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Effect of Drip Irrigation Intervals and Fertigation Frequency on Yield and Yield Components of Cucumber under Greenhouse Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted in a cooled plastic tunnel greenhouse during March-August of 2022 and 2023 to study the effect of drip irrigation intervals and fertigation frequency on yield and yield components of cucumber under greenhouse conditions at Kassala State, Sudan. Seedlings of the most popular cucumber hybrid (Fatin) were planted on 40cm and 50 cm inter and intra-row spacing, respectively. The experiment was composed of two factors; irrigation intervals (every day, every 2 days and every 3 days) and fertigation frequencies applied at (one dose per week, two

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doses per week and 3 doses per week). The results showed that drip irrigation every day had recorded highest yield and yield components in both seasons. Maximum yields of cucumber were recorded with fertigation at three dose/week compared to fertigation at one dose/week in both seasons. Moreover, the highest values of yield, yield components, water productivity, economic water productivity and partial factor productivity of nitrogen were obtained under drip irrigation every day with fertigation at 3 dose/week on both seasons.

Keywords: Drip irrigation intervals; fertigation; frequency; yield components and plastic tunnel greenhouse.

1. INTRODUCTION

"The technology of indoor (greenhouse) is the most important facilities for the production of off-season horticultural crops" [1]. "Cucumber (*Cucumis sativus* L.) is one of the most important crops grown in greenhouses in Kassala which has high and early production; benefits cost ration and economic returns" [2].

"Water application interval of cucumber is very important because insufficient irrigation causes water stress and reduces production" [3]. Responses of cucumber to drip irrigation frequency it reported by some researchers. Mamun Hossain et al. [4] found that "application of drip water at 85% of field capacity was successfully used to improve cucumber marketable yield".

"Fertilization and irrigation are the main factors limiting crop production in arid and semiarid regions" [5]. "Method of fertilizer application, type, dose, and time play an important role in the fertilizer use efficiency" [6].

"Fertigation is a technique for injection of fertilizers into the water and then transporting them into the root zone" [7]. "Fertigation generally allows for a significant increase of nutrient use efficiency in terms of plant nutrient recovery, with much higher results (up to 90%) than in other fertilizer application systems (40-45%)" [8]. "The proper irrigation frequency is vital in improving the water use efficiency and the productivity by applying the required amount of water when it is needed" [9]. Alomran et al [10] reported that "the irrigation level of 100 % is the highest yield in all irrigation techniques, with a general average of 14.9 kg m- 2 for all irrigation techniques during the winter season and 16.4 kg m- ^{2} during the summer". However, Qu [11] conclude that "the irrigation amount (AT) was mainly limited factor for the comprehensive growth of cucumber in three growing seasons".

"Good fertilization and water management are the main factors to ensure high quality yield of cucumber" [1]. "Yield and quality of cucumber were increased with the increase in fertilization and water levels but decreased under excessive fertilizer applications" [12]. The objective of this study was to determine the effect of drip irrigation intervals and fertigation frequency on yield and yield components of cucumber under greenhouse conditions of Kassala.

2. MATERIALS AND METHODS

The experiment was conducted in the greenhouses of the tissue culture unit of Kassala and Gash Research Station, Kassala, Kassala State, Sudan during March and August of the 2022 and 2023. The site is located at latitude 15° 45´ N and longitude 36° 36´ E with average elevation of 504 m above mean sea level. The greenhouses are plastic tunnels with an area of 306m2 (34m×9m).

Seeds of the most cultivated cucumber hybrid (Fatin) were planted at an intra-row spacing of 40 cm with inter-row (beds) spacing of 50 cm as recommended by Khalifa et al. [13]. Irrigation was applied by drip irrigation system every 3 days (2.5 liter/plant) according to Mohamed and Ahmed, [14]. The recommended dose of fertilizer was (50g/m2/week) of NPK (20:20:20) and the first dose was applied at 2 weeks after planting according to Khalifa et al. [15].

The experiment was composed of two factors; the one factor was irrigation intervals (every day, every 2 days and every 3 days) and the other factor was fertigation frequencies applied at (one dose per week, two doses per week and 3 doses per week). These factors were arranged in split plot design with three replications. The main plots were allocated for irrigation intervals and subplots for fertigation frequencies. The subplot size was 200cm×70cm (bed/mastaba). The nine treatments were randomly distributed in each replicate.

The cultural practices (hoeing and weeding) were carried as recommended by Agricultural Research Corporation (ARC).

The measured parameters were; plant height (cm), fruit length (cm), fruit diameter (cm), fruit weight (g), yield (kg/m2) and yield (t/ha).

