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Comparative Study of Irrigation and Fertigation Strategies on Performance of Papaya (*Carica papaya* L.) Under Shade Net House

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Abstract
Experimental conducted aimed to entitle "Comparative Study of Irrigation and Fertigation Strategies on Performance of Papaya (*Carica papaya* L.) Under Shade Net House" was carried out at the Agriculture Farm (Horticulture), Career Point University, Alaniya, Kota during 2024-2025. The experiment was laid out in Factorial Randomized Block Design three replication with 09 treatment combinations, comprising like Factor- A treatments isI_1- Drip Irrigation IE/CPE- 0.4 ECP, I_2Drip Irrigation IE/CPE- 0.6 ECP, I_3- Drip Irrigation IE/CPE- 0.8 ECP. Factor -BRDF is F_1-60% RDF through fertigation and F_2-80% RDF through fertigation and F_3- 100% RDF through fertigation.
The application of irrigation on productivity was found most effective improve success all parameters of papaya. Plant height was found to be maximum (113.71, 154.90, 199.58 cm), maximum number of leaves (33.10, 54.28 and 68.78), The maximum number of fruit (20.24 fruit per plant), The maximum d fruit weight (0.910 g) Fruit yield was found to be maximum (18.42 kg /plant) Highest TSS (11.20 ^{0}brix) and the ascorbic acid was found to be maximum (44.95 mg/100) under treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP).
Fertilization RDF significantly height plant height was found to be maximum (114.95, 151.04 and 203.90 cm) number of leaves be maximum (30.64, 52.70 and 66.85), Number of fruit was found to be maximum (19.46 fruit per plant), fruit weight maximum (0.877 g), Fruit yield be maximum (17.07 kg/plant) Fertilization RDF significantly height plant height was found to be maximum (114.95, 151.04 and 203.90 cm) number of leaves be maximum (30.64, 52.70 and 66.85), Number of fruit was found to be maximum (19.46 fruit per plant), fruit weight maximum (0.877 g), Fruit yield be maximum (17.07 kg/plant) TSS was found to be maximum (10.60 ^{0}brix), ascorbic acid was found to be maximum (41.27 mg/100)under treatmentF_3 (100% RDF through fertigation).
Interaction effect of fertigation and RDF were recorded maximum plant height (125.33, 157.83 and 217.72 cm), highest number of leaves (34.85 and 57.54), maximum number of fruit (21.76), maximum fruit weight (1.07 kg), maximum fruit yield (23.28 kg), maximum TSS (11.66 ^{0}brix) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation.

Keywords: Irrigation and fertigation papaya

Introduction
Papaya (*Carica papaya* L.) is one of the important delicious fruit crops grown in tropical and sub-tropical parts of the world, covering 32 ^{0}N and S latitudes on the globe. It can be grown up to 1000 m above mean sea level. Papaya fruit receded one of the highest production of fruits per hectare and an income next to banana.

Due to its great degree of unpredictability, the climate is the most significant component in agricultural output; thus, a protected environment can alter the atmosphere in which the crops are grown. (Iizumi *et al*., 2015) [6]. It is important to assess the conditions under which plants are grown and to keep in mind that environmental elements affect the fruit's quality. (Martínez *et al*., 2017) [8]. Some of the environmental that have an important effect on temperature and relative humidity.
Fertigation is the application of fertilizer through micro irrigation systems. Irrigation with use of fertilizer is permits application of various fertilizer formulations directly at the site of active root zone area of plant. Elfving, (1982) [4] found that drip irrigation with fertilizer is much more precise than other methods at delivering nutrients to the root where it can be effectively utilized and therefore, resulting in greater uptake and use efficiency.

In Irrigation with use of fertilizer nutrient use efficiency have as a high as 90-95 per cent as compared to conventional methods (Solaimalai *et al*., 2005). In addition it saves the fertilizers, time and labour. Generally crop response to fertilizer application through drip irrigation has been excellent. So far as papaya is concerned, its demand for nitrogen, phosphorus and potassium under conventional method of fertilization is high, which can be considerably slashed when applied through drip in small quantities at frequent intervals in accordance to crop need. Chaudhri *et al*. (2001) [2] found 50 per cent saving of fertilizer and 53 per cent water saving with substantial increase in yield of papaya. Because papaya is an indeterminate crop, its vegetative and reproductive stages overlap, and it need nutrients all the way up to the fruit ripening stage for optimal growth and fruit size, fertigation works wonders for papaya.

