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Favorable Irrigation Timing with Timer and Fruiting Position Focused on the Fruit Quality and Harvesting Time in Perlite Culture of Muskmelon[1]

Kim, Hye Jin · Young Shik Kim*
Department of Horticultural Science, Sangmyung University, San 98-20 Anso-dong, Cheonan 330-720
(*Corresponding author)

Abstract

The efficient timer-controlled irrigation and the favorable fruiting position were investigated for highly quality melon fruits from Feb. 18 to July 5, 1999. The nutrient solution was supplied either at every hour from 6:00 to 18:00 (T-1) or at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00 (T-2). A fruit was set at the first node of the fruit bearing branch from the 10, 12, or 13th node of the main stem. Pot weight was maintained at almost a constant level, regardless of the daily integrated solar radiation in T-2. Soluble solids content (SSC) and fresh weight of fruit were not significantly different among the irrigation treatments at each harvesting time. At the first harvest, SSC and fresh weight of fruit were not significantly different between the fruiting positions within the irrigation treatment. At the second harvest, SSC was higher in T-2 than T-1. The SSC was low in the fruit of the 10th node in T-1, while it was not significantly different between fruiting positions in T-2. Fruit fresh weight was the highest at the 12 and 13th nodes in T-1, and the 13th node in T-2. Fresh and dry weights of leaf except petiole, regardless of harvesting time, increased as the node position was higher. The higher the fruiting position was, the lower the leaf weight was. Therefore, it is recommended to irrigate more frequently during the mid-noon. Fruits can be harvested earlier at the lower nodes in the spring crop production.

***Additional key words*: *Cucumis melo*, fruit set, hydroponics, soluble solids content, fruit weight**

Introduction

Timer-controlled irrigation has been used most widely because the installation of system and its operation is simple and inexpensive (Hardy et al., 1989). Timers are normally used to initiate semiautomatic irrigations and to determine the application duration (Humpherys, 1995). The irrigation by the semiautomatic timer control system provides operator convenience and reduces water and labor use compared to the manual irrigation (Humpherys, 1995).

To implement timer irrigation, the grower uses his experience and daily observations in order to determine irrigation quantity and intervals. Irrigation scheduling is usually maintained until permanent change in the weather takes place (Raviv et al., 1993). If nutrient solution is managed in this way, the irrigation regime by timer control is apt to bring the deficiency and excess of the amount of nutrient solution by the weather conditions in growing period of plants. Timing is the key to irrigation controlled by timer. The appropriate control algorithms for irrigation with timer depend on the supplying time, the frequency, and the total quantity of irrigation. This experiment focused on the time intervals by timer-controlled irrigation during daytime.

The melon consumption is expected to be increased in line with growing personal income as melon is a high-priced fruit. The size, shape and soluble solids content (SSC) of the fruit are the main factors estimating the fruit quality, and then influenced on fruiting position (Han and Park, 1993; Hwang et al., 1998). The fruiting position affects the timing of fruit set and harvesting time (Sin et al., 1991). Therefore, it is very important to determine the fruiting position in melon cultivation.

At present, optimum irrigation management controlled by timer and fruiting position for melons are not being investigated extensively in perlite culture. Therefore, suitable irrigation intervals and the desirable fruiting position were determined to improve the fruit quality of the melon grown in perlite culture.

Materials and Methods

Plant culture. This study was carried out from Feb. 18 to July 5, 1999 in the three quarter glasshouse at Sangmyung University. The muskmelon seeds, *Cucumis melo* L. cv. World (Nonghyup Seed Development Center), were sown in the plug trays filled with Baroker (Seoul Agricultural Materials) substrate on Feb. 18. Yamazaki's nutrient solution for melon (Yamazaki, 1982) with half ionic strength was supplied by the ebb and flow method during raising the seedlings. On April 7 Each of young plants was planted into a cylindrical pot (diameter 35 cm, depth 26 cm) filled with perlite, of which particle size was 1.2~5 mm and dry bulk density was 0.115~0.145 $kg \cdot L^{-1}$. The substrate was completely wetted up with nutrient solution 3 days before planting, and then irrigated by the drippers. The concentration of nutrient solution was 2.0~2.2 $dS \cdot m^{-1}$ and pH was 5.5~6.5 during the whole growing period. Nutrient solution was applied to each plant via four drippers of 2 $L \cdot h^{-1}$ per pot. The computerized automatic system developed in our laboratory was used to monitor the concentration and pH of the nutrient solution. Plants were topped off at the 22nd node of the main stem. Flowers were pollinated during May 4~10. Only one fruit was set on a single plant.

