*Research article*

# Effects of Drip Irrigation Frequency on Growth and Yield of Melon (*Cucumis melo* L.) under Net-house's Conditions

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Received 11 February 2019 Accepted 24 May 2019 (*Corresponding Author)

**Abstract** Irrigation plays an important role in melon (*Cucumis melo* L.) production. The study was conducted to compare the influence of irrigation frequency on growth and yield of melon and to identify the irrigation water use efficiencies of each treatment. The experimental plot was designed in RCBD layout divided into four treatments with three replications. They were Treatment 1 (T1), irrigated by drip irrigation 1 time per day, Treatment 2 (T2) irrigated by drip irrigation 2 times per day, Treatment 3 (T3) irrigated by drip irrigation 3 times per day, and Treatment 4 (T4) irrigated by hand-watering 2 times per day. All treatments were applied with the same amount of irrigation water based on crop water requirement calculation. Statistical analysis was done by ANOVA in SPSS software. The results indicate that T3 significantly affected on vegetative development (plant height and plant diameter), water use efficiency (WUE), dried and wet mass and yield of melon. The highest yields were obtained from T3 of 46.75 tons/ha with WUE of 78.18 kg $m^{-3}$, while the plant height and plant diameters were 164.33 cm and 10.55 mm and the lowest at the T4 of 29.17 tons/ha with WUE of 51.98 kg $m^{-3}$, while the plant height and plant diameters were 148.33 cm and 9.63 mm. However, there were no significant differences in water use efficiency between T1, T2 and T4 which are 55.60 kg $m^{-3}$, 64.10 kg $m^{-3}$ and 51.98 kg $m^{-3}$, respectively. Therefore, based on vegetative development, yield and quality of melon, T3 treatment would be the most appropriate irrigation for melon growers in controlled conditions.

**Keywords** drip irrigation, frequency, growth, melon, water use efficiency, yield

## INTRODUCTION

Irrigation plays an important role to increase the crop yield or crop productivity (Nut et al., 2017), especially inside greenhouse (Li et al., 2012). 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. On the other hand, the poor irrigation frequency can lead to the development of crop water deficit and result in a reduced yield due to water and nutrient deficiency. Water saving and higher water use efficiency will be significant factors in agricultural production. In most cases from agronomic, water conservation and economic aspects, drip irrigation has many advantages for crop production, particularly under protected culture condition (Ertek et al., 2006; Kumar et al., 2007;

Fernandez et al., 2007; Nut et al., 2017). Compared with furrow irrigation, drip irrigation can irrigate the crop root from the topsoil to increase water use efficiency.

Melon (*Cucumis melo* L.) is an important horticultural crop in the world, and is often cultivated with irrigation in semiarid or arid regions (Li et al., 2012). In Cambodia, tens of thousands of melons are grown every year by local farmers on increasing local demand. Some research has shown that melon is sensitive to water stress as the water deficit can reduce fruit yield and quality (Fabeiro et al., 2002). From seed sowing to emergence, excessive soil water can damage melon and cause fruit quality problems (Sensoy et al., 2007). At the same time, the relatively shallow depth of melon roots require soil water to be maintained at a minimum of 65% of capacity in order to avoid water deficit (Sensoy et al., 2007). Excessive irrigation immediately after transplantation can result in long and coarse growth, underdeveloped flower stalks and premature flower death of some plants such as squash, cucumber, watermelon and melon (Fabeiro et al., 2002; Kirnak et al., 2005; Ertek et al., 2006). Therefore, irrigation should be scheduled to avoid excessive water that can lead to reduced yield, lower quality, lower irrigation water use efficiency (IWUE), plant disease and fruit deformation in field or inside greenhouse (Sensoy et al., 2007).

## OBJECTIVE

The research aims: 1). To compare the influence of irrigation frequency on growth and yield of melon and 2). To identify the irrigation water use efficiencies of each treatment.

