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Effect of Different Levels of Fertigation on Cucumber (*Cucumis sativus* L.) Production Grown under Polyhouse Condition

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Abstract

The present research entitled "Studies on effect of different levels fertigation on cucumber (*Cucumis sativus* L.) Production grown under polyhouse cultivation" was carried out 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. The treatments consisted of T_1: control, T_2: 50% Fertigation, T_3: 75% Fertigation, T_4: 100% Fertigation, T_5: 125% Fertigation. Application of different levels of fertigation increased the growth, yield, quality of cucumber along with soil parameters. The maximum plant height (4.16m), number of primary branches (15.60), leaf length (22.28 cm), leaf diameter (15.06 cm), days to first flowering (29.80), days to 50% flowering (38.00) days to first picking (44.20) were recorded maximum with the application of 125% fertigation., Number of fruits per plant (14.39), fruit length(17.00 cm), fruit diameter (4.13 cm), average fruit weight (155.32 g), fruit yield per plant (2.00 kg), fruit yield per hectare (60.13 t), fruit pH (5.55), TSS (4.19 °B), Titrable acidity (0.12 %), fruit firmness (4.42 kg cm^{-2}), ascorbic acid (6.32 mg/100g), were recorded with the application of 100% fertigation. Whereas, soil pH (7.02) electrical conductivity (0.36 ds/m), organic carbon (0.77%), available nitrogen (290.21 kg/ha), available phosphorus (23.23 kg/ha), available potassium (160.43 kg/ha) were recorded maximum with the application of 100% fertigation. The treatment T_4: 100% RDF also produces the highest cost of cultivation (313093.75), gross income (1322860.00), net returns of Rs. (1010366.25) along with benefit : cost ratio (3:23). These results suggested that optimum production of cucumber can be obtained with application of 100% RDF through fertigation.

***Key words*:** *Cucumis sativus*, Fertigation, Growth, Polyhouse, Quality, Yield

Within the family Cucurbitaceae, the cucumber (*Cucumis sativus* L.) also referred to as "Khira," is the most lucrative vegetable crop farmed under protected cultivation methods worldwide [1]. It is found in about 117 taxa and 825 species globally. Cucumbers rank as the fourth most important vegetable, after potatoes, tomatoes, and onions. It is one of the oldest vegetable crops, having been grown in India for over three millennia [2]. Cucumbers have high water content (96%) and are naturally low in fat, cholesterol, calories, carbs, and sodium.

It has 45 calories, 2 grams of protein, several minerals (140 mg calcium, 30 mg phosphorus, and 0.6 mg iron), 2 grams of fibre, 11 grams of carbs, and 4.0 mg vitamin C. Cucumbers also contains antioxidants that may reduce the risk of cancer and heart, lung and autoimmune disease. It also helps in lowering blood sugar, prevent constipation and support weight loss [3]. Around 2,261,318 hectares area is covered by cucumber with a production of 80616 thousand metric tons and production of 1,258.27metric tonnes per hectare across the world [4]. In India, it is grown in an area of 74 thousand hectares with a production of 1068 metric tons [5]. In Punjab, it is an important cash crop and are grown in an area of about 13.41 thousand hectares with an annual production of 108.71 thousand tonnes [6]. The most modern method for increasing the quality and quantity of crops produced is greenhouse or sheltered cultivation. Over the past few decades, its use has significantly increased on a global scale. The controlled microclimate of the farmed region with high productivity, water and land conservation, and environmental preservation is often referred to as protected cultivation [7]. Water stress is an important component since fruit production loss was higher in conditions of optimal water supply [8]. However, excessive cucumber water application might also result in a reduction in production. The amount of irrigation had a good impact on fruit characteristics such as length, diameter and weight [9]. In the production of vegetable crops under a greenhouse, the employment of contemporary methods like spray irrigation and drip irrigation restricts the development of the plant's root system and then focuses on the moistness of the root zone. So, during key times when crops are in need of nutrients, there should be a regular supply of irrigation water and fertilizers (fertigation) for the root zone soil [10]. Fertigation is defined as the application of fertilizers along with irrigation. Fertigation is the most efficient method of fertilizer application, as it ensures the application of the fertilizers directly to the plant roots [11]. One of the most widely used methods of fertilization is fertigation, which involves the application of liquid or solid fertilizer via a drip irrigation system. Fertilizer needs to be

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applied frequently, in small amounts, at regular intervals to maximize water utilization and deliver nutrients to the plant's root zone. The kind of soil, crop, area, irrigation technique, water quality, types of fertilizers available, and viability from an economic standpoint all affect the amount of fertigation. Owing to indeterminate growth, the vegetative and reproductive stages overlap in naturally ventilated polyhouses (NVPs), and for optimal growth and development, nutrient requirements extend to the fruit ripening stage.

By controlling the amounts of fertilizer applied through irrigation water, it is possible to maximize crop output and quality while minimizing nutrient loss below the rooting zone. According to Sivanappan and Ranghaswami [12], when fertilizer is administered using drip irrigation, the yield rises and 30% of the fertilizer can be conserved.

