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IMPACT OF WATER STRESS ON CUCUMBER GROWTH AND YIELD

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Abstract *Efficient irrigation plays a vital role in the production of vegetables and fruits. Too low or high water application can reduce the growth and development process of plants, which may negatively affect the crop yield. To investigate the fact, a field experiment was carried out to check the growth and yield of cucumber on a sandy soil, under greenhouse conditions by using a drip irrigation system having a flow rate of drippers 2 liters per hour respectively. The field study was carried out on a random block design (RCBD) having five different rates of irrigation, i.e. (T1 = one time, T2 = two times, T3 = three times, T4 = four times, and T5 = five times) application per day, respectively. The results revealed that different levels of irrigation with constant doses of fertilizers brought a positive effect in cucumber production. T5 was found to be the most economic and suitable of all the treatments because it took fewer days for the plants to develop flowers (30.385 days), set fruit (9.055 days), mature fruit (6.178 days), produce more fruits per plant (33.746), have the longest fruit (17.812 cm), the heaviest fruit (131.977 g), the maximum vine length (2.73 m), and have the highest fruit yield (57.644 tons ha^{-1}). On all the metrics, however, treatment T1's outcomes were insufficient. The results indicate that, when utilizing a drip irrigation system in a greenhouse, five times a day for five minutes each time, with a 45-minute interval between applications, is optimal for the best potential development and yield of cucumbers.*

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Introduction

Due to the fast-growing demand in domestic and local markets, vegetable production in UAE is gaining importance day by day. In general, farmers usually grow vegetables during the winter season on a large scale, as the winter season is of a short duration, and the rest of the year the agro-ecological environment and conditions are not fit for the open field production of vegetables. Moreover, during the summer season, the yield and quality of the vegetables are also not up to the mark. Greenhouse vegetable production is an newly introduced technology in UAE to produce vegetables like cucumbers, tomatoes, marrow (koosa), chilies peppers, bell pepper etc, during the summer season (Arshad and Abasi 2017). Based on available data, Pakistan currently has approximately 3,150 greenhouses, which are expected to provide 32,125 tons of high-quality vegetables annually to the region's markets. 71% of these vegetables were cucumbers, while 29% were other varieties. Because cucumbers are easy to grow in many types of soil and can withstand salinity to some extent, farmers in Pakistan are more interested in growing them. Cucumbers are climbing vines that belong to the Cucurbitaceae family, which is known scientifically as "*Cucumis sativus* L." (Hashem et al., 2011). Cucumbers require plenty of water, especially during the flowering and fruiting period, as the fruits contain about 95% water. Therefore, the shortage of water during flowering and fruit development stages in soil may result in flower and fruit dropping (Kaya et al., 2005). In order to get good yield, it is essential that soil water supply should be kept at optimal level during cucumber production (Kirnak and Demirtas 2006). In greenhouse farming, the plants are usually being irrigated through a drip irrigation system, as it minimizes the soil storage and provides optimum water supply to the roots and helps in controlling soil matric potential in the rhizosphere, which ultimately reduce the plant water stress (Wang et al., 2009). One of the most excellent features of drip irrigation is that water and nutrients can be supplied directly to the plants, which ultimately boosts the vigorous growth of plants and helps in getting maximum yield (Kunyanga et al., 2012). According to a number of studies, drip irrigation systems were associated with higher yields of cucumber-harvested fruit because irrigation quantities had a substantial impact on fruit parameters such as length, diameter, number of fruits, and weight (Zhang et al., 2011). Based on the previously discussed facts, the present research was carried out utilizing the drip irrigation system to assess the effects of various irrigation treatment levels with constant fertilizer dosages on the development and production parameters of cucumber under greenhouse circumstances.