## MATERIALS AND METHODS

**Experimental conditions:** The experiments were carried out at Department of Agricultural Engineering, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (Latitude: 11° 34.23' N; Longitude: 104° 52.20' E; Altitude; 280 m above sea level) during the growing seasons 2017/2018. Soil samples at the study area were taken to the laboratory of Royal University of Agriculture (RUA) to analyse pH = 7.21, Soil Organic Matter (SOM) = 0.84% was determined by the method of Walkley and Black (1934), Electrical conductivity (Ec) = 5,300 μS $cm^{-1}$, Nitrogen (N) = 0.021%, Phosphorus (P) = 32.90%, and Potassium (K) = 0.47%, Soil bulk density = 1.55 g $cm^{-3}$, Soil water content = 4.50%, and Soil texture (Sand = 77.14%, Silt = 14.29% and clay = 8.57%) = loamy sand was determined by a hydrometer (Bouyoucos, 1951).

**Treatments and experimental design:** The experiments were laid-out in randomized complete block design (RCBD) with three replications. Each experimental plot was raised 15 cm as a ditch above the ground with the size of 2 meters long and 1 meter wide occupying an area of $2m^2$. Melons were planted in two rows on the plot on 28 October 2017. The water budget system for irrigation is relatively straightforward, but must be adjusted for crop growth stage and environmental conditions such as rain. Applied water was calculated by estimating crop evapotranspiration (ETc), which was calculated using the FAO method (Doorenbos and Pruitt 1977) as ETc = ETo x Kc. The same amount of water was applied to all treatments (Table 1).

**Table 1 Definitions of experimental treatments of irrigation water**

| Irrigation treatment | Description | Irrigation frequency | Amount of irrigated water ($m^3$/ha) |
|---|---|---|---|
| Treatment $T_1$ | Drip irrigation | 1 time/day | 2,990 |
| Treatment $T_2$ | Drip irrigation | 2 times/day | 2,990 |
| Treatment $T_3$ | Drip irrigation | 3 times/day | 2,990 |
| Treatment $T_4$ | Hand-watering | 2 times/day | 2,990 |

**Data collection:** The cumulative trends of the vegetative growth parameters (plant height and plant diameter) for different treatments was recorded weekly when the plant reached 25 days old after planting (Table 2(. Plant heights were determined by measuring the growing point of the main stem per 7 days, so a total of 9 times during the vegetative growth stage from 28 October to 04 November, 2017 were determined. Four plant samples were chosen from each plot in W-shape in order to measure some parameters such as plant height and plant diameter, blossom rate, fruit weight and fruit diameter, dried and wet mass of the plant.

Water use efficiency (WUE expressed in; kg $m^{-3}$) on yield basis was determined by dividing the yield (kg $ha^{-1}$) by the quantity of water applied ($m^3$ $ha^{-1}$) (sum of rainfall and quantity of water added by irrigation) during the growth period (Stanhill, 1987).

**Statistical analysis and data interpretation:** Collected data were subjected to the proper of statistical analysis of variance (ANOVA) of randomized complete block design (RCBD) as mentioned by Gomez and Gomez (1984). The combined ANOVA was carried out according to Steel et al. (1997), to estimate the main effects of the different sources of variation and their interactions. Differences were considered significant at $p < 0.05$. Treatment means were compared at 5% level of probability using the least significant difference (LSD) method (Steel et al., 1997), when the F-test for these treatments was significant at 5% probability level. Finally, all statistical analysis was carried out using SPSS computer software package while the graphic design was done with Microsoft Excel.