MATERIALS AND METHODS

The study was carried out in partially ventilated Poly-house of Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India, during 2021 and 2022. The experimental material comprised of F_1 hybrid of cucumber named Multistar RZ F_1 produced by Rijkzwaan India seeds Pvt. Ltd which is recommended for cultivation in month of January to February and May to June in plain conditions. Raised beds of 17 m×1 m were prepared with a walking space of 60 cm between beds. Afterwards the seeds were sown on 2nd February, 2022 at the depth of 1-2 cm with seed rate 2.5 kg/ha and spacing of 60×60 cm within and Zigzag system of planting was followed to have more aeration space between the plants. The recommended dose of fertilizer i.e. 150 kg N7 + 5 kg P + 75 kg ha^{-1} K applied in the form of split doses containing an equal amount of fertilizer in each application. Fertigation was done on alternative days by drip irrigation. All the recommended cultural practices were followed on time to ensure 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 laid out in randomized block design with five replications comprising of five treatments combination i.e. T_1: Control (No RDF), T_2: 50% RDF of NPK, T_3: 75% RDF of NPK, T_4: 100% RDF of NPK and T_5: 125% RDF of NPK. Observations were recorded on three competitive plants in each replication and average was calculated. 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 and days to first flowering, days to First picking, harvest duration (days), average fruit weight (g), number of fruits per plant, fruit length (mm), fruit diameter (mm), fruit yield per plant (g), fruit yield per hectare (t), harvest index (%) were taken at harvest. The data pertaining to attributes were statistically analyzed as per design of experiment and treatments mean was tested at 5% level of significance [13].

RESULTS AND DISCUSSION

Effect on growth parameter

A perusal of the data revealed that there was significant effect of various treatments on growth parameters. 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 sowing (DAS) presented in (Table 1-2).

Table 1 Effect of different levels of fertigation on plant height (m) and number of primary branches of cucumber

Treatments	Plant height (m)				Number of primary branches			
	30 Days	60 Days	90 Days	At harvest	30 Days	60 Days	90 Days	At harvest
T_1: Control	0.08	0.65	1.06	1.98	1.40	2.40	4.40	7.40
T_2: 50% RDF	0.11	0.93	1.63	2.44	1.80	3.60	7.40	10.60
T_3: 75% RDF	0.12	1.13	2.10	3.57	2.00	5.20	9.40	12.20
T_4: 100% RDF	0.13	1.57	2.72	3.93	2.20	6.80	11.20	13.60
T_5: 125% RDF	0.14	1.75	3.01	4.16	2.60	7.80	12.60	15.60
SE (m)±	0.02	0.06	0.11	0.09	0.39	0.50	0.48	0.68
CD $_{(0.05)}$	0.05	0.19	0.32	0.27	1.16	1.51	1.45	2.04

Table 2 Effect of different levels of fertigation on leaf length (cm) and leaf diameter (cm) of cucumber

Treatments	Leaf length (cm)				Leaf Diameter (cm)			
	30 Days	60 Days	90 Days	At harvest	30 Days	60 Days	90 Days	At harvest
T_1: Control	2.06	7.65	8.44	9.05	2.06	4.66	6.85	7.87
T_2: 50% RDF	2.62	9.64	13.64	14.06	2.58	7.65	9.67	11.45
T_3: 75% RDF	3.08	10.66	16.04	16.08	2.82	9.24	10.86	12.65
T_4: 100% RDF	3.17	12.04	19.62	20.85	3.02	11.13	12.84	14.46
T_5: 125% RDF	3.55	13.23	21.29	22.28	3.46	12.24	14.05	15.06
SE (m)±	0.43	0.52	0.58	0.63	0.44	0.54	0.45	0.27
CD $_{(0.05)}$	1.28	1.55	1.74	1.88	1.30	1.63	1.33	0.80

At 30 DAS, maximum plant height (0.48m), number of primary branches (4.20), leaf length (9.24 cm) and leaf diameter (8.34 cm) was found maximum in treatment T_5 (125%) whereas minimum plant height (0.08m), number of primary branches (1.40), leaf length (2.06 cm) and leaf diameter (2.06 cm) was recorded in control treatment (T_1). At 60 DAS, maximum plant height (1.75m), number of primary branches (7.80), leaf length(13.23cm) and leaf diameter (12.24 cm) was found maximum in treatment T_5 (125%) whereas minimum plant height (0.65m), number of primary branches (2.40), leaf length (7.65 cm) and leaf diameter (4.66 cm) was recorded in control treatment (T_1). At 90 DAS, maximum plant height (3.01m), number of primary branches (12.60), leaf length (21.29 cm) and leaf diameter (14.05 cm) was found maximum in treatment T_5 (125%) whereas minimum plant height (1.06 m), number of primary branches (4.40), leaf length (8.44 cm) and leaf diameter (6.85 cm) was recorded in control treatment (T_1). At harvest the maximum plant height (4.16m), number of primary branches (15.60), leaf length (22.28 cm) and leaf diameter (15.06 cm) was found maximum in treatment T_5 (125%) whereas minimum plant height (1.98 m), number of primary branches (7.40), leaf length (9.05 cm) and leaf diameter (7.87 cm) was recorded in