Flexible and precise fertilizer application is another potential advantage of the drip system. Fertigationthe application of fertilizer through micro irrigation systems. Fertigation permits application of various fertilizer formulations directly at the site of active root zone area of plant. Elfving (1982) [4] found that Fertilizer applied by drip irrigation is far more accurate than other techniques in getting nutrients to the root where they may be used efficiently, increasing absorption and usage efficiency.

Materials and Methods

The research was conducted at Research Farm Department of Horticulture, School of Agriculture Science, Career Point University Kota, India. Variety used in research Red Lady period of experiment work 5 Month. The site is situated in Humid South Eastern Plain Zone V which falls in south eastern part of Rajasthan and covers geographical area of 26.43 lakh ha and represents 7.71 per cent of the total geographical area of the state. The zone is located between $23^0 45'$ and $26^0 33'$ North latitudes and $75^0 27'$ and $77^0 26'$ East longitudes. The experiment was laid out in Factorial Randomized Block Design. Replicated thrice with nine treatment combination of drip Irrigation with RDF and through fertigation.

Results and Discussion

- **Growth parameters**

The height of papaya plant growth was recorded significant increased. Plant height was found to be maximum (113.71, 154.90, 199.58 cm) at 150, 200 and 250 DAT, under treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP), which was at par with I_2. The minimum plant height (107.26, 137.00 and 183.71 cm) at 150, 200 and 250 DAT was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP)

A data presented to reveals that the significantly height of papaya plant in RDF through fertigation level plant height was found to be maximum (114.95, 151.04 and 203.90 cm) at 150, 200 and 250 DAT, under treatment F_3 (100% RDF through fertigation) The minimum plant height (106.73, 138.41 and 180.87cm) at 150, 200 and 250 DAT was recorded in F_1 (60% RDF through fertigation).

A data brought the significantly variation in different irrigation level on number of leaves. The highest number of leaves (33.10, 54.28 and 68.78) were recorded in treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP) at 150, 200 and 250 DAT. The minimum number of leaves (26.32, 47.32and 62.59) respectively, at 150, 200 and 250 DAT was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP.

A that the significantly number of leaves of papaya plant in RDF through fertigation level highest number of leaves was found (30.64, 52.70 and 66.85) at 150, 200 and 250 DAT, under treatment F_3 (100% RDF through fertigation). The minimum number of leaves (106.73, 138.41 and 180.87cm) respectively, at 150, 200 and 250 DAT was recorded in F_1 (60% RDF through fertigation).

A data that brought the significantly variation in different irrigation level on number of fruit. The highest number of fruit (20.24 fruit per plant) were noted in treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP) at 150, 200 and 250 DAT. The minimum number of fruit (18.09 fruit per plant) was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP).

Drip irrigation levels of IE/CPE- 0.8 ECPin case of papaya may be due to retention of soil moisture always at field capacity. This help in more absorption of moisture and nutrients from soil which may reflect an increase in cell turgidity and cell elongation. This was again aided with higher photosynthetic rate at different stages of growth. Better availability of plant nutrients that promote their accumulation in the soil may have resulted from the simple availability of water-soluble nutrients to the crop's root zone by fertigation in a balanced form using 100% RDF. In order to address the nutritional needs of the crop during crop development, 100% RDF is applied via fertigation of water-soluble fertilisers dispersed across the growth period and separated into splits according to growth stages for papaya beginning from 30 DAT. This might be explained by enhanced food intake during the development phase, which raised protoplasm and protein synthesis for a faster rate of mitosis and, eventually, growth parameters. This result is in agreement with those reported by earlier workers (Sharma *et al*., 2005) [14] and (Sadarunnisa *et al*., 2010) [11]. The increase in papaya plant height and trunk girth could be related to improved soil physical characteristics, improved nutrient uptake, and increased microbial activity resulted in better carbohydrates production (Hazarika *et al*., 2016 and Yadav *et al*. 2011) [5, 7]. Mirza *et al*., (2018) [9] observed increase leaf number might be due to the reason that ferigation (F_3) helps in enhancing of physiological process and stimulatory effect of chemicals to form new leaves at a faster rate.

- **Yield parameters**

A significantly variation in number of fruit of papaya plant in RDF through fertigation. Number of fruit was found to be maximum (19.46 fruit per plant), under treatment F_3 (100% RDF through fertigation). The minimum number of fruit (18.69 fruit per plant) respectively, was recorded in F_1 (60% RDF through fertigation).

