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The Effects of Watering Volume and Topping on the Fruit Quality of Two Melon Varieties in a Substrate Hydroponic System

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Abstract

Melons are horticultural fruits with increasing demand and high economic value. In 2020, the export demand for melons was 388.98 tons, with key destinations including Hong Kong, the United Arab Emirates, Qatar, Saudi Arabia, Germany, Malaysia, East Timor, and Singapore. However, quality degradation, such as fruit cracking, can negatively impact marketability. Dorais et al. (2004) identified several factors contributing to fruit splitting, including genetics, pruning time, water management (rain, high humidity, or intensive irrigation following drought), high temperatures, light, calcium content, and the strength of fruit cell walls. Effective and efficient cultivation practices are essential to mitigate these issues. This research aimed to determine the effect of watering volume and topping treatment on the growth and quality of two melon varieties in a substrate hydroponic system. The experiment was conducted from March 2021 to May 2021 in the greenhouse of the Leuwikopo IPB University Experimental Garden, located at an altitude of 218.79 meters above sea level. Two melon varieties were used: “Alisha” (V1) and “Glamour” (V2), with four replications for each treatment. The treatments were watering volume and topping. Watering consists of consistent watering volume of 250 ml per plant until harvest, variable watering volume according to the growth phase, i.e., 200 ml per plant, 300 ml per plant, and 350 ml per plant for phase, 1, 2, and 3, respectively. The effects of the treatments on all agronomic traits and fruit quality were assessed. The results showed that topping did not significantly affect any of the agronomic traits or fruit quality. Maintaining a consistent watering volume of 250 ml per plant until harvest is beneficial for the growth and quality of melon varieties “Alisha” and “Glamour” in a substrate hydroponic system. Effective water management is crucial in melon cultivation to ensure high-quality fruit production and minimize issues such as fruit cracking. Future research could explore additional factors influencing melon quality and yield to further optimize cultivation practices.

Keywords: drip irrigation, water volume, varieties.

Introduction

Melon (*Cucumis melo* L.) is a species belonging to the Cucurbitaceae family, rich in various nutrients including amino acids, fatty acids, apocarotenoids, ascorbic acid, beta carotene, flavonoids, terpenoids, chromone derivatives, carbohydrates, phospholipids, glycolipids, volatile compounds, and various minerals (Milind and Kulwant, 2011). To meet market demands, melons must adhere to certain quality standards, both physically and nutritionally. High-quality melons should have a good physical appearance without defects or cracks, appropriate weight according to fruit specifications, and a fragrant aroma at the base. They generally should have T-shaped branch stalks suitable for melon harvesting methods, commercial-quality flesh thickness of 2.9 cm–3.2 cm, and a total soluble solids value above 13 °Brix. Park et al. (2018) reported that the level of soluble solids (°Brix) is a key factor determining consumer preference for fruit quality. Fruit weight and sweetness level are also critical factors in assessing fruit quality. Nutritionally, quality melons contain 23 calories of energy per 100 grams, 0.6 g protein, 17 mg calcium, 2,400 IU vitamin A, 30 mg vitamin C, 0.045 mg thiamin, 6.5 µg riboflavin, 1.0 mg niacin, 6.0 g carbohydrates, 0.4 mg iron, 0.5 mg nicotinamide, 93 ml water, and 0.4 g fiber (Samadi, 1995). These attributes are important benchmarks for product acceptance by consumers and competitiveness in the market. However, the quality of melons, which are generally consumed

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fresh, can decrease if the fruit is cracked, affecting both the quality and quantity of marketable fruit. In the United States, crop losses due to broken fruit have been recorded at 35% (Dorais et al., 2004). Such losses can be mitigated through proper cultivation management, using superior varieties, balancing water and plant nutrition needs, and implementing effective cultivation practices (Masarirambi et al., 2009). Dorais et al. (2004) identified several factors contributing to fruit splitting, including genetics, pruning time, water-related factors (rain, high humidity, intensive irrigation after a drought), high temperatures, high light intensity, and calcium content (Dorais, 2004; Liebisch et al., 2009), and the strength of fruit cell walls (Simon, 2006).