control treatment (T_1). This might be due to better nutritional environment in the root zone for the growth and development of the plants as nitrogen and phosphorus are considered as major nutrients required for proper growth and development of the plant. Beside this, nitrogen is main constituent of protoplasm, cell nucleus, amino acids, chlorophyll and many other metabolic processes like transpiration [14]. Another possible reason may be due to the increasing levels of nitrogen and phosphorus through drip restricted fertilizers to the wetted zone of soil where the active roots are concentrated thus, leads to better utilization of nutrients, their uptake and enhanced vegetative growth [15]. 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 is represented in (Table 3). Among the all treatments, early flower initiation (29.80 days) was recorded under T_5 (125%) which was significantly superior over the other treatments. The maximum days for flower initiation (40.40 days) were recorded under T_1 (control). This may be due to the better nutrition environment in the root zone for growth and development of the plant and due to frequent and increased application of fertilizers directly in the vicinity of the root zone increases the availability and uptake of nutrients which leads to increase the cell size and cell elongation resulted in healthy and vigorous plant growth. These results were in accordance with Sharma *et al.* [16] in cucumber. However, minimum days taken for first picking of fruits (44.20) were recorded under T_5 (125%) which was significantly at par with T_4 (100%). The maximum days taken for picking of fruits (56.00) was observed in T_1 (control). Because the higher dose of NPK promotes vegetative growth and improves vegetation and delay lower initiation and application of 100% recommended dose of fertilizers might have provided balanced nutrition and brought better growth, development and promoted early flowering and timely first picking [17-18].

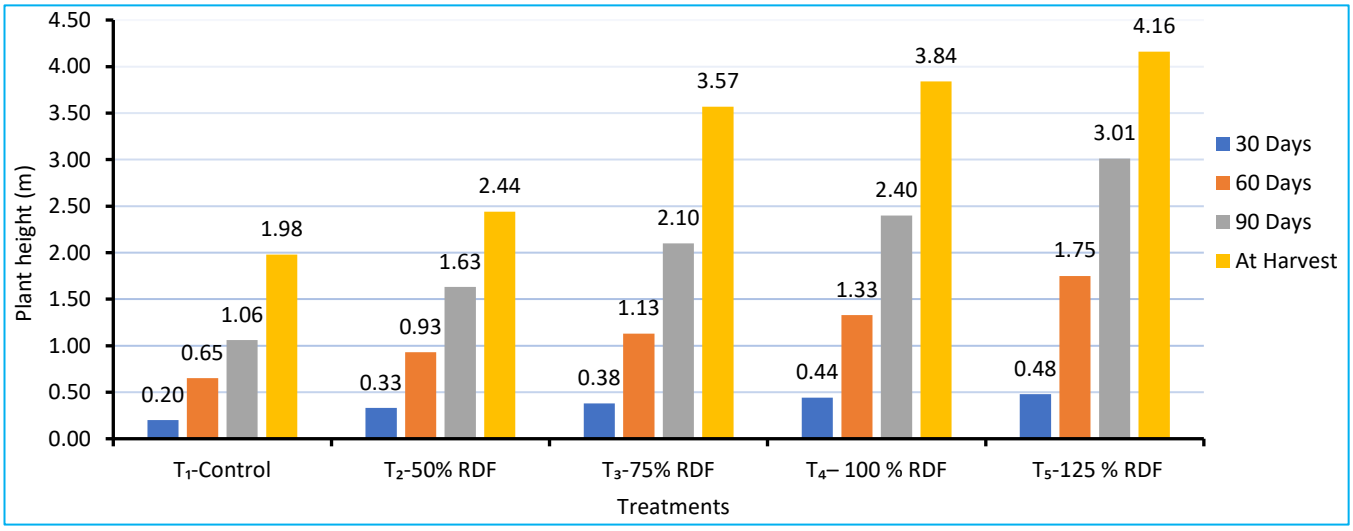

Fig 1.I Effect of different levels of fertigation on plant height (m) of cucumber

