadth were taken at different stages of 30, 60, 90 and at harvest days after transplanting (DAT) as presented on (Table 1-2, Fig 1.1, 1.2) respectively.

Table 1 Response of different levels of fertigation on plant height and plant diameter of capsicum (cm)

| Treatments | Plant height (cm) | | | | Plant diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 days | 60 days | 90 days | At harvest | 30 days | 60 days | 90 days | At harvest |
| $T_1$: Control | 18.97 | 23.70 | 48.54 | 120.36 | 16.09 | 16.16 | 20.29 | 34.73 |
| $T_2$: 40% RDF | 20.03 | 26.77 | 55.35 | 133.11 | 17.89 | 19.72 | 24.46 | 40.45 |
| $T_3$: 60% RDF | 21.41 | 28.11 | 62.78 | 138.11 | 17.94 | 22.44 | 27.87 | 43.51 |
| $T_4$: 80% RDF | 22.83 | 30.35 | 65.75 | 141.94 | 18.12 | 24.34 | 29.56 | 46.76 |
| $T_5$: 100% RDF | 23.64 | 32.20 | 74.04 | 146.52 | 19.05 | 26.31 | 33.33 | 50.16 |
| $T_6$: 120% RDF | 24.89 | 33.76 | 76.35 | 148.77 | 19.08 | 27.46 | 35.25 | 52.43 |
| SE (m) ± | NS | 0.48 | 0.58 | 0.79 | NS | 0.45 | 0.66 | 0.78 |
| $CD_{0.05}$ | | 1.41 | 1.71 | 2.32 | | 1.31 | 1.94 | 2.30 |

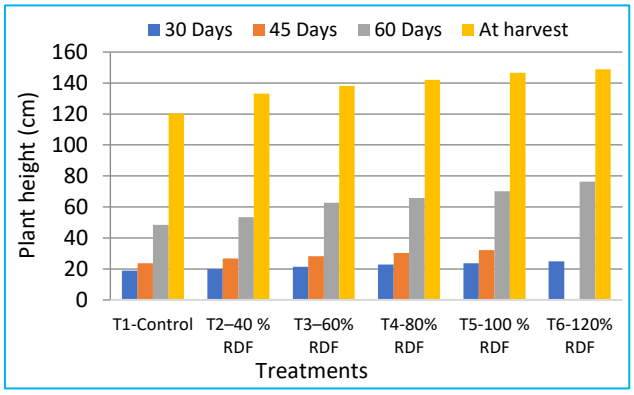


Fig 1.1 Effect of different levels of fertigation on plant height (cm) of capsicum

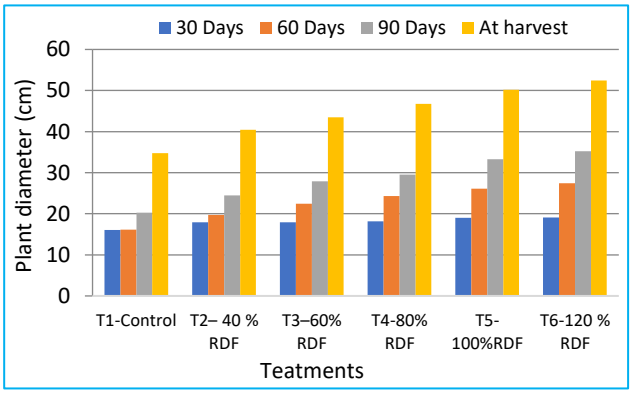


Fig 1.2 Effect of different levels of fertigation on plant diameter (cm) of capsicum