Water productivity (WP) was calculated as the ratio of the crop yield to the total seasonal irrigation water applied (m3/ha) using the following formula:

WP (kg/m3) = Yield (kg /ha) / Total water applied (m3/ha)……..……. (1)

Economic water productivity (EWP) was calculated as the gross income in Sudanese Pounds (SDG) per gross water supplied in m3 using the following relation:

EWP = GI/GIWR…… (2)

where:

GI is the gross income from the sale of product (SDG/ha) and GIWR is the gross irrigation water applied (m3/ha).

Nutrient use efficiency (NUE) was calculated as the partial factor productivity of nitrogen ((PFPN) kg crop yield per kg nutrient applied) using the following formula according to Mosier and Nimah [16].

PFPN (%) = yield (kg ha-1) /Total nutrient applied (kg ha-1) …… (3)

Statistic 8 statistical package was used for data analysis and the least significant difference test (LSD) was used for mean separation at the probability level of 0.05.

3. RESULTS AND DISCUSSION

3.1 Effect of Drip Irrigation Intervals and Fertigation Frequency on Plant Height and Yield

Drip irrigation intervals showed significant differences on plant height and yield of cucumber on both seasons (Table 1). There were no significant differences between irrigation every day and every 2 days in both seasons. The taller plants and higher yield were recorded under drip irrigation every day compared to drip irrigation every 3 days for both seasons (Table 1). This

Table 1. Effect of drip irrigation intervals and fertigation frequency on plant height and yield of cucumber under greenhouse conditions

Treatments	Plant height (cm)		Yield(kg/m2)		Yield (ton/306m2)	
	2022	2023	2022	2023	2022	2023
Irrigation every day (D1)	88.4a	93.9a	21.2a	17.4a	6.5a	5.3a
Irrigation every 2 days (D2)	86.8a	89.2b	20.6a	16.8a	6.4a	5.1a
Irrigation every 3day (D3)	74.4b	65.1c	19.4b	13.8b	6.0b	4.1b
LSD	6.38	2.08	0.69	3.16	0.25	0.95
Significant level	**	***	***	*	**	*
CV%	5.86	1.93	2.57	15.28	3.08	15.03
Fertigation at one dose /week (W1)	76.7c	72.3c	18.9c	14.1c	5.9c	4.3c
Fertigation at 2 dose /week (W2)	82.6b	84.1b	20.2b	15.6b	6.2b	4.8b
Fertigation at 3 dose /week (W3)	90.4a	91.8a	22.0a	17.7a	6.8a	5.4a
LSD	3.06	2.67	1.08	1.24	0.34	0.38
D1W1	79.0de	81.0d	19.5cde	15.5bc	6.0cde	4.7bc
D1W2	89.0bc	96.3b	20.6cde	16.7b	6.4bcd	5.1b
D1W3	97.3a	104.3a	23.4a	20.0a	7.2a	6.1a
D2W1	84.0cd	78.0d	18.9e	15.6bc	5.9de	4.7bc
D2W2	85.3cd	90.3c	21.0bc	17.3ab	6.5bc	5.3ab
D2W3	91.0ab	99.3b	21.7b	17.4ab	6.7ab	5.4ab
D3W1	67.0f	58.0g	18.3e	11.3d	5.7e	3.5d
D3W2	73.3e	65.7f	19.0de	12.7cd	5.9de	3.9cd
D3W3	83.0cd	71.7e	20.9bc	15.8b	6.5bc	4.8b
LSD	**7.66**	**4.30**	**1.66**	**3.60**	**0.54**	**1.09**
Significant level	***	***	***	***	***	***
CV%	**3.58**	**3.15**	**5.14**	**7.66**	**5.19**	**7.62**

Table 2. Effect of drip irrigation intervals and fertigation frequency on fruit length, fruit diameter and fruit weight of cucumber under greenhouse conditions