Non-optimal watering significantly affects crop yields and fruit quality (Anas and Wijayanti, 2013). Suryani (2015) emphasized that watering volume is a critical factor in hydroponic systems, as the availability of water and nutrients is essential for achieving optimal plant quality. Proper cultivation practices, including regulating watering volume, are necessary to support plant growth. Additionally, topping or pruning is a factor that can influence fruit cracking in melons, impacting both the quality and quantity of production. Proper pruning helps regulate the balance between source and sink, ensuring controlled production, stimulating female flower development, accelerating fruit formation, and improving fruit quality (Pribadi, 2001). Based on this understanding, this research aims to study and evaluate the effect of watering volume and topping on fruit burst resistance in two melon varieties in a substrate hydroponic system.

Material and Methods

Experimental Design

The research was carried out from March 2021 to May 2021 in the greenhouse of the Leuwikopo IPB Experimental Garden which is located at latitude -6.5507 and longitude 106.7286 and an altitude of 218.79 meters above sea level (masl). Postharvest analysis including fruit quality was conducted at the Postharvest Laboratory, Department of Agronomy and Horticulture, Bogor Agricultural Institute. This experiment used two melon varieties, namely “Alisha” (V1) and “Glamour” (V2). Each variety used a nested design with four replications. The topping treatment (T) is placed at each level of watering volume (W). Topping (T) consists of 2 levels, T1 = topping T2 = without topping. Topping was conducted by cutting the top part of the plant when plant height reaches ± 2 m, leaving 30 – 35 leaves. The cutting of the top part of the plant uses pruning scissors that have been sterilized with alcohol. Watering volume (W) consists of 2 levels, W1 = watering volume (250 ml per plant) until harvest W2 = watering volume according to the growth phase until harvest which consists of phase 1 = 200 ml per plant, phase 2 = 300 ml per plants, and phase 3 = 350 ml per plant, or an average of 285 ml per plant. The number of experimental units was 32. Each experimental unit consisted of 3 plants so that the total number of plants was 96 plants. Combined analysis was performed to study interactions between factors. The variables measured in this study are plant morphology which included plant height, stem diameter, number of leaves, number of segments, male flowering age, and hermaphroditic flowering age, while fruit quality variables included fruit weight, fruit length, fruit diameter, fruit flesh thickness, fruit skin thickness, total dissolved solids, fruit flesh softness, and fruit position.

Plant Cultivation and Treatments Application

“Alisha” and “Glamour” seeds were sown in nursery trays using rockwool planting media. Before sowing, the seeds were soaked for 15 minutes to break seed dormancy. One seed was planted per planting hole.. Fertilization on seedlings was carried out 2 times at the age of 1 WAS (weeks after seedling) and 2WAS in the form of Gandasil D fertilizer at a rate of 1.5 $g.L^{-1}$ of water. Pollination is carried out on the ovary flower located on the 8th segment. Topping is carried out on each lateral shoot that appears on the 1st to 8th segment and 14th to 20th segment. Shoots that appear on the 9th to 13th segments are maintained to bear fruit. The fruit thinning was carried out by leaving the best fruit growing on the 9th to 13th segments. Topping in the treatment was carried out when the plant was about 2.25 meters tall and already formed perfect fruits. Melon fruit ripeness is indicated by a change in the surface color of the fruit from dark green to white or yellow (Cuevas et al., 2010, Sobir and Siregar, 2014). The supply of water and nutrition is administered via drip irrigation which is automatically regulated by a timer. The timer will turn on 4 times a day at 08.00 am, 11.00 am, 1 pm and 2 pm, for 5 minutes with a volume of 250-300 ml per plant or according to the watering volume in the treatment. During the vegetative phase EC of the nutrient solution was maintained at 1.2-1.3.

Statistical Analysis

The data were analyzed using analysis of variance with STAR software (bbi.irri.org) and Microsoft Excel 2021. If the results were significant, the Duncan Multiple Range Test (DMRT) at a 5% significance level was performed to evaluate the differences among treatment means.