## RESULTS AND DISCUSSION

### Combined Analysis of Variance on Vegetative Growth

**Table 2 Mean plant height and stem diameter for different treatments during vegetative growth period**

| Parameters | Days of planting | Treatment (Mean±S.E.) | | | |
|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 |
| Plant height (cm) | 25 days | 11.7 ± 1.1 | 12.1 ± 0.2 | 12.7 ± 1.2 | 12.5 ± 0.2 |
| | 32 days | 22.7 ± 0.7 | 25.7 ± 0.5 | 28.2 ± 1.1 | 25.0 ± 0.6 |
| | 39 days | 33.7 ± 0.3 | 35.3 ± 0.3 | 38.8 ± 0.3 | 30.4 ± 1.2 |
| | 46 days | 52.7 ± 1.5 | 58.1 ± 0.5 | 63.3 ± 0.4 | 49.3 ± 1.8 |
| | 53 days | 70.3 ± 1.6 | 73.3 ± 1.7 | 81.8 ± 3.0 | 63.0 ± 1.5 |
| | 60 days | 95.0 ± 2.5 | 101.3 ± 4.0 | 111.7 ± 2.1 | 87.0 ± 5.1 |
| | 67 days | 122.3 ± 1.5 | 137.3 ± 4.2 | 145.5 ± 6.1 | 110.7 ± 5.2 |
| | 74 days | 148.3 ± 4.4 | 160.0 ± 0.0 | 176.9 ± 2.0 | 138.3 ± 4.4 |
| | 81 days | 164.3 ± 3.5 | 170.3 ± 2.6 | 187.0 ± 2.0 | 148.3 ± 7.3 |
| Plant diameter (mm) | 25 days | 3.9 ± 0.1 | 3.8 ± 0.1 | 3.9 ± 0.0 | 3.8 ± 0.1 |
| | 32 days | 5.6 ± 0.1 | 5.3 ± 0.2 | 5.5 ± 0.1 | 5.1 ± 0.2 |
| | 39 days | 6.8 ± 0.1 | 6.6 ± 0.1 | 6.9 ± 0.2 | 6.2 ± 0.1 |
| | 46 days | 7.4 ± 0.2 | 7.1 ± 0.1 | 8.2 ± 0.2 | 6.8 ± 0.0 |
| | 53 days | 8.3 ± 0.3 | 7.8 ± 0.2 | 8.8 ± 0.3 | 7.3 ± 0.2 |
| | 60 days | 8.7 ± 0.2 | 8.2 ± 0.1 | 9.4 ± 0.3 | 7.8 ± 0.2 |
| | 67 days | 9.8 ± 0.1 | 9.4 ± 0.2 | 10.7 ± 0.3 | 8.6 ± 0.1 |
| | 74 days | 10.4 ± 0.1 | 10.2 ± 0.0 | 11.2 ± 0.2 | 9.3 ± 0.2 |
| | 81 days | 10.6 ± 0.1 | 0.8 ± 0.1 | 11.5 ± 0.3 | 9.6 ± 0.1 |

*Data were shown in mean ± S.E.*

Irrigation regimes are one of the essential factors which can significantly affect the crop growth and yield. The plant height growth rate was defined as the ratio of the plant net growth amount for the adjacent measured values and the former plant height values, and the former plant height values is the reference (100%) value. It is an important index to research plants' dynamic growth (Zeng et al., 2009). During the first stage after 25-day-old planting, the plant height were 11.7 cm, 12.1 cm, 12.7 cm and 12.5 cm for T1, T2, T3 and T4, respectively. The plant height gradually increases from 25 to 39 days after planting, and from 46 to 81 days the plant heights grow faster which increases with the frequency of the irrigation water as it is in the development stage. It can be seen that the plant height of T3 (187 cm) was significantly different at $p<0.05$ for all treatments, T1 (164.33 cm), T2 (170.33 cm) and T4 (148.33 cm). There is no significant difference between the applications of irrigation frequency once or twice time per day.

The plant diameter was measured weekly at the third internode uniformly. Table 2 shows that the plant diameter increased with plant growth, and the more frequency of irrigation water applied, the larger plant diameter was obtained. These results are consistent with studies of different irrigation scheduling on melon and cucumber (Mannini, 1988) which found that when the irrigation interval was prolonged and less frequent, it reduced the growth of various parts of the plant. In addition, Wang et al., 2006 found that drip irrigation frequency affected the temporal and spatial distribution of soil water when total irrigation water was the same and influenced the growing stage of potato. Moreover, it is similarly with (Wang et al., 2009) studied on subsurface drip irrigation scheduling for cucumber in solar greenhouse.

Table 3 indicates that the frequency of irrigation had significant effects on fruit yield of all treatments. Total yields of T3 (46.75 t/ha) were higher than other treatments. Moreover, more frequent irrigation resulted in greater numbers of marketable fruit which were statistically significant difference (Table 3). Similarly, Sensoy et al. (2007) found that the highest melon yield was obtained from the treatment with the highest irrigation compensation, which combined more frequent irrigation (6-day intervals) with greater amounts of water.