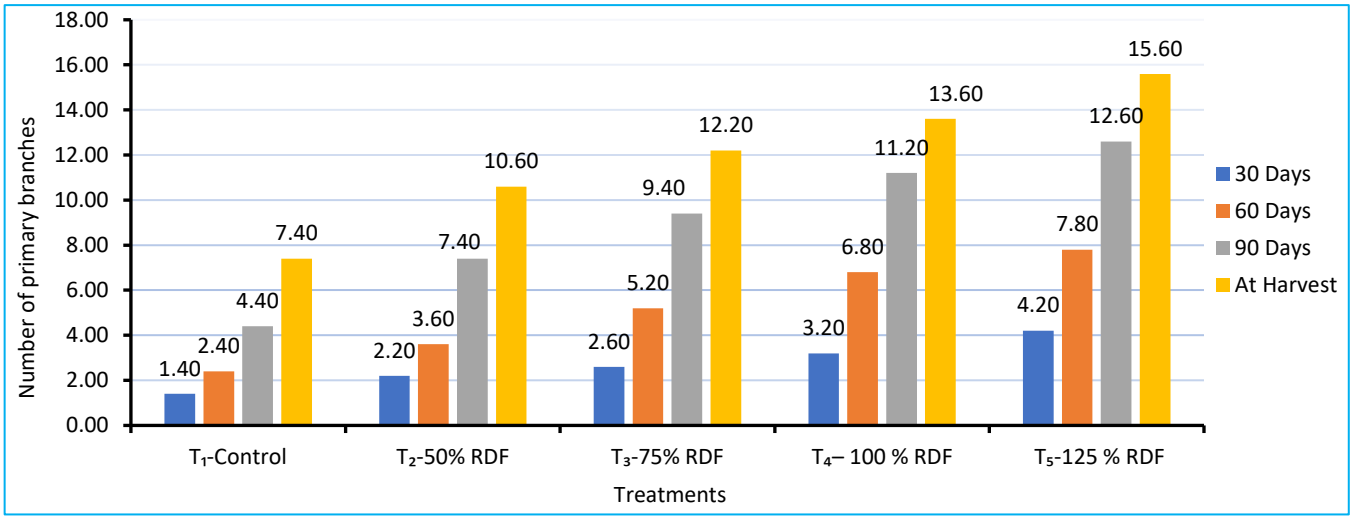

Fig 1.II Effect of different levels of fertigation on number of primary branches of cucumber

Table 3 Effect of different levels of fertigation on growth parameters of cucumber

Treatments	Days to first flowering	Days to 50% flowering	Days to first picking
T_1: Control	40.40	49.60	56.00
T_2: 50% RDF	35.00	42.60	51.20
T_3: 75% RDF	33.60	40.80	48.80
T_4: 100% RDF	31.20	39.60	45.00
T_5: 125% RDF	29.80	38.00	44.20
SE (m)±	0.83	1.20	0.74
CD $_{(0.05)}$	2.49	3.60	2.22

Table 4 Effect of different levels of fertigation on yield parameters of cucumber

Treatments	Average fruit weight (g)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit yield per plant (kg)	Fruit yield per hectare (t)	Harvest index (%)
T_1: Control	142.29	8.18	12.37	2.98	1.16	35.90	51.49
T_2: 50% RDF	149.39	11.28	13.84	3.22	1.51	45.19	58.79
T_3: 75% RDF	151.86	12.35	14.58	3.42	1.59	49.39	69.18
T_4: 100% RDF	155.32	14.39	17.00	4.13	2.00	60.13	86.72
T_5: 125% RDF	153.27	13.48	16.16	3.94	1.86	55.93	77.20
SE (m)±	1.23	0.30	0.46	0.06	0.08	2.30	7.40
CD $_{(0.05)}$	3.70	0.91	1.39	0.19	0.25	6.90	22.19

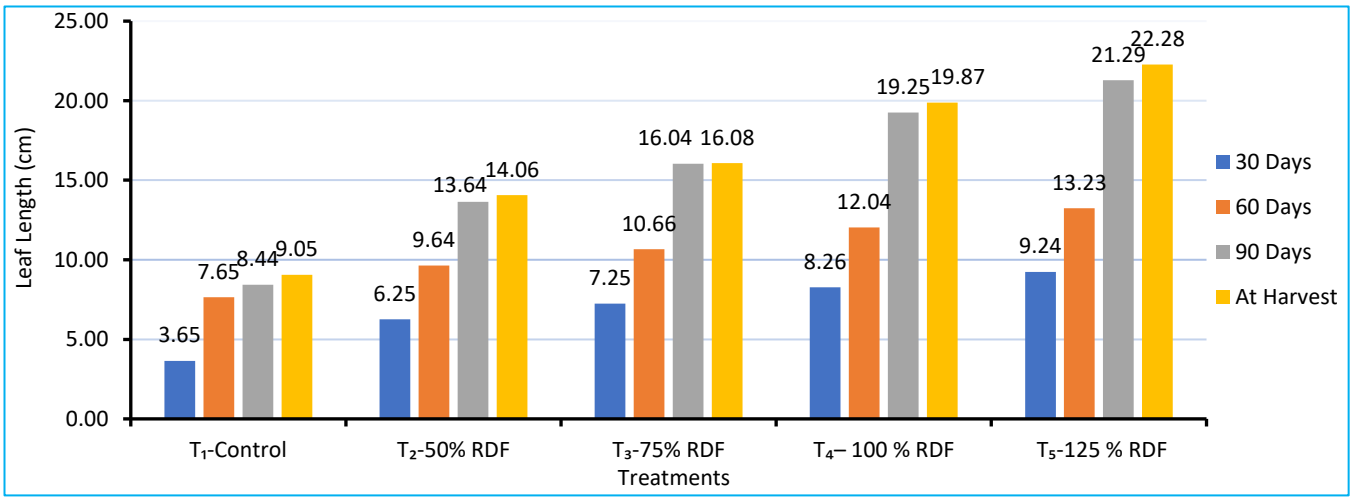

Fig 2.I Effect of different levels of fertigation on plant height (m) of cucumber