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Result and Discussion

Vegetative Phase Plant Growth

The results showed that the height of "Alisha" at 6 weeks after planting (WAP) was 49.73 cm taller in the 250 ml per plant watering treatment compared to the 285 ml per plant watering treatment (Table 1). Meanwhile, the "Glamour" variety in the 250 ml per plant treatment was 29.56 cm taller than in the 285 ml per plant treatment. Differences in plant height between varieties are attributed to genetic factors. According to Asnawi and Dwiwarni (2000), several agronomic traits are influenced by genotype (G), environment (E), and G x E interactions (Table 1). It is important to maintain a steady water supply during cell division and enlargement (Samanhudi, 2010).

In the generative phase, plants allocate photosynthetic products to the reproductive organs, which require high energy to form flowers. Photosynthates are partitioned for plant growth and flowering (Daryono and Nofriarno, 2018), so it is important to prevent water shortage at this stage. Wahb-Allah et al. (2011) stated that a shortage of water supply will cause a decrease in plant height. Plants that were not stressed produced were the tallest compared to those that were stressed (Pervez et al., 2009). Water stress in cultivated plants inhibits the distribution of assimilates to reproductive organs and the process of photosynthesis (Jemrifs et al., 2013). Assimilation is the process of forming organic compounds (glucose/ carbohydrates) from inorganic compounds (such as water), and photosynthesis is a key part of this process. Nurrohman et al. (2014) also noted that an increase in the number and size of cells could affect plant height, adding that lower available water content results in shorter plants. In this study, topping treatment did not show a significant effect on plant height of the two melon varieties (Table 1). Although the topping treatment did not show a significant effect, it may help optimize the photosynthesis process and the distribution of photosynthetic products. Topping allows sunlight to penetrate the plant canopy more effectively, optimizing the photosynthesis process (Yadi et al., 2012). The products of photosynthesis then support plant growth, including the formation of roots, leaves, stems, and fruit during the generative phase (Yadi et al., 2012).

The stem diameter of the "Alisha" variety at 6 weeks after planting (WAP) was 0.57 mm greater in the 250 ml per plant watering treatment compared to the 285 ml per plant treatment. For the "Glamour" variety, the 250 ml per plant treatment resulted in stems that were 0.45 mm thicker than those in the 285 ml per plant treatment. For the "Alisha" variety, the 250 ml per plant treatment was the optimal watering volume, showing a significant effect at 4 WAP, 5 WAP, and 6 WAP. Similarly, the "Glamour" variety responded well to 250 ml per plant watering volume at 3 WAP to 6 WAP (Table 1). A larger stem diameter supports better plant growth. This aligns with Sari's (2019) statement that a larger stem diameter indicates a stronger plant, better able to perform its functions. The stem is a crucial organ in plants as it supports the growth of leaves, branches, and flowers, and facilitates the distribution of nutrients from the roots to the leaves, as well as the transport of photosynthesis products from the leaves to the rest of the plant. The topping treatment did not show a significant influence on both melon varieties. This is likely because, during this phase, photosynthates are allocated to the growth of generative organs, particularly fruit formation. Zamzami et al. (2015) supports this, stating that topping can inhibit the growth of vegetative organs, allowing the assimilates produced by the plant to focus on generative growth.

The effects of the treatment on the number of leaves varies with melon varieties; it affects the "Alisha" at 6 weeks after planting (WAP) but did not affect "Glamour" significantly (Table 1). This difference is attributed to physiological and genetic factors in plants, where plants undergo photosynthesis and have differing water requirements to support this process.