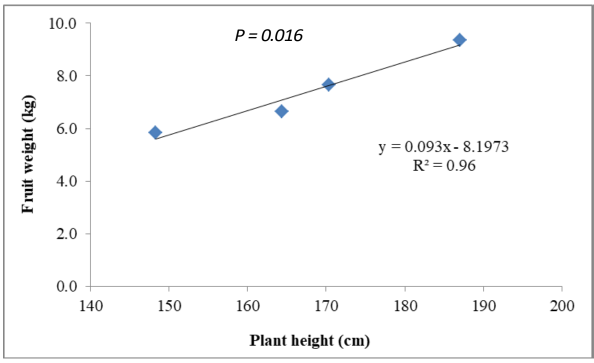
**Table 3 Some parameters of yield and irrigation under different irrigation treatments**

| Parameters | Treatment | | | | |
|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | S.D |
| 50% Blooming (day) | 34b | 33b | 31a | 36c | 0.67 |
| 100% Blooming (day) | 36b | 35b | 33a | 38c | 0.70 |
| Numbers of nodes per plant | 16a | 15ab | 16ab | 14b | 0.56 |
| Plant height (cm) | 164.33b | 170.33b | 187.00a | 148.33c | 3.59 |
| Plant diameter (mm) | 10.55b | 10.79b | 11.54a | 9.63c | 0.23 |
| Mean fruit weight (kg) | 6.65bc | 7.67b | 9.35a | 5.93c | 1.52 |
| Fruit diameter (cm) | 107.00b | 116.33c | 140.00a | 95.75d | 1.82 |
| Good fruit yield (t/ha) | 29.17bc | 34.17b | 41.67a | 25.58c | 2.61 |
| Bad fruit yield (t/ha) | 4.08b | 4.17b | 5.08a | 3.58b | 0.30 |
| Total fruit yield (t/ha) | 33.25bc | 38.34b | 46.75a | 29.16c | 2.71 |
| Wet mass of stem (g/plant) | 106.67b | 109.67ab | 123.33a | 90.00c | 5.67 |
| Dried mass of stem (g/plant) | 9.33ab | 9.79ab | 11.48a | 7.76b | 0.91 |
| Wet mass of leaf (g/plant) | 148.33c | 167.67b | 190.00a | 127.67d | 5.81 |
| Dried mass of leaf (g/plant) | 15.51ab | 16.17ab | 19.33a | 11.33b | 0.83 |
| WUE (kg/m$^3$) | 55.60b | 64.10b | 78.18a | 51.98b | 5.37 |

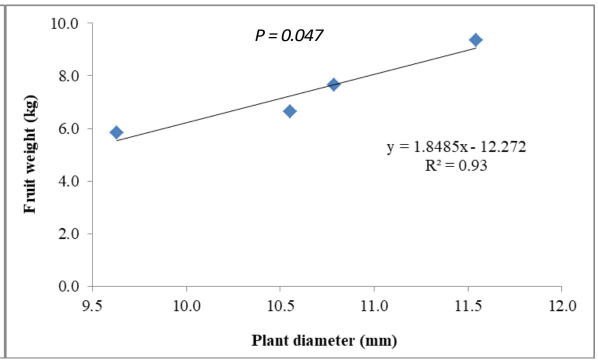
*The values with the same letter are statistically non-significant by F-test at $p < 0.05$.*