A data examines reveals that brought the significantly variation in different irrigation level on fruit weight. The maximum d fruit weight (0.910 g) respectively, was recorded in treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP). The minimum fruit weight (0.772 g) was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP).

The significantly fruit weight of papaya plant in RDF through fertigation fruit weight was found to be maximum (0.877 g) respectively, under treatment F_3 (100% RDF through fertigation). The minimum fruit weight (0.787 g) was recorded in F_1 (60% RDF through fertigation).

The fruit yield was recorded significantly increased. Fruit yield was found to be maximum (18.42 kg /plant), under

treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP), which was at par with I_2. The minimum fruit yield (13.97 kg/plant) was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP.

The significantly in RDF through fertigation level fruit yield was found to be maximum (17.07 kg/plant), under treatment F_3 (100% RDF through fertigation). The minimum fruit yield (14.67 kg/plant) was recorded in F_1 (60% RDF through fertigation).

Application of fertilizer (nutrient) directly to the root zone through drip irrigation could improve plant growth and development by maintaining optimum soil moisture and eliminating water stress to the plant (Deshmukh *et al*., 2014) [3]. The increase in production caused by drip irrigation levels of IE/CPE- 0.8 ECP could be attributable to an increase in balanced vegetative development with maximum solar light harvest. Further, fertigation level (100% of RDF) resulted in highest yield closely. Fertigation may have increased output by providing nutrients for a longer length of time throughout the growth, blooming, and fruiting phases. Further, more healthy and optimum vegetative growth with the application of treatment drip irrigation levels of IE/CPE- 0.8 ECP+ 100% RDF might have augmented photosynthesis, The outcomes are consistent with the findings of (Kumawat *et al*., 2019 and Hazarika 2016) [7, 5]. The improve in fruiting set is due to the application of RDF which resulted in the production of reproductive part of plant a, leading to development of flower buds exhibiting all functional reproductive parts, which increased fruit set tremendously compared with the others (Mirza *et al*., 2018) [9]. The negative impact of moisture stress on a plant's regular growth and development may be the cause of the yield loss under stress. (Awada *et al*., 1979, Deshmukh *et al*., 2014, Santana *et al*., 2008) [1, 3, 12]. Application of fertilizers through drip at 100% RDF proved its superiority by recording significantly higher papaya fruit yield than rest of the fertigation levels tried during the year. This could be because consistent application of the necessary amount of nutrients close to the root zone during the crop's growth period improved the nutrient use efficiency, which in turn improved all of the crop's growth and yield characteristics. It could also be because physiological processes increased and photosynthates were efficiently translocated to the reproductive organs, which resulted in a higher yield of papaya fruit.

Sathya *et al*. (2008) [13] reported that the fertigation of nutrients significantly increased saving of fertilizer up to 40 per cent without affecting the yield of crops compared to the conventional method of fertilizer application.

- **Quality parameters**

A TSS significantly through different irrigation level. Highest TSS (11.20 ^{0}brix) was recorded in I_3 (Drip Irrigation IE/CPE- 0.8 ECP), While lowest TSS (9.42 ^{0}brix) was noted in treatment I_1 (Drip Irrigation IE/CPE- 0.4 ECP). TSS was recorded significantly increased. TSS was found to be maximum (10.60 ^{0}brix), under treatment F_3 (100% RDF through fertigation), which was at par with F_2. The minimum TSS (10.13^{0}brix) was recorded in F_1 (60% RDF through fertigation).

Aascorbic acid was recorded significantly increased. The ascorbic acid was found to be maximum (44.95 mg/100), under treatment I_3 (Drip Irrigation IE/CPE- 0.8 ECP), which was at par with I_2. The minimum ascorbic acid (36.62 mg/100) was recorded in I_1 (Drip Irrigation IE/CPE- 0.4 ECP.

A data presented to reveals that the significantly in RDF through fertigation level ascorbic acid was found to be maximum (41.27 mg/100), under treatment F_3 (100% RDF through fertigation). The minimum ascorbic acid (39.68 mg/100 g), was recorded in F_1 (60% RDF through fertigation).

Because potassium is involved in the synthesis of carbohydrates, the breakdown and translocation of starch, the synthesis of proteins, and the neutralisation of physiologically significant organic acids, the quality of TSS and ascorbic acid has improved. Otassium is often unnecessary for increasing output and quality. Additionally, it stimulates enzyme activity, stomata management, and photosynthesis. These elements working together may have raised the papaya fruits' general quality.The superiority of fertigation treatments in increasing the quality of papaya has also been reported by, Sadarunnisa *et al*. (2010) [11], Tank *et al*. (2011) [16], Singh and Singh (2012) [15] and Panigrahi *et al*. (2015) [10].