Materials and methods

Location

The research work was carried out at a private farmhouse, during December 2023. The experiment site was located in Raiwind (Tara Group Experimental Lab) which is about 10 km West of Raiwind. The soil of the farmhouse was sandy in nature, with hydraulic conductivity (1.202 x 10-4 m/sec), bulk density (1.3 g/cm^3), and porosity (0.44) respectively. In order to increase the moisture holding capacity within the soil, poultry manure was mixed with sand and irrigation was done through a drip irrigation system by using a dripper having a flow rate of 2 liters per hour, respectively. In field experiment, The present research was carried out on a randomized complete block design (RCBD) having five different rates of irrigation treatments with three replications. The irrigation water applied in such a way that (T1 = one time, T2 = two times, T3 = three times, T4 = four times, and T5 = five times) application per day respectively. The size of the experimental field was 148.5 m^2 i.e. (9.9m x 15m) and consists of 15 laterals with 20 mm internal diameter and each lateral contains 30 online pressure compensating emitters while the internal diameter of sub-main line and mainline was 40 mm and 60 mm respectively. The sub-main line was located 10 meters away from the water source. The distance between emitters and laterals was 0.50 and 0.66 meters, respectively, along the lateral. A 2-inch water pump was used to supply water to the drip unit at a constant pressure of 20 psi (1.36 atm), respectively. The time of water application to the plants was 5 minutes long in each treatment, and there was a gap of 45 minutes between each irrigation application respectively. Initially, the seed bed was prepared by digging small holes adjacent to the emitters with the help of traditional hoes tool and drip irrigation lines were installed for the irrigation purpose accordingly (Wallace, 2000). For the cultivation of cucumber, the nursery was initially developed with the help of plastic trays and coco peat respectively. The plastic trays were filled with coconut peat and seeds were sown at the depth of 5mm. After the development of 2 or 3 well established leaves, the plants were then transplanted with proper covering of plastic sheet and irrigated in such a way that the plant could take a firm foothold with regard to the root taking process (Arshad, 2017). Applying fertilizers in equal amounts to each subplot was done using a drip irrigation system. After a few days of transplanting, the plants were pruned, stacked, and tied to improve the aeration process. Additionally, cultural practices such as pesticide application, hoeing, and weeding were carried out according to the growing season. The fruits were harvested when they were still slightly unripe to preserve the quality of the cucumbers (Jilani et al., 2009). Ten randomly selected plants from each treatment were taken to determine the agronomic parameters during the study i.e. Days taken to flowering, days to fruit setting, days to fruit maturity, number of fruit per plant, fruit length (cm), fruit weight (grams), vine length (m), and yield (tons ha^{-1}). Finally, all the data analysis and statistical analysis were done through ANOVA procedure accordingly.

Results and discussion

The subject study demonstrated that the various agronomic parameters of cucumber, i.e., the days taken for flowering, fruit setting, fruit maturity, number of fruits, fruit length, fruit weight, vine length, and fruit yield, varied considerably when applying the various irrigation water rates that are detailed in Tables 1 and 2, respectively.

Days to Flowering

Statistically remarkable results were observed for the time taken to flowering for all treatments as shown in Table 1. Treatment T5 took less number of days (30.835 days) to produce flowers, followed by T4 (32.489 days) and T3 (33.445 days) respectively. While the maximum number of days was recorded for T1 with (37.624 days) to produce flowers. The plants which are irrigated with the required amount of water took fewer days to develop flowers. While plants irrigated with less amount of water took more days to set flowers. These results are in agreement with Arshad and Abbasi (2017), who concluded that continuous increase in irrigation levels can reduce the days taken to set flowers in alfalfa up to some extent and vice versa.

Days to Fruit Setting

Different irrigation levels had a significant effect on the time required to fruit setting as shown in Table 1. The lowest numbers of days to set fruit were observed for treatment T5 (9.055 days), followed by T4 (10.623 days) and T3 (11.666 days); However, there was little difference between T3 and T4. Once more, T1 had the highest number of days (14.637 days) for fruit sitting. These outcomes are consistent with those of Kunyanga et al. (2012), who found that high pulse irrigation levels can shorten the time it takes for cucumbers to set fruit.

Days to Maturity

The time taken to fruit maturity was significantly affected by different levels of irrigation treatments as shown in Table 1. The maximum numbers of days (10.576 days) for fruit maturity were recorded for treatment T1, followed by T2 with (9.510 days) respectively. While minimum numbers of days for fruit maturity, once again recorded for treatment T5 with (6.178 days), followed by T4 (7.424 days) and T3 (8.436 days) with no significant difference among them respectively. Fewer days are needed for fruit to reach maturity, which is advantageous and directly related to getting an earlier yield of cucumbers. These findings are consistent with those of Aassoulin et al. (2006), who found a proportionate relationship between fruit maturity days and pulse irrigation, with more pulse irrigation leading to earlier fruit maturity for capsicum bells.

Number of Fruits per Plant

The outcome of the data showed statistically remarkable results for the number of fruits per plant for all treatments as shown in Table 1. T5 (33.746 fruits) had the highest number of fruits seen, whereas T4 (30.138 fruits) had the lowest number, respectively. The difference between T5 and T4, however, was not noteworthy. Treatment T1 (23.290 fruits) per plant had the lowest number of fruits ever recorded. A suitable quantity of water application stimulates the strong growth of cucumber, which in turn increases the number of fruits per plant. This is consistent with the findings of Sahin et al. (2015) regarding cucumber when water is applied to the plants at a high rate by pulse irrigation.