Table 2 Response of different levels of fertigation on leaf length and leaf breadth of capsicum (cm)

| Treatments | Leaf length (cm) | | | | Leaf breadth (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 days | 60 days | 90 days | At harvest | 30 days | 60 days | 90 days | At harvest |
| $T_1$: Control | 4.99 | 5.92 | 8.75 | 10.70 | 2.01 | 2.78 | 3.80 | 4.85 |
| $T_2$: 40% RDF | 5.59 | 7.88 | 10.68 | 12.56 | 2.53 | 3.83 | 4.27 | 5.81 |
| $T_3$: 60% RDF | 5.83 | 8.23 | 10.95 | 13.06 | 2.55 | 4.51 | 5.33 | 6.46 |
| $T_4$: 80% RDF | 5.90 | 9.07 | 10.98 | 14.58 | 2.58 | 4.64 | 5.65 | 7.14 |
| $T_5$: 100% RDF | 5.93 | 9.36 | 11.53 | 16.98 | 2.61 | 5.10 | 5.88 | 8.53 |
| $T_6$: 120% RDF | 6.01 | 10.18 | 12.25 | 18.02 | 3.15 | 5.74 | 6.28 | 9.10 |
| SE (m) ± | NS | 0.31 | 0.28 | 0.36 | NS | 0.23 | 0.16 | 0.20 |
| $CD_{0.05}$ | | 0.92 | 0.82 | 1.07 | | 0.67 | 0.46 | 0.59 |

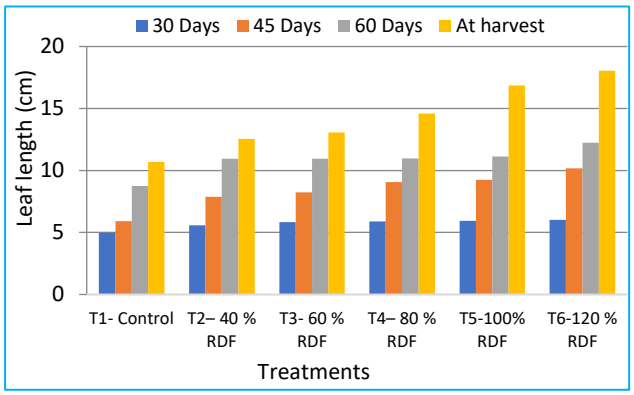


Fig 2.1 Effect of different levels of fertigation on leaf length (cm) of capsicum

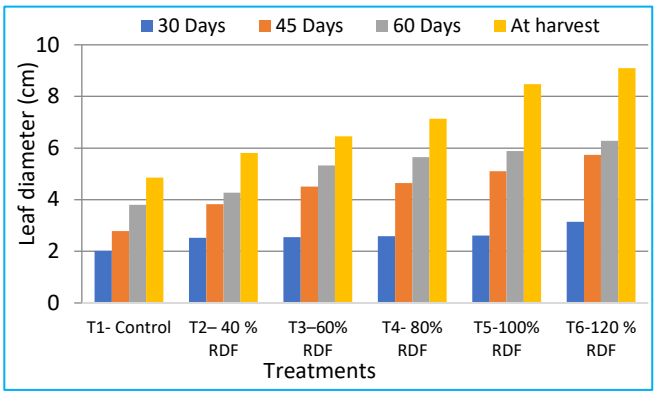


Fig 2.2 Effect of different levels of fertigation on leaf diameter (cm) of capsicum