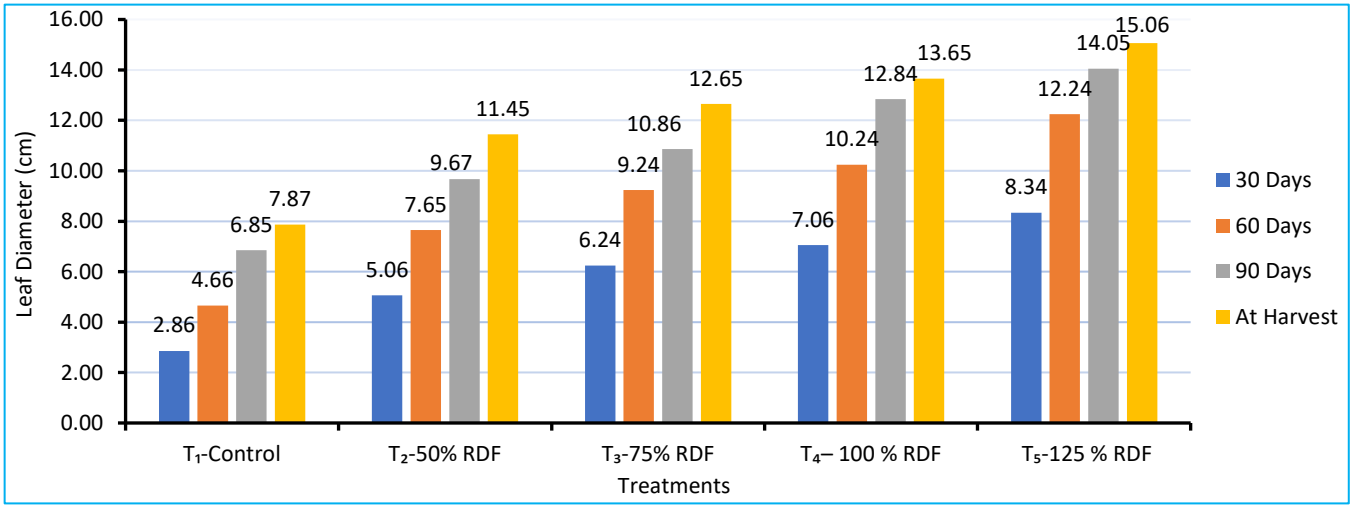

Fig 2.II Effect of different levels of fertigation on number of primary branches of cucumber

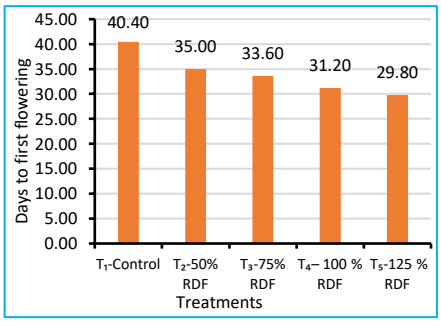

Fig 3.I Effect of different levels of fertigation on days to first flowering of cucumber

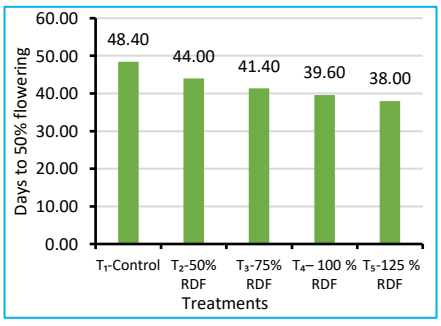

Fig 3.II Effect of different levels of fertigation on days to 50% flowering of cucumber

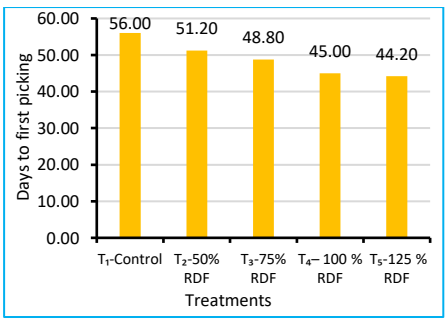

Fig 3.III Effect of different levels of fertigation on days to first picking of cucumber

Effect on yield parameters

The main focus of cultivating a crop is to have maximum yield for better returns and the fertigation level of 100% recommended dose of fertilizer exhibited maximum fruit yield. The maximum average fruit length (17.00 cm) and fruit diameter (13.04 cm) were recorded in treatment T_4 (100%).