Water requirements can vary with plant type and age. At 6 WAP, plants enter the flower formation phase, which requires more water. According to Putriantari and Edi (2014), a higher number of leaves correlates with increased water requirements. Plants at 6 WAP are at the peak of the vegetative phase, characterized by maximum leaf count and plant height, with water serving as the primary necessity during this phase. Sari et al. (2013) further reported that water scarcity during the generative phase adversely reduces both the quality and quantity of plants. Conversely, excessive water supply renders it inefficient for plant growth. Moreover, the number of leaves influences the transpiration rate in plants, which in turn affects physiological responses due to water loss through this process. Therefore, water plays a crucial role in regulating water volume related to growth and development, aiming to replenish water loss in tissues due to plant transpiration. The topping treatment for each variety did not demonstrate a significant effect on any growth phase. This may be attributed to the competing needs for sources and sinks within each plant. Consistent with this, Widodo (2016) highlighted the competition between plants for nutrients, water, and sunlight, resulting in suboptimal plant growth and development.

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Table 1. Melon vegetative growth characteristics at two levels of watering volume and topping treatments.

Treatment	Plant height (cm)	Stem diameter (mm)	Number of leaves	Number of nodes (nodes)
"*Alisha*"				
250ml per plant	260.19 ± 10.31 [a]	7.22 ± 0.22 [a]	35.92 ± 0.34 [a]	36.88 ± 0.33
285ml per plant	249.85 ± 16.77 [b]	7.16 ± 0.13 [b]	34.96 ± 1.09 [b]	35.96 ± 1.09
Topping	279.88 ± 8.31	6.91 ± 0.16	36.46 ± 0.64	37.42 ± 0.64 [a]
No topping	230.15 ± 12.22	7.47 ± 0.13	34.42 ± 0.82	35.42 ± 0.82 [b]
"Glamour"				
250ml per plant	306.79 ± 14.54	9.06 ± 0.10 [a]	37.33 ± 0.10	37.63 ± 0.45
285ml per plant	277.23 ± 8.51	8.56 ± 0.11 [b]	35.42 ± 0.11	37.67 ± 0.94
Topping	295.63 ± 12.37	8.84 ± 0.14	36.58 ± 0.46	38.71 ± 0.82
No topping	288.39 ± 13.76	8.74 ± 0.12	36.17 ± 0.70	36.58 ± 0.33

Note: The mean values followed by the same letter in each water volume treatment or topping treatment shows not significant different based on the Duncan Multiple Range Test (DMRT) at α=0.05

Watering at 250 ml per plant or 285 ml per plant did not effect the number of nodes of both melon varieties (Table 1). Salas et al. (2005) suggested that water availability influences processes related to calcium absorption; insufficient water may limit calcium absorption in plants. When calcium is limited, other elements like magnesium cannot function optimally. Magnesium is crucial for chlorophyll formation and acts as a catalyst for the absorption of elements such as potassium, phosphorus, and boron, which are vital for plant physiological functions (Munawar, 2011). The topping treatment applied to the "Alisha" variety did not significantly affect plants during the generative phase (6 WAP), and this is likely because the plants allocate photosynthetic products to the fruits. Topping reduces unnecessary organs, allowing photosynthesis to focus on fruit development.

Generative Phase Plant Growth

Neither the watering volume nor the topping treatment exhibited a significant effect on the number of male flowers in either the "Alisha" or "Glamour" varieties (Table 2). Regarding the topping treatment, no effect on flower formation was observed as topping occurred between 8 and 10 weeks after planting (WAP), a period when the flowering phase begins to decline and hermaphroditic flowers initiate. "Glamour" variety demonstrated a significant increase in the number of hermaphrodite flowers with a watering volume of 250 ml per plant, while the effects on the "Alisha" was not significant. This discrepancy may result other factors that hinder flower development that affected "Alisha" only. High temperatures, for instance, can impede pollination or cause flowers to drop prematurely, hindering their development into fruits. Additionally, variations in flowering age for each variety influence the number of flowers formed. In the "Alisha" variety, male flower initiation occurs at 14 days after planting (DAP), followed by hermaphroditic flower formation at 22 DAP, while in the "Glamour" variety, male flowers initiate at 17 DAP and hermaphroditic flowers at 24 DAP (Table 2). Each flower type plays a crucial role in fruit formation, with male flowers serving as sites for the union of male and female gametes to produce seeds, while hermaphroditic flowers serve as the precursors to fruits following the pollination.