At 30 DAT, maximum plant height (24.89 cm), plant diameter (19.08 cm), leaf length (6.01cm) and leaf diameter (3.15 cm) was found maximum in treatment $T_6$ (120%) whereas minimum plant height (18.97 cm), plant diameter (16.09 cm), leaf length (4.99 cm) and leaf diameter (2.01 cm) was recorded in control treatment ($T_1$). At 60 DAT, maximum plant height (33.76 cm), plant diameter (27.46 cm), leaf length (10.18 cm) and leaf diameter (5.74 cm) was observed maximum in treatment $T_6$ (120%). The minimum plant height (23.70 cm), plant diameter (16.16 cm), leaf length (5.92 cm) and leaf diameter (2.78 cm) was minimum under treatment control treatment ($T_1$). At 90 DAT, the maximum plant height (76.35 cm), plant diameter (35.25 cm), leaf length (12.25 cm) and leaf diameter (6.28 cm) was observed maximum in treatment $T_6$ (120%). The minimum plant height (48.54 cm), plant diameter (20.29 cm), leaf length (8.75 cm) and leaf diameter (3.80 cm) was recorded minimum under control treatment ($T_1$). At harvest, maximum plant height (148.77 cm), plant diameter (52.43 cm), leaf length (18.02 cm) and leaf breadth (9.10 cm) was found maximum in treatment $T_6$ (120%). The least plant height (120.36 cm), plant diameter (34.73 cm), leaf length (10.70 cm) and leaf diameter (4.85 cm) was observed minimum in control conditions. During all successive stages of crop growth, all parameters of capsicum was found to be increasing as fertigation level increases. The reason may be the wetted zone of the soil, where the active roots are concentrated which receive higher levels of nitrogen and phosphorus from drip-restricted fertilizers and further resulted into improved nutrient uptake and utilization as well as enhanced the vegetative growth. In addition, nitrogen is essential for many other metabolic activities, including transpiration, amino acids, the cell nucleus, protoplasm and chlorophyll [16]. In each growth stage, the deviation in parameters was minimum under control. This trend might be due to no access of fertigation to plants. The data on days taken for flower initiation, first picking and for harvest duration was represented in (Table 3, Fig 3).

Table 3 Response of different levels of fertigation on growth parameters of capsicum

| Treatments | Days to flowering | Days to first picking | Harvest duration |
|---|---|---|---|
| $T_1$: Control | 56.70 | 92.83 | 52.48 |
| $T_2$: 40% RDF | 52.05 | 87.78 | 55.83 |
| $T_3$: 60% RDF | 51.88 | 82.63 | 61.76 |
| $T_4$: 80% RDF | 50.16 | 78.28 | 65.69 |
| $T_5$: 100% RDF | 48.27 | 76.45 | 68.83 |
| $T_6$: 120% RDF | 46.72 | 74.32 | 67.25 |
| SE (m) ± | 0.53 | 0.49 | 0.56 |
| $CD_{0.05}$ | 1.56 | 1.46 | 1.66 |