Whereas minimum fruit length (13.61 cm) and diameter (2.98 cm) was recorded in treatment T_1 (control) with no fertigation. It was possible due to supply of nutrients through fertigation in the required duration has helped in efficient uptake resulting in increased length and girth of the fruits [19-21]. Treatment T_4 (100%) fertigation resulted maximum (155.32 g) fruit weight. It is may be due to the increase supply of nutrients through increased fertigation level in the root vicinity of plant maintain optimum nutrient concentration in the root zone throughout the crop growth period, which increases the uptake of moisture and nutrients resulted in increasing the average fruit weight of cucumber [22]. The fruit weight was increased with increasing the fertigation level also reported by [23] in cucumber. However, minimum fruit weight (142.29 g) was under T_1 (control) as depicted in (Table 4). Maximum number of fruits plant^{-1}(14.39) was recorded with application T_4(100%). It may be obtained due to an optimum level of synthesis of cytokinin at high level of N and P that resulted in setting of more number of productive flowers ultimately resulted in setting of more number of fruits plant^{-1}. Whereas, minimum fruits plant^{-1} (8.18) was recorded in treatment T_1 (control). The maximum fruit yield (2.00 Kg plant^{-1} and 60.13 t ha^{-1}) was observed with the application T_4 (100%). which is due to improved availability of moisture, nutrients and uniform distribution of fertigated nutrients in the crop root zone throughout the growth stages leading to the better uptake of nutrients [24-25]. The lowest yield (1.16 Kg plant^{-1} and 35.90 t ha^{-1}) was recorded in control conditions.

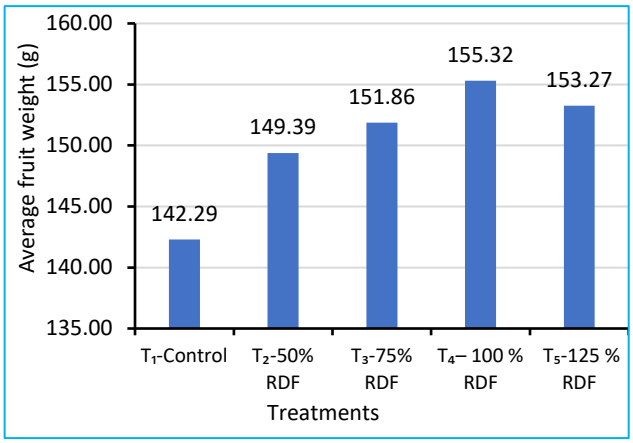

Fig 4.I Effect of different levels of fertigation on on yield parameters of cucumber

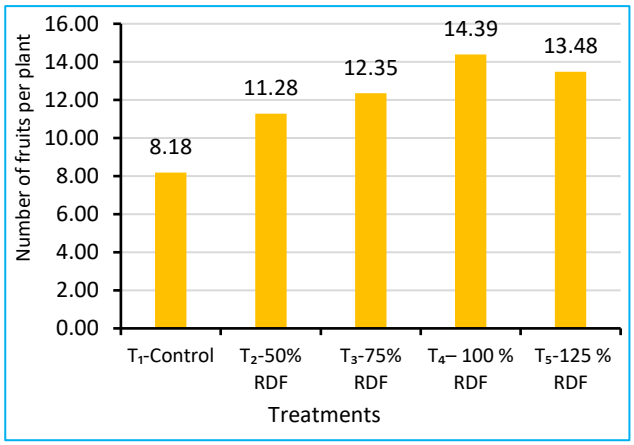

Fig 4.II Effect of different levels of fertigation on on yield parameters of cucumber

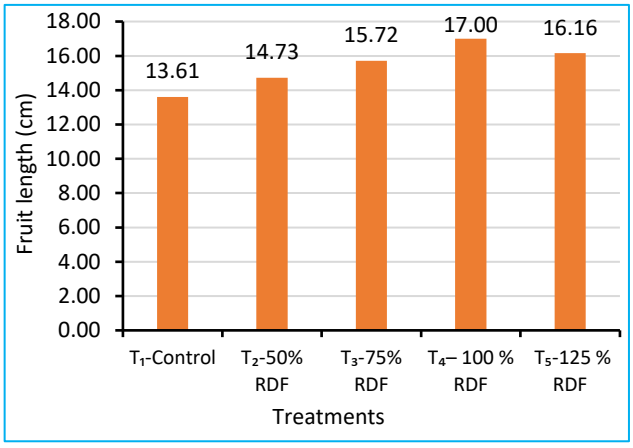

Fig 4III Effect of different levels of fertigation on yield parameters of cucumber

