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Research Article

# Effects of Drip Irrigation Schedules on the Yields of Marigolds

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## Abstract

Marigolds are popular plants in the Asteraceae family with yellow, orange, and red flowers due to their carotenoid compounds. It is reported that drip irrigation is an efficient method for maintaining a constant supply of moisture and nutrients and thus promoting plant growth. The objective of the present study was to examine the effects of drip irrigation schedules on the yield of marigolds. The experiment was conducted by transplanting seedlings of marigolds aged 20 days to plastic pots and then watering them with an automatically controlled mist irrigation system for 1 h twice daily. The irrigation schedules were varied as follows: 07:00–08:00 and 12:00–13:00, 08:00–09:00 and 13:00–14:00, 09:00–10:00 and 14:00–15:00, or 10:00–11:00 and 15:00–16:00. The findings showed that the first method was the best option for cultivating marigolds as it involved the lowest irrigation rate of 773.31 mL/h and the highest yield with the flower size reaching 6.61 cm, the flower weight standing at 10.53 g, and the number of flowers equaling 6.17 per plant.

***Keywords:*** *Watering, Drip irrigation, Yields, Marigolds*

## Introduction

Marigolds are plants in the Asteraceae family cherished for their yellow, orange, and red flowers. Despite their differences, *Calendula officinalis* L. and Tagetes, collectively called marigolds, are both in the Asteraceae family. The former comprises 25 species of edible herbaceous and perennial plants reported to contain a multitude of beneficial carotenoid compounds, such as cannabinoids, xanthophyll pigments (flavoxanthin, rubixanthin, and lutein), and carotenoids (β-carotene, g-carotene, and lycopene), whereas the latter consists of 56 species, most often *Tagetes patula*, commonly referred to as *French marigolds* (with small flowers), and *T. erecta*, commonly referred to as *African marigolds* (with large flowers) [1]–[3].

One method commonly applied to water plants is drip irrigation. As drip irrigation draws on the controlled delivery of water to plants with a network of tubes or pipes, it is highly efficient in supplying constant moisture and nutrients, preventing direct moisture loss from evaporation, and thus promoting plant growth [4]–[7] ; managing scarce water resources by reducing water use and increasing yields [7]–[9] ; curbing soil surface runoff, stopping nutrient leaching and chemical absorption, and increasing the volume of water absorbed in soil and lowering the rate of loss from evaporation [10], [11].

The effects of drip irrigation on plant growth and yields have been investigated in a great deal of research. For instance, Maniin et al. [12] examined how water volumes affected the growth, yields, and quality of 'Kinnaree' organic watermelons cultivated in a nursery installed with an automatically controlled drip irrigation system. Irrigation was scheduled twice daily in the morning and the evening during which water was supplied at 100%, 80%, 60%, and 40% of the holding capacity of the planting materials, or 962.5 milliliter per plant, 770.0 milliliter per plant, 577.5 milliliter per plant, and 385.0 milliliter per plant, respectively. It was found that among the four treatment, the water volume of 577.5 milliliter per plant performed the best, contributing to the highest number of leaves of 68, the highest peel thickness of 0.54 cm, the highest sweetness index of 12.90°Brix, and the EC50 antioxidant effect of 1.19 $mgFWL^{-1}$.

In another study along similar lines, Watcharinrat et al. [13] tested the efficiency of drip irrigation combined with *Bacillus* bacteria in promoting the growth of chilis. Water was irrigated 10 minutes twice daily at 09:30 and 15:30, 5 minutes three times daily at 09:30, 11:30, and 15:30, 10 minutes twice daily at 09:30 and 15:30 combined with the application of *Bacillus* bacteria, and 5 minutes three times daily at 09:30, 11:30, and 15:30 combined with the application of *Bacillus* bacteria. According to their findings, the 5 minutes irrigation treatment could better conserve water than did the 10 minutes counterparts by up to 23.59%, while the latter contributed to higher plant heights. However, the total yields achieved from the four treatments did not differ significantly.

Che et al. [14] went a step further, experimenting on the effects of both water and nitrogen volumes on soil salinity and cotton yields. The irrigation amounts were varied at 75%, 100%, 125%, and 150% of the crop water requirement (ETc) of the cotton in question, and the nitrogen volumes at 195 kg $ha^{-1}$, 255 kg $ha^{-1}$, 315 kg $ha^{-1}$, and 375 kg $ha^{-1}$. Their findings indicated that the highest irrigation amount of 150% ETc and nitrogen volume of 375 kg $ha^{-1}$ during the flower harvest period and throughout the cultivation season produced significantly higher nitrogen absorption levels with the figures rising to 25% – 74% and 39% to 65%, respectively.

Although past studies similarly demonstrate that drip irrigation is a highly efficient method for maintaining a constant supply of moisture and nutrients and promoting plant growth, vital factors that need to be carefully controlled to achieve the best outcomes include irrigation volumes, irrigation scheduling, and plant types. Therefore, the present research aimed to examine the effects of drip irrigation schedules on the yields of marigolds. The drip irrigation system was controlled with an automatic valve set to supply water for 1 h twice daily at different times: 07:00–08:00 and 12:00–13:00, 08:00–09:00 and 13:00–14:00, 09:00–10:00 and 14:00–15:00, or 10:00–11:00 and 15:00–16:00.