Interaction effect

Growth parameters

Maximum plant height (125.33, 157.83 and 217.72 cm) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum plant height (96.69, 131.23 and 175.99cm) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation

Maximum number of leaves (34.85 and 57.54) were recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum number of leaves (25.28 and 45.83) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Yield parameters

Maximum number of fruit (21.76) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum number of fruit (14.76) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Maximum fruit weight (1.07 kg) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum fruit weight (0. 655 kg) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Maximum fruit yield (23.28 kg) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum fruit yield (9.67 kg) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Quality parameters

Maximum TSS (11.66 ^{0}brix) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum TSS (8.87 ^{0}brix) were recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Maximum ascorbic acid (45.66 mg/100) was recorded in (Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation). While minimum ascorbic acid (36.71 mg/100) was recorded in Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation.

Table 1: Study of Irrigation and Fertigation Strategies Performance on Plant Height and Number of leavesUnder Shade Net House

Factor -A	Treatments	Plant height (cm)			Number of leaves		
Factor-A level		150 DAS	200 DAS	250 DAS	150 DAS	200 DAS	250 DAS
I_1	Drip Irrigation IE/CPE- 0.4 ECP	107.26	137.00	183.71	26.32	47.32	62.59
I_2	Drip Irrigation IE/CPE- 0.6 ECP	112.79	141.86	184.53	29.60	50.00	64.32
I_3	Drip Irrigation IE/CPE- 0.8 ECP	113.71	154.90	199.58	33.10	55.32	68.78
SEm±		1.82	3.32	4.34	0.50	1.12	0.62
CD (p = 0.05)		5.33	9.72	12.73	1.47	3.29	1.81
Factor -B level							
F_1	60% RDF through fertigation	106.73	138.41	180.87	28.32	47.52	63.89
F_2	80% RDF through fertigation	112.07	144.30	183.04	30.07	51.38	64.94
F_3	100% RDF through fertigation	114.95	151.04	203.90	30.64	53.73	66.85
SEm±		1.82	3.32	4.34	0.50	1.12	0.62
CD (p = 0.05)		5.33	9.725	12.73	1.47	3.29	1.81

Table 2: Interaction effect of Irrigation and Fertigation Strategies Performance on Plant Height and Number of leavesUnder Shade Net House

	Treatments	Plant height (cm)			Number of leaves		
Symbols		150 DAS	200 DAS	250 DAS	150 DAS	200 DAS	250 DAS
T_1	Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation	96.69	131.23	175.99	25.28	45.83	60.41
T_2	Drip Irrigation IE/CPE- 0.4 ECP+80% RDF through fertigation	122.83	135.56	178.88	26.36	47.12	63.97
T_3	Drip Irrigation IE/CPE- 0.4 ECP+100% RDF through fertigation	102.24	144.20	196.25	27.33	49.00	63.38
T_4	Drip Irrigation IE/CPE- 0.6 ECP+60% RDF through fertigation	120.35	132.31	178.97	29.39	45.67	64.07
T_5	Drip Irrigation IE/CPE- 0.6 ECP+80% RDF through fertigation	100.72	142.18	176.89	29.68	49.68	63.80
T_6	Drip Irrigation IE/CPE- 0.6 ECP+100% RDF through fertigation	117.28	151.10	197.72	29.74	54.65	65.09
T_7	Drip Irrigation IE/CPE- 0.8 ECP+60% RDF through fertigation	103.14	151.70	187.65	30.29	51.06	67.21
T_8	Drip Irrigation IE/CPE- 0.8 ECP+80% RDF through fertigation	112.67	155.16	193.36	34.16	57.35	67.05
T_9	Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation	125.33	157.83	217.72	34.85	57.54	72.09
SEm±		3.15	5.74	7.52	2.55	5.69	3.14
CD (p = 0.05)		9.23	15.60	22.32	7.60	15.65	NS

Table 3: Study of Irrigation and Fertigation Strategies Performance on Fruit Yield of Under Shade Net House