## Water Use Efficiency (kg m$^{-3}$)

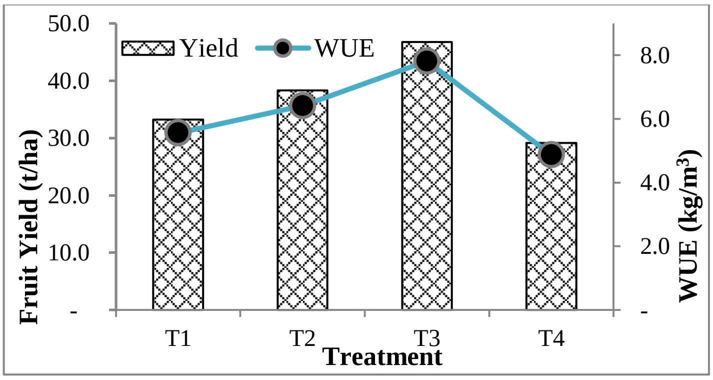
Inside the nethouse, there was a bit rainfall and runoff while using the drip irrigation systems. Irrigation water use efficiency (IWUE) was the relation between yield and irrigation water, and was computed based on melon yield divided by irrigation amount. So, the irrigation water use efficiency (IWUE) is the same as the water use efficiency (WUE). The irrigation water use efficiency of different treatments is listed in Table 3 and Fig. 1. The analysis of variance showed significant differences between irrigation treatments. The highest WUE yield was obtained in T3 by 78.18 kg m$^{-3}$ and the lowest at the T4 with 51.98 kg m$^{-3}$ (Table 2). There were no significant differences in WUE between T1, T2 and T4 which are 55.60 kg m$^{-3}$, 64.10 kg m$^{-3}$ and 51.98 kg m$^{-3}$, respectively. This result was not consistent with the former research (Kirnak et al., 2005; Sensoy et al., 2007) which considered that the lower the amount of irrigation water received the higher the irrigation water use efficiency achieved, but it is similar to the research by Fabeiro et al., (2002). From Table 2, it can be seen that the yield of T1 and T4 was obviously declined compared to T2 and T3, resulted in decrease with IWUE. Ortega and Kretchman (1982) found that in water-stressed plants the growth of large fruits continued, whereas the growth of small fruits was seriously inhibited. In this experiment, the low fruit yields of T1 and T4 maybe suffered from serious water stress due to over-irrigated water by drip irrigation which applied just one time, while the hand-watering applied irrigation twice per day could waste the irrigation water and caused surface runoff resulted in lack of soil water in the root zone of the melon plant.




(A)




(B)




(C)

**Fig. 1 The relationship between fruit weight with plant height (A) and plant diameter (B), and fruit yield and irrigation water use efficiency for different treatments (C)**

Figure 1 shows the relationship between fruit weight with plant height (A) and plant diameter (B) and fruit yield and irrigation water use efficiency for different treatments (C). Through linear regression analysis, a mathematical function was obtained. From Fig. 1 (A) and (B), it can be found the relations of fruit weight and plant diameter and plant height that the fruit weight increased with the stem diameter and plant height which showed the vegetative growth is important for melon fruit. Fig. 1 (C) shows fruit yield and irrigation water use efficiency for different treatments which meant that irrigation water had significantly affected fruit production. Fruit production was the highest for treatment T3 as shown in Table 3 and Fig. 1.

## CONCLUSION

The results of the study showed that irrigation frequency plays significant role in vegetative growth, fruit yield and quality of melon grown in nethouse conditions which may be affected by soil water content, especially the frequency of irrigation, which produced significant differences in yield and components in all treatments of the experiment as the irrigation level was applied at the same amount. In particular, the irrigation frequency increased yield not only by increasing the mean fruit weight, but also by increasing fruit size which was performed in fruit diameter. Of the four irrigation treatments, the highest fruit yield (46.75 t/ha) and WUE (78.18 kg $m^3$) were obtained from the T3. This amount of production was achieved with maximum water use efficiency with irrigation intervals 3 times per day. Therefore, T3 would be the most appropriate thresholds for melon grower irrigating by drip-irrigation which could offer multiple benefits to reduce erosion and loss of nutrients in the soil, makes the ground slow density, reduce grass, use less water, save time, crops grow well and yield increased. However, the further researches on growing melon outside greenhouse's condition should be taken in consideration to spread the results to Cambodian farmers as most of them cannot effort to build the greenhouse for growing crops due to the high investment cost of the construction.

## REFERENCES


Bouyoucos, G.H. 1951. A recalibration of the hydrometer for making mechanical analysis of soils. Agronomy Journal, 43, 434-438.