## Research Methods

### Seedling Cultivation and Transplantation

Marigold seeds under the Sunshine Gold brand of Chia Tai Co., Ltd. were cultivated in peat moss laid on planting trays with 104 holes. After 20 days of aging, the seedlings in good condition were selected and then transplanted to plastic cultivation pots with a diameter of 12 inch containing 5 kg of planting materials comprising raw rice husks, cow manure, soil surface, chopped coir, coconut dust, rice husk ashes, and dolomite lime at the ratio of 1:1:1:1:1:1:1 (by volume). To ensure the best cultivation culture, only one seed was planted in one hole and only one marigold in one cultivation pot.

The experiment was conducted in an outdoor environment under the average relative humidity of 56.67% and the average temperature of 31.38°C (Figure 1). Following a completely randomized design (CRD), three of the marigolds received 1 h of automatically controlled irrigation twice daily for 74 days according to the Treatment below with each being repeated four times.

Treatment 1: 07:00–08:00 and 12:00–13:00

Treatment 2: 08:00–09:00 and 13:00–14:00

Treatment 3: 09:00–10:00 and 14:00–15:00

Treatment 4: 10:00–11:00 and 15:00–16:00

Figure 1: Drip irrigation system installed to water the potted Marigold

### Marigold Nurture

After transplantation, the marigolds were given 2.25 g of a 16-16-16-formula fertilizer. Following blooming, the plants received a 9-25-25-formula fertilizer once weekly. Also, weeds were removed fortnightly, and pesticides were sprayed when pests were spotted.

### Experimental Data Recording

For 74 days after transplantation, the irrigation rate, the flower size, the weight per flower, and the number of flowers per plant were recorded. As for the second criterion, the flower size was classified into grade 1 (8–9 cm), grade 2 (6–7 cm), grade 3 (5 cm), and grade 4 (under 5 cm).

### Experimental Venue and Duration

The research was conducted between February and April, 2021 at the faculty of agricultural technology, Rajamangala University of Technology Thanyaburi, Pathumthani province, Thailand.

### Data Analysis

To compare the mean differences between the four treatment, the data were analyzed using the Duncan multiple range test (DMRT) at the confidence level of 95%.

## Results

### Irrigation Rate per Session

The volume of water irrigated during each of the irrigation sessions did not differ significantly across the four treatments. However, the first treatment was found to lead to the lowest irrigation rate of 773.31 mL/h, while the last treatment resulted in the highest irrigation rate of 883.99 mL/h. The results are displayed in Table 1.

Table 1: Irrigation rate during each session

| Methods | Irrigation rate during each session (mL/h) |
|---|---|
| 07:00–08:00 and 12:00–13:00 | 773.31 |
| 08:00–09:00 and 13:00–14:00 | 794.64 |
| 09:00–10:00 and 14:00–15:00 | 862.65 |
| 10:00–11:00 and 15:00–16:00 | 883.99 |
| F-test | ns |
| CV (%) | 17.44 |

**Notes:** ns demonstrates insignificant differences at the confidence level of 95%.

### Flower Size, Weight per Flower, and Number of Flowers per Plant

As shown in Table 2, the findings indicated that none of the treatments produced grade 1 flowers (8–9 cm). However, all contributed to insignificantly different flower sizes and weight per flower. Additionally, for grade 2 flowers (6–7 cm) the first treatment achieved the significantly highest number of flowers per plant of 6.17 with the flower size and the weight per flower standing at 6.61 cm and 10.53 g, respectively, whereas the third treatment resulted in the significantly lowest number of flowers per plant of 3.67 with the flower size and the weight per flower equaling 6.53 cm and 10.85 g, respectively. Thus, the former could be considered the method giving the highest yield.

Regarding grade 3 flowers (5 cm), the third treatment seems to have led to the best yield, reflected by the largest flower size, weight per flower, and number of flowers per plant of 5.44 cm, 6.79 g, and 6.25, respectively. However, these results did not differ significantly from those of the other treatments.

As for grade 4 flowers (under 5 cm), the four treatments did not differ significant in terms of flower size and weight per flower. However, the second treatment contributed to the significantly highest number of flowers per plant of 9.83, followed by the third one at 8.42 flowers per plant. Thus, these could be viewed as the methods leading to the highest yields.