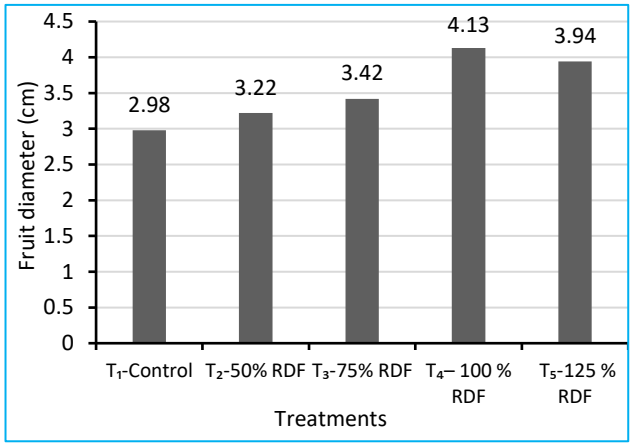

Fig 4.IV Effect of different levels of fertigation on yield parameters of cucumber

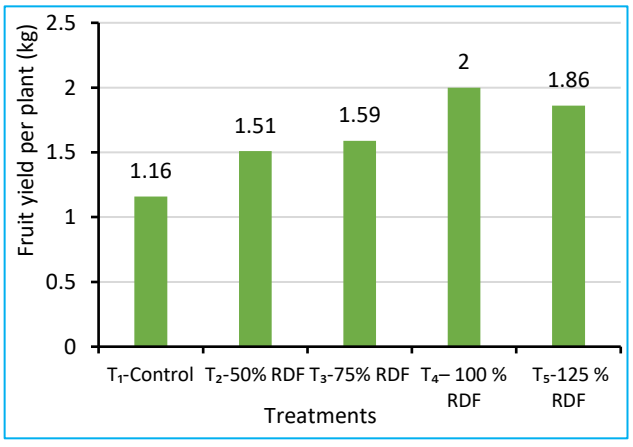

Fig 4.V Effect of different levels of fertigation on yield parameters of cucumber

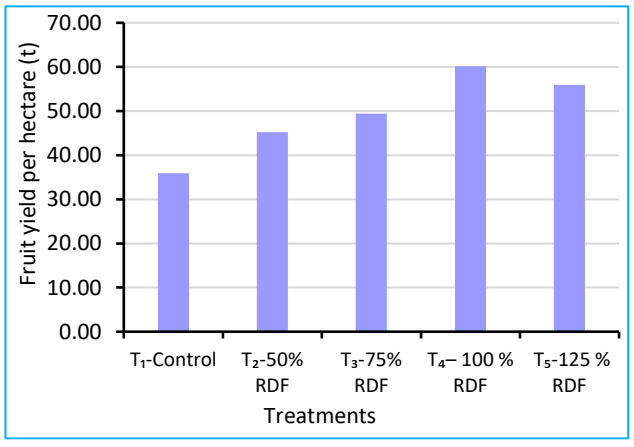

Fig 4 VI Effect of different levels of fertigation on yield parameters of cucumber

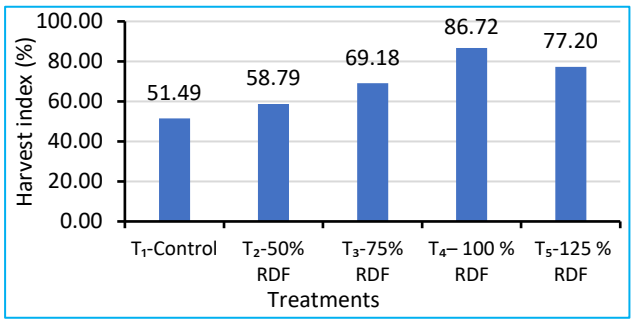

Table 7.VII Effect of different levels of fertigation on yield parameters of cucumber

Effect on crop economics

Observation on economics of various treatments were presented in (Table 5). The cost of cultivation, Gross return, Net return and B:C ratio of the cucumber production, as affected by various treatments revealed that maximum net returns and benefit: cost ratio was computed by the application of 100% fertigation level. Higher cost of cultivation (313093.75 Rs ha^{-1}) was recorded in treatment T_5 i.e. (125%) with B:C of (2.95) however, minimum cost of cultivation was recorded in treatment T_1 (Control). Treatment T_4 (100%) was observed as best treatment exhibiting maximum B:C of (3.23) with gross and net return of (1322860.00 Rs ha^{-1} and 1010366.25 Rs ha^{-1}) respectively [26-27].

Table 5 Effect of different levels of fertigation on economic parameters of cucumber

Treatments	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio (B:C)
T_1: Control	2,59,893.75	7,18,000.00	4,58,106.25	1.76
T_2: 50% RDF	2,61,193.75	9,03,800.00	6,42,606.25	2.46
T_3: 75% RDF	2,61,893.75	9,87,800.00	7,25,906.25	2.77
T_4: 100% RDF	2,62,493.75	12,02,600.00	9,40,106.25	3.58
T_5: 125% RDF	2,63,093.75	11,18,600.00	8,55,506.25	3.25

*Data in parentheses is original and transform by (√ x + 0.5)