Doorenbos, J. and Pruitt, W.O. 1977. Guidelines for predicting crop water requirements. Irrigation and Drainage, Paper No. 24, Food and Agr. Organization, Rome.

Ertek, A., Sensoy, S., Gedik, I. and Kucukyumuk, C. 2006. Irrigation scheduling based on pan evaporation values for cucumber (*Cucumis sativus* L.) grown under field conditions. Agric. Water Manage., 81, 159-172.

Fabeiro, C., Martín de Santa Olalla, F. and De Juan, J.A. 2002. Production of muskmelon (*Cucumis melo* L.) under controlled deficit irrigation in a semi-arid climate. Agric. Water Manag., 54, 93-105. https://doi.org/10.1016/S0378-3774(01)00151-2

Fernandez, M.D., Gonzalez, A.M., Carrerio, J., Perez, C. and Bonachela, S. 2007. Analysis of on-farm irrigation performance in Mediterranean greenhouses. Agric. Water Manage., 89, 251-260.

Gomez, K.A and Gomez, A.A. 1984. Statistical procedures for agricultural research. 2nd Ed., John Wiley and Sons, Inc., 108-116, New York.

Kirnak, H., Higgs, D., Kaya, C. and Tas, I. 2005. Effects of irrigation and nitrogen rates on growth, yield, and quality of muskmelon in semiarid regions. J. Plant Nutr., 28, 621-638. https://doi.org/10.1081/PLN-200052635

Kumar, S., Imtiyaz, M., Kumar, A. and Singh, R. 2007. Response of onion (*Allium cepa* L.) to different levels of irrigation water. Agric. Water Manage., 89, 161-166.

Li, Y.J., Yuan, B.Z., Bie, Z.L. and Kang, Y. 2012. Effect of drip irrigation criteria on yield and quality of muskmelon grown in greenhouse conditions. Agric. Water Manag., 109, 30-35. https://doi.org/10.1016/j.agwat.2012.02.003

Mannini, P. 1988. Effects of different irrigation scheduling and systems on yield response of melon and cucumber. Acta Hortic., 228, 155-162. DOI: 10.17660/ActaHortic.1988.228.16. https://doi.org/10.17660/ActaHortic.1988.228.16

Nut, N., Seng, S. and Mihara, M. 2017. Effect of drip - fertigation intervals and hand - watering on tomato growth and yield. International Journal of Environmental and Rural Development, 8 (1), 1-6. https://doi.org/10.32115/ijerd.8.1_1

Ortega, D.G. and Kretchman, D.W. 1982. Water stress effects on pickling cucumber. HortScience, 107, 409-412.

Sensoy, S., Ertek, A., Gedik, I. and Kucukyumuk, C. 2007. Irrigation frequency and amount affect yield and quality of field-grown melon (*Cucumis melo* L.). Agric. Water Manag., 88, 269-274. https://doi.org/10.1016/j.agwat.2006.10.015

Stanhill, G. 1987. Water use efficiency. Adv. Agron., 39, 53-85.

Steel, R.G.D., Torrie, J.H. and Dickey, D.A. 1997. Principles and procedures of statistics: A biometrical approach. McGraw Hill Book International Co., New York.

Walkley, A. and Black, J.A. 1934. An examination of the dichormate method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science, 37, 29-38.

Wang, F., Kang, Y. and Liu, S. 2006. Effects of drip irrigation frequency on soil wetting pattern and potato growth in North China Plain. Agric. Water Manag., 79, 248-264. https://doi.org/10.1016/j.agwat.2005.02.016

Wang, Z., Liu, Z., Zhang, Z. and Liu, X. 2009. Scientia horticulturae subsurface drip irrigation scheduling for cucumber (*Cucumis sativus* L.) grown in solar greenhouse based on 20 cm standard pan evaporation in Northeast China. 123, 51-57. https://doi.org/10.1016/j.scienta.2009.07.020

Yuan, B.Z., Nishiyama, S. and Kang, Y. 2003. Effects of different irrigation regimes on the growth and yield of drip-irrigated potato. Agric. Water Manag., 63, 153-167. https://doi.org/10.1016/S0378-3774(03)00174-4