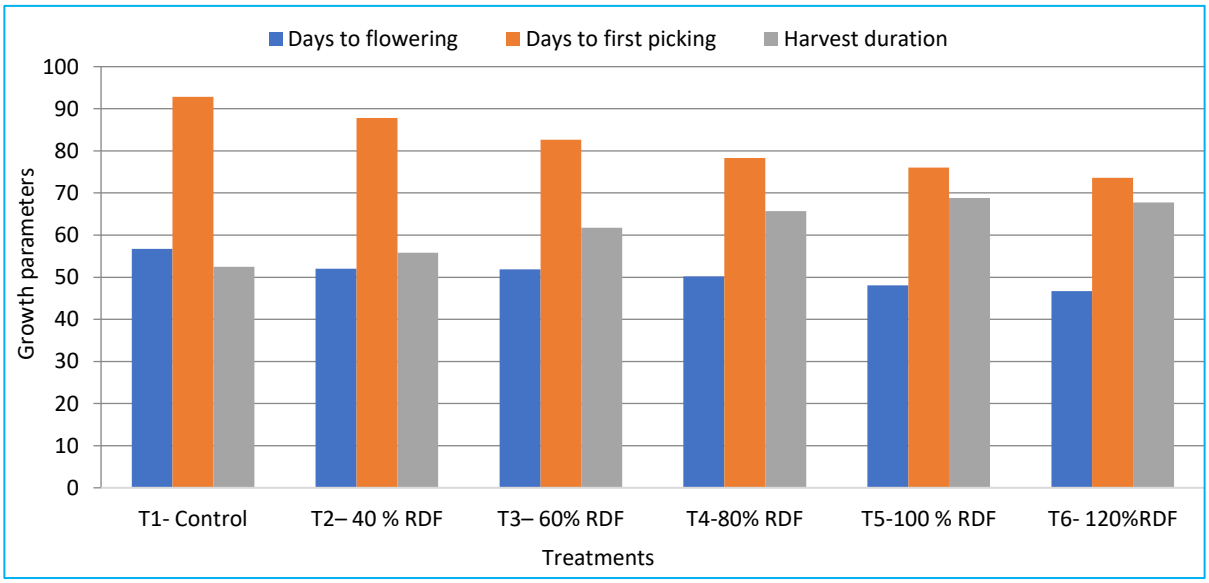


Fig 3 Effect of different levels of fertigation on growth parameters of capsicum

Among the all treatments, early flower initiation (46.72 days) was recorded under $T_6$ (100%) which was significantly superior over the other treatments. The late flower initiation (56.70 days) was recorded under $T_1$ (control). This might be because the absorbed nutrients have a simulative effect on the photosynthetic process, which accelerate the vegetative phase and positively influences the initiation of flowers [17]. However, minimum days taken for first picking of fruits (76.45) was recorded under $T_5$ (100%) which was significantly at par with $T_6$ (120%). The maximum days taken for picking of fruits (92.83) was observed in $T_1$ (control). It might be obtained due to effect of 100% RDF of NPK through fertigation which accelerated the blooming date with rise in temperature in the rhizosphere. This temperature and the higher amounts of potassium may be responsible for the earlier start of flowering [18]. The maximum days (68.83) for harvest duration was calculated in treatment $T_5$ (100%) which was significantly superior over the rest of treatments. Whereas, the minimum days (52.48) for harvest duration was recorded under control conditions. This is due to congenial micro climate for the flowering, pollination and harvest duration. Overall, applying 100% RDF of NPK seems to enhance flowering, reduce time to first harvest, and extend the harvest duration, providing a balanced nutrient supply that supports optimal plant growth.

Table 4 Response of different levels of fertigation on yield and yield contributing characteristics of capsicum

| Treatments | Average fruit weight (g) | Number of fruits per plant | Fruit length (mm) | Fruit diameter (mm) | Fruit yield per plant (g/plant) | Fruit yield per hectare (t/ha) |
|---|---|---|---|---|---|---|
| $T_1$: Control | 61.97 | 7.62 | 60.66 | 47.57 | 580.01 | 16.11 |
| $T_2$: 40% RDF | 63.52 | 9.35 | 65.75 | 52.12 | 983.02 | 27.34 |
| $T_3$: 60% RDF | 65.73 | 10.31 | 67.56 | 54.64 | 1033.47 | 28.70 |
| $T_4$: 80% RDF | 67.93 | 12.09 | 68.35 | 55.96 | 1128.41 | 31.34 |
| $T_5$: 100% RDF | 70.47 | 13.29 | 72.98 | 58.50 | 1208.49 | 33.50 |
| $T_6$: 120% RDF | 69.35 | 12.50 | 69.51 | 56.36 | 1180.08 | 32.71 |
| SE (m) ± | 0.41 | 0.25 | 1.19 | 0.73 | 9.75 | 0.27 |
| $CD_{0.05}$ | 1.21 | 0.73 | 3.50 | 2.17 | 28.75 | 0.81 |

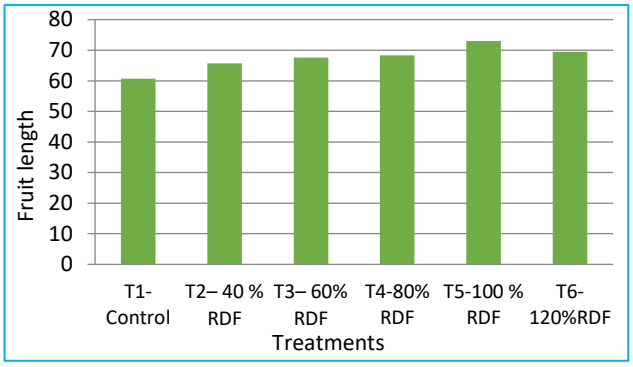


Fig 4.1 Effect of different levels of fertigation on fruit length (mm) of capsicum