Table 2: Flower size, weight per flower, and number of flowers per plant

| Methods | Flower size (cm) | Weight per flower (g) | Number of flowers per plant |
|---|---|---|---|
| Grade 1 (8–9 cm) | | | |
| None of the experimental methods resulted in the growth of grade 1 flowers. | | | |
| Grade 2 (6–7 cm) | | | |
| 07:00–08:00 and 12:00–13:00 | 6.61 | 10.53 | 6.17[a] |
| 08:00–09:00 and 13:00–14:00 | 6.54 | 10.49 | 4.25[b] |
| 09:00–10:00 and 14:00–15:00 | 6.53 | 10.85 | 3.67[b] |
| 10:00–11:00 and 15:00–16:00 | 6.48 | 10.96 | 4.50[b] |
| F-test | ns | ns | * |
| CV (%) | 1.64 | 8.19 | 25.46 |
| Grade 3 (5 cm) | | | |
| 07:00–08:00 and 12:00–13:00 | 5.43 | 6.55 | 4.17 |
| 08:00–09:00 and 13:00–14:00 | 5.43 | 6.51 | 5.67 |
| 09:00–10:00 and 14:00–15:00 | 5.44 | 6.79 | 6.25 |
| 10:00–11:00 and 15:00–16:00 | 5.44 | 6.76 | 5.42 |
| F-test | ns | ns | ns |
| CV (%) | 0.96 | 5.81 | 30.29 |
| Grade 4 (under 5 cm) | | | |
| 07:00–08:00 and 12:00–13:00 | 4.19 | 3.66 | 7.17[b] |
| 08:00–09:00 and 13:00–14:00 | 4.17 | 3.42 | 9.83[a] |
| 09:00–10:00 and 14:00–15:00 | 4.15 | 3.51 | 8.42[ab] |
| 10:00–11:00 and 15:00–16:00 | 4.13 | 3.41 | 7.42[b] |
| F-test | ns | ns | * |
| CV (%) | 2.42 | 6.07 | 18.69 |

**Notes:** ns demonstrates insignificant differences at the confidence level of 95%.

* demonstrates significant differences at the confidence level of 95%.

From the DMRT, means with different vertical letters, i.e. b, a, c, demonstrate significant differences in the groupings at the confidence level of 95%.

## Discussion

It was found that overall, the four treatments did not differ significantly in terms of irrigation rate, flower size, and weight per flower. However, the first treatment produced the significantly highest number of grade 2 flowers per plant of 6.17 at the insignificantly lowest irrigation rate of 773.31 mL/h and with the insignificantly highest flower size and weight per flower of 6.61 cm and 10.53 g, respectively. The present findings are consistent with those of Phuangchik [15], which tested the crop water requirement of 10 bamboo varieties, namely *Dendrocalamus* sp. (Pai Beijing), *D. asper* (Pai Tong Mor), *D. membranaceus* Munro (Pai Sang Nuan), *D. brandisii* Kurz (Pai Bongyai), *Dendrocalamus* sp. cl. Sead Pha (Pai Sang Mon 'Sead Pha'), *Dendrocalamus* sp. cl. Phamon (Pai Sang Mon 'Phamon'), *Dendrocalamus* sp. cl. Nuan Rachini (Pai Sang Mon 'Nuan Rachini'), *Dendrocalamus* sp. (Pai Giant), *Bambusa beecheyana* Munro (Pai Kim Sung), and B. *beecheyana* Munro (Pai Tong Luem Lang). Irrigation was carried out once every two or every four days at the volume of 10 literl per plant. It was found that throughout the cultivation period under investigation, the two treatments did not lead to significantly different growth rates. In addition, at 18 months after the beginning of cultivation the average number of culms per clump, plant height, and plant diameter were in the range of 3.25–19.12, 2.95–7.62 m, and 2.55–6.91 cm, respectively.

The present findings are also partially corroborated by those reported in Watcharinrat et al. [13], [16]. Watcharinrat et al. [16] conducted their experiment by drip irrigating water for 5 minutes or 10 minutes every 8 h, discovering that the 5 minutes irrigation accounted for the highest total yield. In comparison, Watcharinrat [13] carried out their study by drip irrigating water for 10 minutes twice daily at 09:30 and 15:30 and drip irrigating water for 5 minutes three times daily at 09:30, 11:30, and 15:30. The results demonstrated that the outcomes of the two treatments did not differ significantly. However, the three times daily treatments conserved water by as much as 23.59% and contributed to the highest plant height. In contrast, the twice daily treatment yielded the highest fresh plant and root weights.

Based on the foregoing discussion, it is evident that crop irrigation needs to take into consideration an array of factors, including crop types, irrigation scheduling, and irrigation frequency. Also, further research should investigate why and how a lower irrigation rate can bring a higher yield, as suggested by the findings of previous research.

## Conclusion

In this study, the effects of watering on the yields of marigolds were examined by scheduling 1 h irrigation at 07:00–08:00 and 12:00–13:00, 08:00–09:00 and 13:00–14:00, 09:00–10:00 and 14:00–15:00, or 10:00–11:00 and 15:00–16:00. The findings showed that the first treatment resulted in the lowest irrigation rate of 773.31 mL/h, whereas the last treatment led to the highest irrigation rate of 883.99 mL/h. In addition, none of the treatments produced grade 1 (8–9 cm) flowers. However, for grade 2 flowers the first treatment contributed to the significantly highest number of flowers per plant, and the same was true of grade 4 flowers cultivated with the second treatment. Therefore, it is recommended that irrigation be scheduled at 07:00–08:00 and 12:00–13:00 as such watering times is most likely to produce the highest yield of size 2 (6–7 cm) flowers at the lowest irrigation rate.

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