Treatments	Fruits length (cm)		Fruits diameter (cm)		Fruits weight (g)	
	2022	2023	2022	2023	2022	2023
Irrigation every day (D1)	19.4a	4.3a	4.2a	19.4a	159a	160a
Irrigation every 2 days (D2)	18.4ab	4.2b	4.1a	18.4ab	156ab	152b
Irrigation every 3day (D3)	17.6b	4.0b	4.0a	16.8b	148b	127c
LSD	1.40	0.27	0.27	1.90	6.95	5.47
Significant level	*	NS	NS	*	***	***
CV%	5.80	4.94	4.91	7.97	3.46	2.85
Fertigation at one dose /week (W1)	19.9a	4.0b	4.0b	17.0c	144c	136c
Fertigation at 2 dose /week (W2)	18.3b	4.1ab	4.2ab	18.2b	149b	145b
Fertigation at 3 dose /week (W3)	17.2b	4.3a	4.3a	19.4a	167a	160a
LSD	1.55	0.25	6.31	0.97	3.83	2.87
D1W1	18.0bc	3.97cd	4.0ab	18.0bcd	150cd	146de
D1W2	19.3ab	4.40abc	4.3ab	19.0bc	153c	157bc
D1W3	21.1a	4.43a	4.5a	21.3a	174a	178a
D2W1	17.3bc	3.93cd	4.0ab	17.0cd	144de	141ef
D2W2	18.3bc	4.2abcd	4.2ab	18.7bc	150cd	152ed
D2W3	19.7ab	4.4ab	4.3ab	19.7ab	164b	163b
D3W1	16.3c	4.0abcd	3.9b	16.0d	138e	119h
D3W2	17.3bc	3.83d	4.0ab	17.0cd	144dc	125g
D3W3	19.0abc	4.0abcd	4.2ab	17.3cd	162b	138f
LSD	2.59	0.44	0.51	2.33	8.75	6.76
Significant level	**	*	*	***	***	***
CV%		**5.84**	**7.17**	**5.17**	**2.43**	**1.91**

might be due to the improved soil moisture under the higher frequent of drip irrigation. These results are in agreement with those of Bagali, et al. [17] who reported that irrigation schedule at daily interval recorded significantly higher bulb yield over other irrigation intervals.

Plant height and yield were significantly affected by Fertigation frequency in both seasons (Table 1). The taller plants and maximum yields of cucumber were recorded with fertigation at 3 dose/week while, the lowest were recorded with fertigation at 1 dose /week in both seasons (Table 1). This might be due to the short fertigation frequency irrigation which favoring higher nutrient uptake and in turn improved all growth and yield. These results are in close agreement with the findings of Singh et al. [18] who observed that daily method of fertigation and 100% recommended dose of NPK fertilizer resulted in better fruit yield compared to other treatments of tomato.

For the interaction between drip irrigation intervals and fertigation frequency the results showed that there was significant difference in plant height and yield for both seasons (Table 1). The taller plants and higher yield were recorded under drip irrigation every day with fertigation at 3 dose/week while, the shorter plants and low yield were observed at drip irrigation every 3 days with fertigation at one dose/week in both seasons (Table 1). This might be due to the positive effect on soil moisture and fertigation improvement. These results are in conformity with the findings of Fasina et al. [19] who reported that the highest yield of cucumber was obtained by three times a week irrigation with N at 180 kg/ha as urea.

3.1.1 Effect of drip irrigation intervals and fertigation frequency on fruit length, fruit diameter and fruit weight

The results showed highly significant differences in the fruit length, fruit diameter and fruit weight for both seasons (Table 2). The highest fruit length, diameter and weight were observed on drip irrigation every day which was closely followed by drip irrigation every two days while,

the lowest were observed in drip irrigation every three days on both seasons (Table 2). This result corroborated the findings of Mustafa and Mohamed [20] who reported that strawberry quality was recorded every one- and two-days intervals under drip irrigation system. Moreover, El-Boraie, et al. [21] stated that applying irrigation everyday produced yield components of groundnut.

Fertigation frequency at 3doses/week recorded the highest fruit length, diameter and weight compared to fertigation frequency at one dose/week on both seasons (Table 2). This might be due to the higher availability of nutrients under fertigation frequency at 3doses/week in the soil solution and consequently led to higher nutrients uptake.

Similarly, findings of Singh et al. [18] who found that daily method fertigation of tomato increased average fruit weight and fruit diameter.

Among the interaction between drip irrigation intervals and fertigation frequency the highest fruits length, diameter and weight were obtained under drip irrigation every day with fertigation at 3 dose/week compared to drip irrigation every 3 days with fertigation at one dose/week on both seasons (Table 2). This might be due to the favorable soil moisture and nutrients. This result complies with that of Fasina et al. [19] who found that drip irrigation scheduling of three times a week combined with N-fertilization successfully improve cucumber.