Table 1. Impact of rate of irrigation applications on morphological traits of cucumber

Treatment	Days required for Fruit setting	Fruit Count per Plant	Days required for flowering	Days required for fruit maturity
T_1	14.701cd	23.232d	37.647d	10.590d
T_2	13.344c	25.890cd	35.190c	9.490c
T_3	11.678b	26.440b	33.479b	8.474bc
T_4	9.060a	30.189ab	31.589ab	7.428b
T_5	9.101a	33.765a	30.890a	6.190a
(P< 0.05)	**0.361**	**2.006**	**0.627**	**0.933**

Means assigned with different letters show results significant at 5% significance level

Fruit Length

As indicated in Table 2, significant results were observed for the fruit length of each plant. Broadly speaking, longer cucumber was typically found in plants that received higher irrigation pulses than in those that received fewer irrigation pulses. The maximum length of fruit (17.812 cm) was observed for treatment T5, succeeded by T4 (15.872 cm) and T3 (14.456 cm), with no statistically significant differences among the plants. One more time, the general length of fruit was observed for treatment T1 is (12.923 cm). Cucumber required a sufficient amount of water for moisture and crackling, hence escalating the extent of irrigation water to a specific level T5, the fruit length shows growth and vice versa. Similar results were recorded by El-Mogy et al. (2012), for green beans, who said that plants that lack enough amount of water produce irregular and deformed fruits.

Fruit Weight

The data of fruit weight from (Table 2) indicated that the intermittent irrigation promptly affected the weight of the fruit and shows significant differences with respect to irrigation treatments. The highest fruit weight (131.977 g) was noted for treatment T5, and the lowest fruit weight (106.334 g) was noted for treatment T1 respectively. The findings demonstrated that increasing the amount of NPK nutrient supplements, along with intermittent irrigation, can expand fruit weight. These results are consistent with those of Arshad (2017) for cucumber, who also observed that fruit weight can be increased by administering an abundant amount of irrigation water and fertilizers.

Vine Length

During the experiment, it had been demonstrated that diverse irrigation applications considerably affected the vine length of the cucumber. The T5 treatment showed the highest vine length (2.736 m), succeeded by T4 (2.455 m), and T3 (2.067 m) respectively. The shortest vine length (1.892 m) was noted for treatment T1 when irrigation was given once a day (Table 2). The increase in length of the vine clearly depends upon the environment and agronomy-related factors; Hence, plants receiving frequent irrigations may raise the water in the roots, which will ultimately increase the amount of macronutrients that plants of cucumber move out of the soil. Likewise, soil texture and condition are important factors in extending the root length. The present findings are corroborated by Kirnak and Demirtas (2006), ho concluded that high pulse irrigation may lengthen the cucumber vine to a certain extent; nevertheless, over-irrigation may promote diseases and yellowish scars on the fruit.

Table 1. Impact of rate of irrigation applications on yield traits of cucumber

Treatments	Fruit length (cm)	Vine Length (m)	Fruit Weight (g)	Fruit Yield (tons ha^{-1})
T_1	12.329d	1.875cd	106.345d	43.899d
T_2	13.989c	1.998c	116.765c	45.765c
T_3	14.465bc	2.087b	123.369b	50.476bc
T_4	15.901b	2.089b	129.187ab	54.890b
T_5	17.789a	2.64a	131.978a	57.656a
(P< 0.05)	**0.960**	**0.117**	**15.077**	**0.826**

Means assigned with different letters show results significant at 5% significance level

Fruit Yield

As indicated in Table 2, the observed results indicated that varying rates of irrigation treatments for cucumber had a substantial impact on fruit yields. When the fruits were large enough to be used, and the peel became dark green, they were considered harvested. High frequency irrigation treatment T5 increased yield of fruits as much as (57.644 tons ha^{-1}), succeeded by T4 (54.887 tons ha^{-1}) and T3 (50.431 tons ha^{-1}) in the corresponding order. On the other hand, no significant differences were recorded between T4 and T3. The lowest fruit output per hectare was noted for treatment T1 (43.910 tons). Frequently, pulse irrigation increased the foliage development and chemical constituents of fruits, which ultimately gave more fruit length and fruit weight, hence affecting fruit yield. Similar results were recorded by Arshad (2017), who also concluded that irrigation treatments with abundant fertilizer increase the fruit output of green bell *capsicum*.

Conclusion

From the above results, it can be inferred that diverse irrigation treatments with continuous application of fertilizers brought an increase in cucumber under greenhouse cultivation.

Conflict of Interest

The authors affirm that the research was conducted without any involvement of commercial or financial relationships that could be perceived as a possible conflict of interest.

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Declaration

Authors' Contributions

The author (AZT) was involved in the conception, design, drafted the present manuscript and data analysis. All authors (MA, MK, AI) were involved in analysis and interpretation of data. AI and SHUHS have been involved in critically revising the manuscript for important intellectual content.

Conflicts of Interest

The authors declare that they have no competing interests.

Ethics approval and consent to participate

Not applicable

Availability of data and materials

All the generated data in this article.

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