Treatments. Irrigation treatments controlled by timer were initiated on June 12. The nutrient solution was supplied at every hour from 6:00 to 18:00 (T-1) or at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00 (T-2). The duration of irrigation in each application by timer-controlled irrigation was 80 seconds with the amount of 192 mL per plant. The fruit was set at the first node of the fruit bearing branch at the 10, 12, and 13th node of main stem to know the effect of the fruiting position on the quality of the fruit. The melon fruits were harvested firstly on June 21 (1ST), 48 days after pollination, or secondly on July 5 (2ND), 62 days after pollination.

Growth measurements and analyses. Pot weights in each treatment were measured dynamically with the weighing sensor of panel type (CAS, CI-5010A). The computerized automatic system developed in our laboratory was used to measure the weight values.

After harvest, fresh weight and SSC of fruit, evaluated as Brix, were investigated. As the SSC varied within the different regions of the same melon fruit, the fruits were cut along the longitudinal axis. Samples were taken from 2 regions of flesh of a fruit, 0.5 cm apart from the juicy part, and then measured with a hand digital refractometer (TRM-110, N.O.W.). The leaf fresh weight at each node was also measured. All data were analyzed using analysis of variance with SAS, and means were separated by Duncan's multiple range test where analysis of variance indicated statistical significance at the $p < 0.05$ level (SAS, 1999).

Results and Discussion

The pot weight ratio was calculated by dividing the present weight by the initial weight as the pot weight in each treatment was not the same when the treatment was started. The pot weight ratio was influenced more in T-1 than in T-2, no matter what daily integrated solar radia-

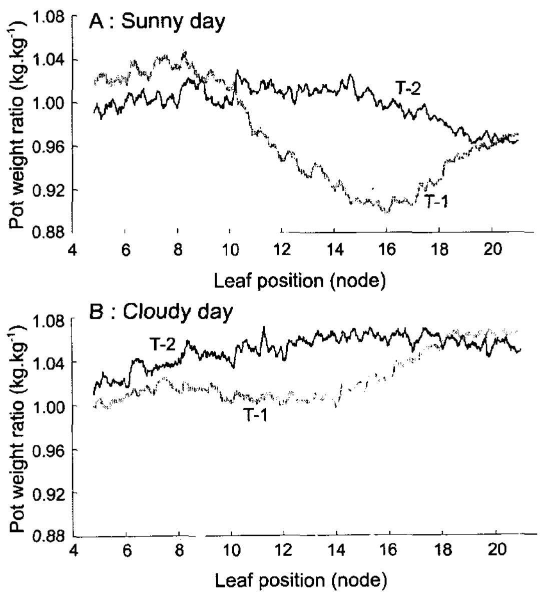

Fig. 1. Pot weight ratio on the sunny day (daily integrated solar radiation, DISR 18.8 $MJ \cdot m^{-2}$) and cloudy day (DISR 3.3 $MJ \cdot m^{-2}$). T-1, Irrigation at every hour from 6:00~18:00; and T-2, Irrigation at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00.

tion (DISR) was (Fig. 1). The reason is considered that the irrigations were applied 3 times more in T-2 than in T-1 in the period of time between 10:00 and 14:00. This result is similar with the previous report (Kim and Kim 2000). On the sunny day (DISR of 18.8 $MJ \cdot m^{-2}$), the pot weight ratio after 20:00 was similar among the treatments (Fig. 1A). On the cloudy day (DISR of 3.3 $MJ \cdot m^{-2}$), the ratio after 18:00 was also similar between the treatments (Fig. 1B). The trends in the variation of pot weight, depending on the DISR, were similar to those on other weather conditions (data were not shown).

In the experimental result for irrigation timing and harvesting time, SSC and fresh weight of fruit were not significantly different between irrigation timing in each harvesting time, though SSC was slightly higher in T-2 (Table 1). Maybe the reason is that the nutrient solution in T-2 was supplied more than in T-1 at noon when the solar radiation was higher. This result shows similarity with the earlier published work (Kim and Kim, 2000). Regardless of irrigation treatments, SSC and fresh weight of fruit were higher at 2ND harvest than 1ST harvest.