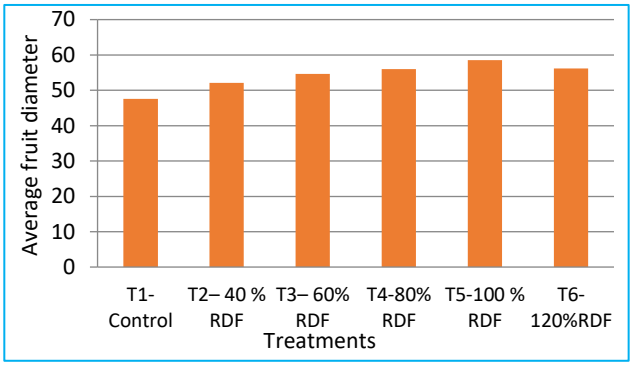


Fig 4.2 Effect of different levels of fertigation on fruit diameter (mm) of capsicum

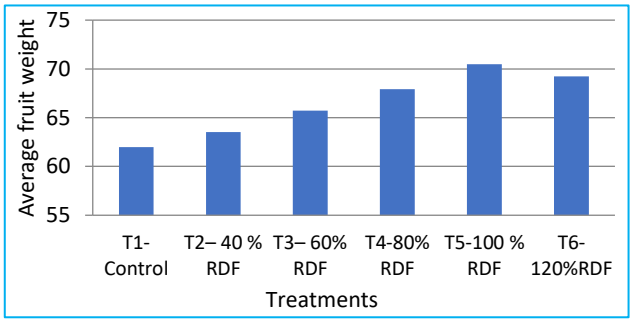


Fig 4.3 Effect of different levels of fertigation on average fruit weight of capsicum

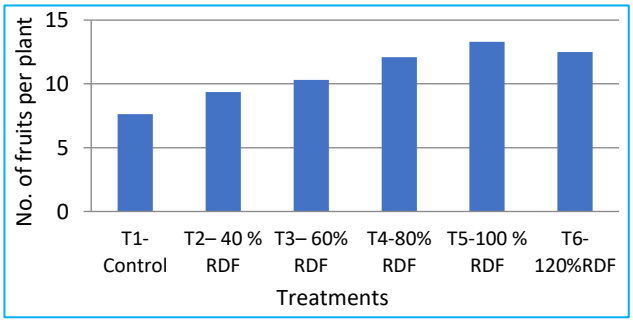


Fig 4.4 Effect of different levels of fertigation on number of fruits per plant of capsicum

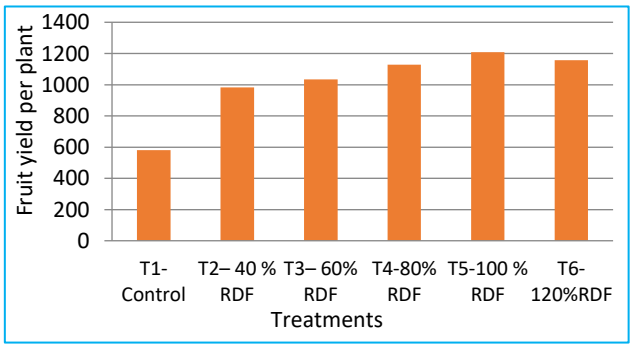


Fig 4.5 Effect of different levels of fertigation on fruit yield per plant of capsicum

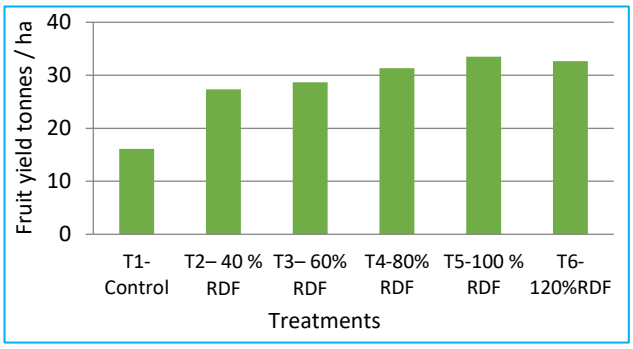


Fig 4.6 Effect of different levels of fertigation on fruit yield tonnes per hectare of capsicum