3.1.2 Effect of drip irrigation intervals and fertigation frequency on water productivity and economic water productivity

Drip irrigation every day with fertigation at 3 dose/week showed the highest values of water and economic productivities in both seasons (Figs. 1 and 2). The productivity was increased with the decreased intervals of drip irrigation and increased doses of fertigation. The increase in the water and economic productivities might be attributed to the adequate supplies of nutrients which resulted in triggering the production. These results are in conformity with the findings of Khalifa et al. [22] who found that the daily micro sprinkler irrigation improved water and economic productivities of onion yield in Kassala. Similar, El-Hendawy et al. [23] who found that water use efficiency increased with increasing irrigation frequency and reached the maximum values at once every 2 and 3 days. Moreover, Al-Omran et al. [24] reported that water use efficiency values increased linearly with applied irrigation water and decreased at the highest irrigation level [25].

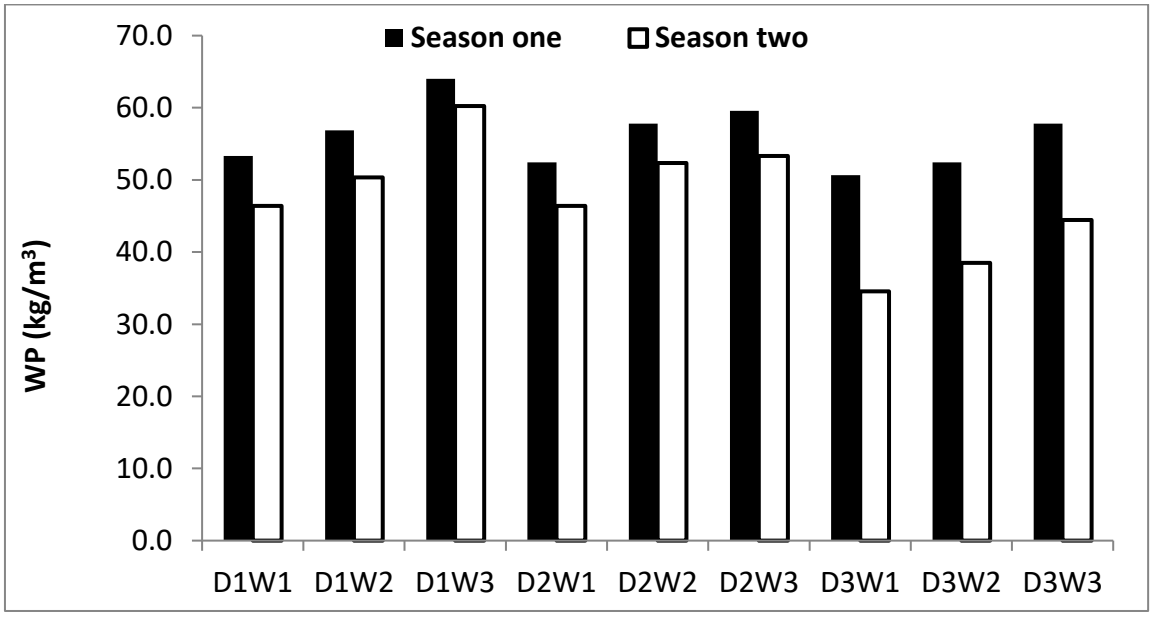

Fig. 1. Effect of drip irrigation intervals and fertigation frequency on Water Productivity (WP) of cucumber grown under greenhouse conditions