In the comparison among fruiting positions by irrigation timing and harvesting time, SSC was not significantly different among fruiting positions within the irrigation timing treatments at 1ST harvest, though it was indicated higher in the fruit at the 10th node in T-1 and T-2. At 2ND harvest, SSC was low in the fruit at the 10th node in T-1, while it was not significantly different between the fruiting positions in T-2 (Table 2). At 1ST harvest, fruit fresh weight was significantly different between irrigation treatments and fruiting positions, for all that it seemed to be slightly higher in the fruit at the 13th node in T-2. At 2ND harvest, fruit fresh weight was highest at the 12th and 13th nodes in T-1, and the 13th node in T-2 (Table 3). There can be some reasons for that SSC and fresh weight of fruit appeared differently according to the fruiting position. Firstly, all leaves exported photosynthetic assimilates to the fruit, but the contribution of the leaves differed according to their position and distance from the fruit in muskmelon, following the approaches by Shishido et al. (1992). This indicates that upper leaves and lower leaves of the fruiting posi-

Table 1. Soluble solids content (SSC) and fresh weight of fruit by timer-controlled irrigation and harvesting time.

Harvesting time	Treatment	SSC (Brix %)	Fruit fresh weight (kg)
1ST[z]	T-1[y]	13.2 c[x]	1.77 b
	T-2	13.6 bc	1.81 b
2ND	T-1	14.5 ab	2.03 a
	T-2	15.1 a	2.00 ab

[z]1ST and 2ND: Harvested 48 (June 21) and 62 (July 5) days after pollination, respectively.
[y]T-1, Irrigated at every hour from 6:00 to 18:00; and T-2, Irrigated at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00.
[x]Mean separation within column by Duncan's multiple range test at 5% level.

Table 2. Soluble solids content by fruiting position and harvesting time.

Treatment	Fruiting position (node)	Soluble solids content	
		1ST[z]	2ND
T-1[y]	10	14.2	13.5 b[x]
	12	13.0	14.8 a
	13	12.8	15.2 a
T-2	10	14.2	15.3 a
	12	13.5	14.9 a
	13	13.0	15.0 a

[z]1ST and 2ND: Harvested 48 (June 21) and 62 (July 5) days after pollination, respectively.
[y]T-1, Irrigated at every hour from 6:0018:00; and T-2, Irrigated at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00.
[x]Mean separation within column by Duncan's multiple range test at 5% level.

Table 3. Fruit fresh weight by fruiting position and harvesting time.

Treatment	Fruiting position (node)	Fruit fresh weight (kg)	
		1ST[z]	2ND
T-1[y]	10	1.72 b[x]	1.85 b
	12	1.77 ab	2.12 a
	13	1.83 ab	2.12 a
T-2	10	1.69 b	1.75 b
	12	1.85 ab	1.79 b
	13	1.91 a	2.09 a

[z]1ST and 2ND: Harvested 48 (June 21) and 62 (July 5) days after pollination, respectively.
[y]T-1, Irrigated at every hour from 6:0018:00; and T-2, Irrigated at 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, and 17:00.
[x]Mean separation within column by Duncan's multiple range test at 5% level.

tion influence on the fruit growth. For the influence of upper leaves, according to Han and Park (1993), leaf area, fruit length, fruit diameter, fruit weight, thickness of mesocarp, and SSC of the oriental melon were increased with the increase of the leaf numbers above the fruiting position, such as 2, 4, 6, 8, 10, and 12 leaves. For the influence of lower leaves, Sin et al. (1991) reported that SSC did not show any differences among fruits with different fruiting positions, but fruit fresh weight was higher when fruiting position was higher in the same pinching position. According to Hwang et al. (1998), larger fruits were produced as fruits were set at higher nodes with the same pinching position. Generally leaves above the fruiting position have an influence on the fruit development from appearance of netting on the fruit to harvest, and leaves under fruiting position have an influence on the size of ovary until flowering and determine the size of the fruit (Yang, 1997). Secondly, the competition between leaves and roots must be considered. In this experiment, the lower the total leaf weight was, the higher the fruiting position. The leaves in the treatment, setting fruit at the 10th node, were estimated to focus more on the vegetative growth than the fruit growth because the fruiting position was low. The fruit at a lower position than 10th node appeared to compete with roots for utilization of water and nutrition (Shiyama et al., 1987; Yang, 1997). From the above-mentioned reasons, fruit growth and quality may be influenced by the leaves because leaves play an important role as a source of sucrose accumulation and fruits do as a sink (Han and Park, 1993; Shishido et al., 1992).