Table 5 Economics of various treatments in capsicum cv. Indira production

| Treatments | Total cost of cultivation (Rs. ha$^{-1}$) | Gross returns (Rs. ha$^{-1}$) | Net return (Rs. ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|
| $T_1$: Control | 16.11 | 623656.01 | 966600 | 392943.99 |
| $T_2$: 40% RDF | 27.34 | 624642.73 | 1640400 | 1065757.27 |
| $T_3$: 60% RDF | 28.70 | 625210.01 | 1722000 | 1096789.99 |
| $T_4$: 80% RDF | 31.34 | 625728.01 | 1880400 | 1254671.99 |
| $T_5$: 100% RDF | 33.50 | 626036.01 | 2010000 | 1383963.99 |
| $T_6$: 120% RDF | 32.71 | 626512.01 | 1959600 | 1334087.99 |
| SE (m) ± | 16.11 | 623656.01 | 966600 | 392943.99 |
| $CD_{0.05}$ | 27.34 | 624642.73 | 1640400 | 1065757.27 |

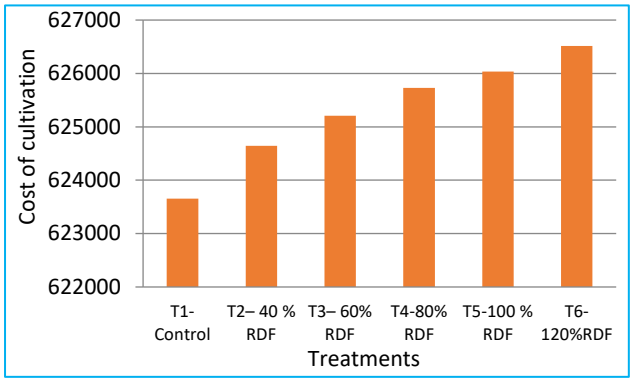


Fig 5.1 Effect of different levels of fertigation on cost of cultivation (Rs/ha) of capsicum

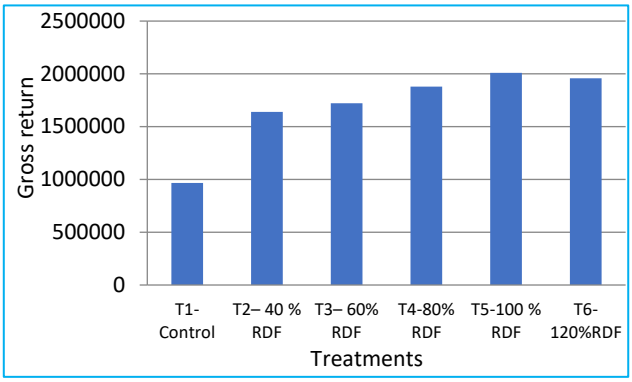


Fig 5.2 Effect of different levels of fertigation on gross income (Rs/ha) of capsicum

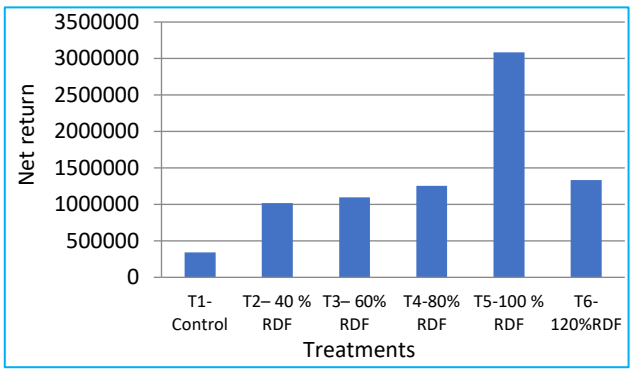


Fig 5.3 Effect of different levels of fertigation on net return (Rs/ha) of capsicum