Factor-A level	Treatments	Number of fruit	Fruit weight (g)	Fruit yield (kg/ plant)
I_1	Drip Irrigation IE/CPE- 0.4 ECP	18.09	0.772	13.97
I_2	Drip Irrigation IE/CPE- 0.6 ECP	18.88	0.781	14.75
I_3	Drip Irrigation IE/CPE- 0.8 ECP	20.24	0.910	18.42
SEm±		0.14	0.011	0.13
CD (p = 0.05)		0.41	0.032	0.38
Factor -B level				
F_1	60% RDF through fertigation	18.69	0.787	14.67
F_2	80% RDF through fertigation	19.07	0.798	15.22
F_3	100% RDF through fertigation	19.46	0.877	17.07
SEm±		0.14	0.011	0.13
CD (p = 0.05)		0.412	0.032	0.38

Table 4: Interaction of Irrigation and Fertigation Strategies Performance on Fruit Yield of Under Shade Net House

Symbols	Treatments	Number of fruit	Fruit weight (kg)	Fruit yield (kg/ plant)
T_1	Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation	14.76	0.655	9.67
T_2	Drip Irrigation IE/CPE- 0.4 ECP+80% RDF through fertigation	18.66	0.785	14.65
T_3	Drip Irrigation IE/CPE- 0.4 ECP+100% RDF through fertigation	20.86	0.875	18.25
T_4	Drip Irrigation IE/CPE- 0.6 ECP+60% RDF through fertigation	20.21	0.813	16.43
T_5	Drip Irrigation IE/CPE- 0.6 ECP+80% RDF through fertigation	20.67	0.845	17.47
T_6	Drip Irrigation IE/CPE- 0.6 ECP+100% RDF through fertigation	15.76	0.685	10.80
T_7	Drip Irrigation IE/CPE- 0.8 ECP+60% RDF through fertigation	21.09	0.894	18.86
T_8	Drip Irrigation IE/CPE- 0.8 ECP+80% RDF through fertigation	17.87	0.765	13.67
T_9	Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation	21.76	1.07	23.28
SEm±		0.24	0.02	0.23
CD (p = 0.05)		0.71	0.05	0.66

Table 5: Study of Irrigation and Fertigation Strategies on Performance on Quality of Under Shade Net House

Factor-A level	Treatments	TSS (^{0}Brix)	Ascorbic acid
I_1	Drip Irrigation IE/CPE- 0.4 ECP	9.42	36.61
I_2	Drip Irrigation IE/CPE- 0.6 ECP	10.45	39.27
I_3	Drip Irrigation IE/CPE- 0.8 ECP	11.20	44.95
SEm±		0.08	0.34
CD (p = 0.05)		0.24	0.99
Factor -B level			
F_1	60% RDF through fertigation	10.13	39.68
F_2	80% RDF through fertigation	10.35	39.88
F_3	100% RDF through fertigation	10.60	41.27
SEm±		0.08	0.34
CD (p = 0.05)		0.24	0.99

Table 6: Interaction Effect of Irrigation and Fertigation Strategies on Performance on Quality of Under Shade Net House

Symbols	Treatments	TSS	Ascorbic acid
T_1	Drip Irrigation IE/CPE- 0.4 ECP+60% RDF through fertigation	8.87	36.71
T_2	Drip Irrigation IE/CPE- 0.4 ECP+80% RDF through fertigation	9.67	36.56
T_3	Drip Irrigation IE/CPE- 0.4 ECP+100% RDF through fertigation	9.72	36.56
T_4	Drip Irrigation IE/CPE- 0.6 ECP+60% RDF through fertigation	10.29	37.74
T_5	Drip Irrigation IE/CPE- 0.6 ECP+80% RDF through fertigation	10.65	38.50
T_6	Drip Irrigation IE/CPE- 0.6 ECP+100% RDF through fertigation	10.41	41.58
T_7	Drip Irrigation IE/CPE- 0.8 ECP+60% RDF through fertigation	11.21	44.59
T_8	Drip Irrigation IE/CPE- 0.8 ECP+80% RDF through fertigation	10.73	44.59
T_9	Drip Irrigation IE/CPE- 0.8 ECP+100% RDF through fertigation	11.66	45.66
SEm±		0.14	0.58
CD (p = 0.05)		0.42	1.71

Conclusion

In the light of results summarized above, it may be concluded that for higher growth yield and quality was found irrigation and fertilizer level I_3 (Drip Irrigation IE/CPE- 0.8 ECP) + F_3 (100% RDF through fertigation) should preferred over other combination under protected cultivation of papaya. The observations are based on one season data, to get more precise information, it is suggested that the experiment.

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