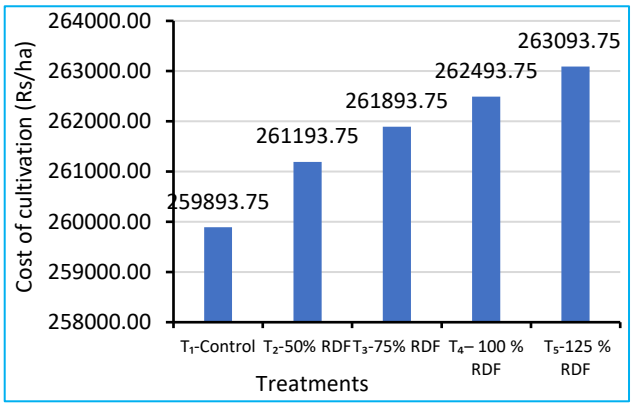

Fig 5.I Effect of different levels of fertigation on economic parameters of cucumber

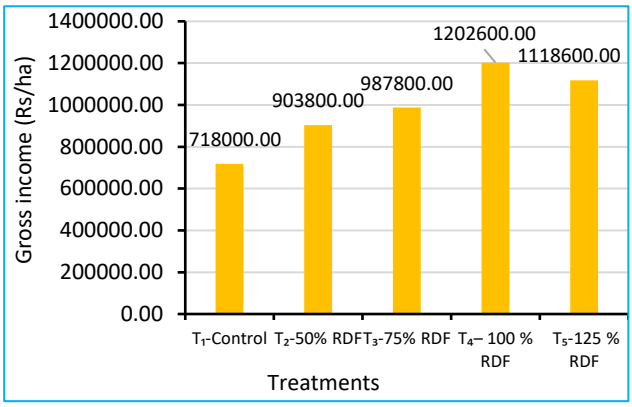

Fig 5.II Effect of different levels of fertigation on economic parameters of cucumber

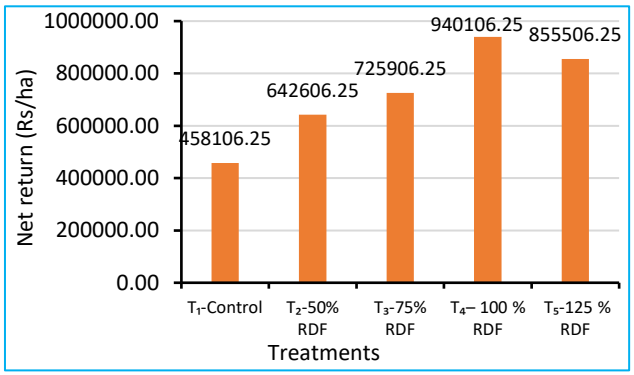

Fig 5.III Effect of different levels of fertigation on economic parameters of cucumber

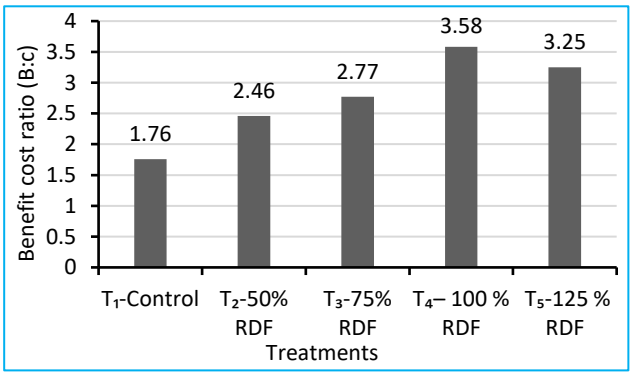

Fig 5.IV Effect of different levels of fertigation on economic parameters of cucumber

CONCLUSION

The findings from this study highlight the importance of optimizing NPK fertilizer application for enhancing cucumber growth and yield. The results indicate that applying 125% of the recommended NPK dose has a significant positive impact on various growth parameters, including plant height, leaf length, leaf diameter, number of primary branches, and the timing of key phenological events such as the days to first flowering, days to 50% flowering, and days to first picking. Additionally, the harvest index was also favorably influenced by this higher dosage, suggesting that the enhanced nutrient availability during critical growth stages can lead to more robust vegetative growth and potentially earlier crop maturation. However, when assessing yield-related parameters, a different trend emerged. The study found that the application of 100% of the recommended NPK dose resulted in superior performance concerning average fruit weight, the number of fruits per plant, fruit length, fruit diameter, and overall fruit yield per plant and per hectare. This suggests that while an

increased NPK dosage may promote vegetative growth, it does not necessarily translate to higher fruit yields. Instead, the standard NPK recommendation appears to be optimal for maximizing yield in cucumber cultivation. Given these observations, the study suggests that the application of 100% of the recommended NPK dose is sufficient and potentially more effective for achieving the best yield outcomes in cucumber production. However, it is advised that this recommendation be validated through on-farm testing in different environmental and soil conditions to ensure its consistency and reliability across various contexts. Such trials would help confirm that this NPK regimen can reliably maximize fruit yield per unit area, making it a practical recommendation for commercial cucumber cultivation.

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LITERATURE CITED

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