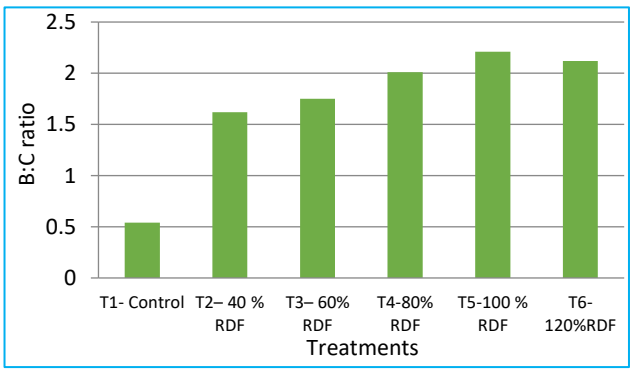


Fig 5.4 Effect of different levels of fertigation on B:C ratio of capsicum

*Effect on yield parameters*

The primary goal of crop cultivation is to maximize production for better returns and various fertigation levels showed great impact on yield parameter. The yield performance of Indra hybrid of capsicum was influenced by different fertigation level was depicted in (Table 4, Fig 4.1, 4.2, 4.3, 4.4, 4.5, 4.6) respectively. Fruit length and diameter is the most desired marketable and commercial character in capsicum. The maximum average fruit length (72.98 mm) and fruit diameter (58.50 mm) were recorded in treatment $T_5$ (100%). Whereas minimum fruit length (60.66 mm) and diameter (47.57 mm) was recorded in treatment $T_1$ (control) which receiving no fertigation. The reason could be the accumulation of carbohydrates due to greater photosynthesis which further results into the increase in diameter and length of fruit [19]. Treatment $T_5$ (100%) fertigation resulted maximum (70.47 g) fruit weight. The possible reason is due to favourable effect of soluble fertilizer applied in active root zone and resulted in overall better growth of plant and ultimately increases average weight of fruit [20]. However, minimum fruit weight (61.97g) was under $T_1$ (control). The maximum number of fruits plant$^{-1}$ (13.29) was recorded with application $T_5$ (100%). It might have been produced by optimal cytokinin synthesis at high N and P levels, which led to the setting of more fruit plants$^{-1}$ by producing more productive flowers. Whereas, minimum fruits plant$^{-1}$ (7.62) was recorded in treatment $T_1$(control). The maximum fruit yield (1208.49 g plant$^{-1}$ and 33.50 t ha$^{-1}$) was obtained with the application $T_5$ (100%). This is because there is more moisture available and fertigated nutrients are evenly distributed in the crop root zone throughout all growth phases, which improves nutrient uptake and increases fruit output per hectare [21-22]. The lowest yield (580.01 g plant$^{-1}$ and 16.11 t ha$^{-1}$) was recorded in control conditions.

*Effect on crop economics*

Observation on economics of various treatments was displayed in (Table 5, Fig 5.1, 5.2, 5.3, 5.4) respectively. The cost of cultivation, gross income, net return and B:C ratio of capsicum treatment wise calculated for one season for an area of one hectare in partial controlled polyhouse. The net realization of treatments was largely dependent upon marketable yield and market price. Higher cost of cultivation (626512.01 Rs ha$^{-1}$) was recorded in treatment $T_6$ (120%) with BCR of (2.12) however, minimum cost of cultivation was recorded in treatment $T_1$ (Control). Treatment $T_5$ (100%) was recorded as best treatment exhibiting maximum BCR of (2:21) with gross and net realization of (2010000 Rs ha$^{-1}$ and 1383963.99 Rs ha$^{-1}$) respectively [23].

## CONCLUSION

From this study it is concluded that growing capsicum under polyhouse with fertigation works better with the approach of 120 % recommended dose of NPK performs better in terms of growth parameters like plant height, plant diameter, leaf length, and leaf diameter, as well as days to first flowering, days to first picking, and harvest duration. Yield parameters like average fruit weight, number of fruits per plant, fruit length, fruit diameter, fruit yield per plant and per hectare performed better with 100% NPK. In order to achieve the highest fruit output per unit area in commercial production of capsicum, it may be recommended to apply the 100% of NPK following on-farm testing findings.

***Competing interest***

*Authors have declared that no competing interests exist.*

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