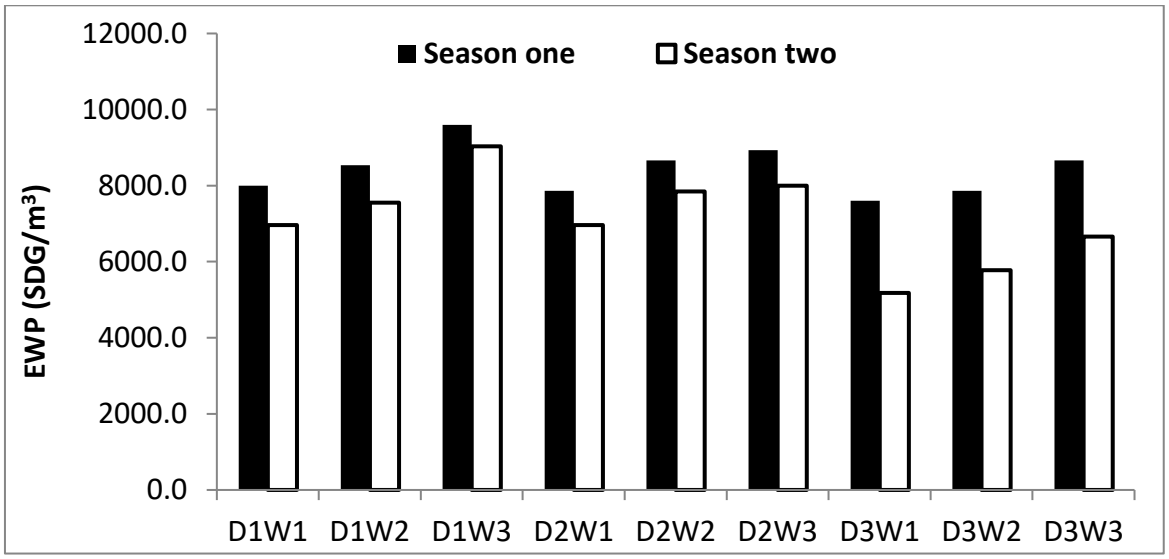

Fig. 2. Effect of drip irrigation intervals and fertigation frequency on Economic Water Productivity (EWP) of cucumber grown under greenhouse conditions

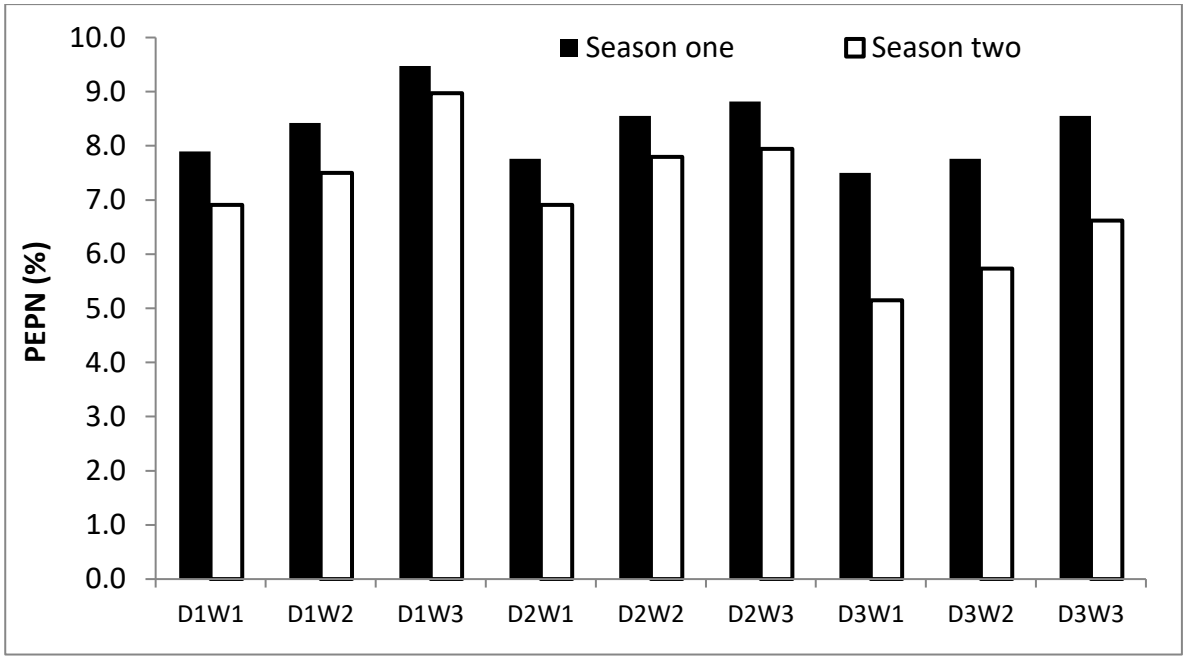

Fig. 3. Effect of drip irrigation intervals and fertigation frequency on economic water productivity of nitrogen (PEPN) of cucumber grown under greenhouse conditions

3.1.3 Effect of drip irrigation intervals and fertigation frequency on partial factor productivity of nitrogen

The result showed that partial factor productivity of nitrogen (PFPN) was affected by drip irrigation intervals and fertigation frequency. The highest values of PFPN were recorded with drip irrigation every day with fertigation at 3 doses/week in both seasons and were 9.5% and 9% for season one and two, respectively (Fig. 3). These results are agreement with those of Wang et al. [1] found that the highest partial factor productivity of nitrogen was obtained from irrigation levels of 80% ETo and 100% ETo.

4. CONCLUSION

The highest yield and yield components, water productivity, economic water productivity and

partial factor productivity of nitrogen of greenhouse cucumber were obtained under drip irrigation every day with fertigation at 3 dose/week.

5. RECOMMENDATION

Based on the findings the treatment of drip irrigation every day with fertigation at 3 dose/week are recommended for improving cucumber productivity under greenhouse in Kassala state, Sudan.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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