In terms of fruiting position and harvesting time, the timing of fruit set can be controlled by the fruiting position, and then fruit set of lower node can shorten harvesting time.

Fresh weights of leaves except petioles at 1ST and second harvest were increased as its position was higher. The higher the fruiting position was, the lower the leaf fresh weight was regardless of leaf positions (Fig. 2). This tendency was similar to leaf dry weight (Fig. 3). The percent dry weight was not different greatly among the treatments (Fig. 4). Leaf weight, tended to increase with higher node, might be affected by plant age, leaf position, leaf area and photosynthetic rates. Mostly leaf aging probably contributed to the percent dry weight. Hwang et

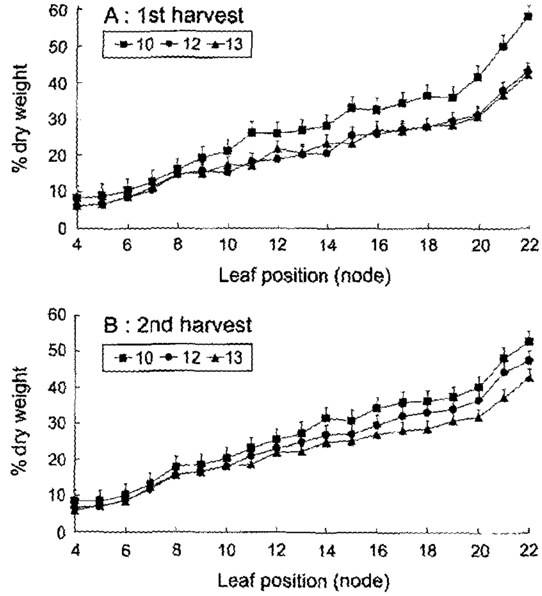

Fig. 2. Fresh weight of leaves except petioles according to the fruiting position at the first (A) and second (B) harvest (48 and 62 days after pollination, respectively). 10, 12, and 13 in legend indicate fruiting position (node). Vertical bars mean SE (n=6).

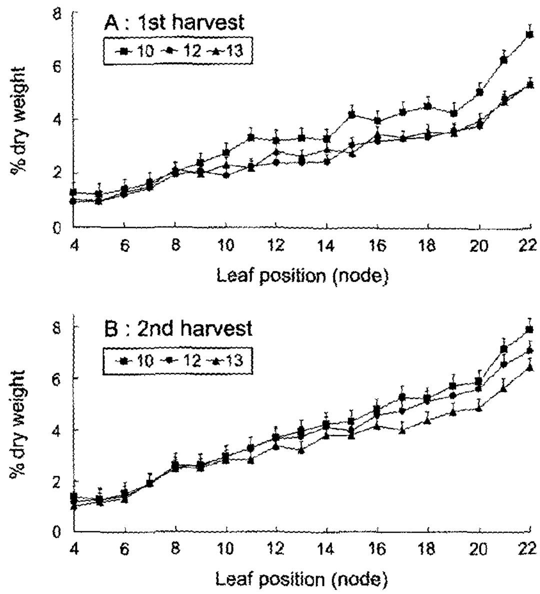

Fig. 3. Dry weight of leaves except petioles according to the fruiting position at the first (A) and second (B) harvest (48 and 62 days after pollination, respectively). 10, 12, and 13 in legend indicate fruiting position (node). Vertical bars mean SE (n=6).

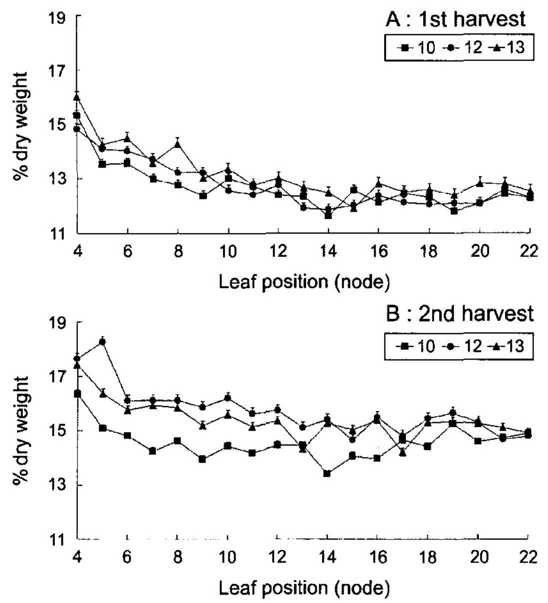

Fig. 4. Percent dry weight of leaves except petioles according to the fruiting position at the first (A) and second (B) harvest (48 and 62 days after pollination, respectively). 10, 12, and 13 in legend indicate fruiting position (node). Vertical bars mean SE (n=6).

al. (1998) reported that leaf width and leaf length were slightly higher with the increase of the fruiting position, regardless of the pinching position. The highest photosynthetic rate is influenced by environmental factors, leaf age and leaf position (Wei et al., 1998). According to Lee et al. (2000), leaves above fruiting position showed higher photosynthetic rates than lower leaves. Photosynthetic rates were reported by Proietti et al. (2000) to be increased with higher leaf positions during the ripening period. These results can be explained precisely by the report of Cohen et al. (1999) that photosynthetic photon flux density fluxes above and below the canopy, showing crop absorption to be 70~77%, or 35~45% of the outdoors global radiation.

In conclusion, T-2, in irrigation timing, is presumed to be favorable regardless of DISR for melons of high SSC and heavy fruits. The fruit set at the 10th node, regardless of irrigation timing, is suggested to be desirable because of the high SSC and marketable fruit fresh weight at the early harvest time (1ST, 48 days after pollination), while the fruit set at the 13th node is considered to be better for melon with high SSC and heavy fruits at the normal harvest time (2ND, 62 days after pollination). Furthermore, heavy fruit with high SSC is speculated to harvest earlier if pinching is carried out at the lower node than this experiment in the spring crop production.

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멜론의 펄라이트 재배시 타이머 제어에 의한 급액 시간과 착과절위가 과실의 품질과 수확시기에 미치는 영향

김혜진 · 김영식*
상명대학교 원예과학과. 충남 천안시 안서동 산 98-20. 우편번호 330-720
(*교신 저자)

적 요

본 연구는 타이머 제어에 의한 관수 시간과 착과절위가 과실 품질에 미치는 영향을 알아보기 위해서 1999년 2월 18일부터 7월 5일까지 수행되었다. 타이머에 의한 시간별 급액 처리는 6:00부터 18:00까지 한 시간 간격으로 관수된 것(T-1)과 6:00, 8:00, 10:00, 11:00, 12:00, 12:30, 13:00, 13:30, 14:00, 14:30, 15:00, 16:00, 및 17:00에 관수된 것(T-2)으로 설정하였다. 과실은 그루당 1개씩 착과 시켰으며, 착과절위처리는 10, 12 혹은 13절위 중 한 절에 착과시켰다. 포트 무게는 일일 적산 일사량과 무관하게 T-2에서 안정적인 값을 유지하였다. 당도와 果重은 수확시기별로 관수 처리구간에 유의적인 차이를 보이지 않았다. 1차 수확에서 당도와 과중은 관수 처리별 착과 절위간에 유의적인 차이를 보이지 않았던 반면, 2차 수확에서 당도는 T-1 처리구보다 T-2 처리구에서 전반적으로 높았다. 착과절위별 비교 실험에서, T-1 처리구에서는 10절에서 낮았던 반면 T-2 처리구에서는 착과절위별 차이를 보이지 않았다. 과중은 T-1 처리구의 12, 13절 그리고 T-2 처리구에서는 13절에서 가장 높았다. 葉柄을 제외한 잎의 생체중과 건물중은 수확시기와 무관하게 높은 절위에서 높게 나타났다. 착과절위가 높을수록 葉重은 낮았다. 결과적으로, 관수는 낮에 자주 행하는 것이 바람직하며, 또한 봄재배시 멜론 과실을 낮은 절위에 착과시키면 수확 시기를 앞당길 수 있을 것으로 사료된다.

주제어 : *Cucumis melo*, 과실착과, 수경재배, 당도, 과중