Postharvest Fruit Quality

The watering volume treatment and topping of each variety did not exert a significant influence on the observed weight variables. Despite the watering level being considered adequate for the plant's requirements, other factors may impact fruit weight increase. Goldsworthy et al. (1992) highlighted external factors influenced by temperature as significant influencers of fruit formation. High temperatures can induce substantial water loss, leading to plant wilting. Under such conditions, plants may shed leaves and flowers to survive, resulting in suboptimal fruit production. Furthermore, Maynard (1987) explained that water deficiency during growth can inhibit cell development, leading to smaller leaves and reduced photosynthesis, ultimately resulting in smaller fruit weight. Insufficient watering during fruit filling may lead to a competition between leaves and fruit for photosynthates, resulting in fewer fruits being formed or smaller fruit sizes, thus affecting fruit weight and quality. The average fruit weight of "Alisha" fruit was lower than that of "Glamour", with watering volume for each treatment and variety showing no significant effect (Table 3). Ginting et al. (2017) noted that plants of different varieties exhibit varying growth

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Table 2. Melon flower characteristics at two levels of watering volume and topping treatments.

Treatment	Number of male flowers	Number of hermaphrodite flowers
"*Alisha*"	14 DAP	22 DAP
250ml per plant	3.00 ± 0.30	5.71 ± 0.39
285ml per plant	2.50 ± 0.29	6.37 ± 0.30
Topping	2.67 ± 0.24	5.96 ± 0.37
No topping	2.50 ± 7.37	6.38 ± 7.36
"Glamour"	17 DAP	24 DAP
250ml per plant	11.63 ± 1.10	4.29 ± 0.21 [a]
285ml per plant	11.08 ± 0.64	3.58 ± 0.12 [b]
Topping	11.13 ± 0.95	4.00 ± 0.22
No topping	11.58 ± 0.85	3.88 ± 0.22

Note: the mean value followed by the same letter in each water volume or topping treatment shows significant difference based on the Duncan Multiple Range Test (DMRT) at α=0.05.

patterns, even when planted in the same environment. Plants are planted simultaneously and under similar conditions will likely set fruit at the same time. This aligns with Sitompul and Guritno (1995), who reported that the speed of each growth phase and its duration determine crop yields. As stated before, male flower initiation in "Alisha" occured at 14 days after planting (DAP), followed by hermaphroditic flower formation at 22 DAP, while in "Glamour" variety, male flowers initiated later at 17 DAP and hermaphroditic flowers at 24 DAP. A delayed generative phase reduces its duration and diminishes assimilate translocation to generative parts like seeds, resulting in suboptimal yield. Several factors contribute to low melon fruit weight, including harvesting age (Cowan et al., 1997; Fukuda and Moriyama, 1997; Ezura, 2001), plant density (Kultur et al., 2001), fruit thinning timing (Long et al., 2004), and fruit position on the segments (Suzuki, 2004).

Fruit length and diameter typically exhibit a positive correlation with fruit weight (Table 3). An increase in fruit length, diameter, and circumference generally leads to higher fruit weights, thus potentially increasing fruit flesh thickness. Afandi (2004) noted that larger and longer fruits tend to have thicker flesh. "Alisha" variety has shorter fruit than "Glamour". The variation in fruit length and diameter directly influences melon weight, as these dimensions correlates with fruit weight and size. Larger fruits typically exhibit greater diameter values. However, melon production is not solely determined by fruit diameter; factors such as flesh thickness and fruit water content also play important roles. Huda et al. (2017) observed a positive correlation between fruit diameter and length, indicating that longer fruits tend to have larger diameters. The development of large fruits is attributed to the availability of nutrient during fruit enlargement.

The thickness of fruit flesh is an important component of fruit quality, as melon sales typically rely solely on the fruit weight without considering flesh thickness. Therefore, increasing fruit flesh thickness is of significant importance as it can significantly boost production quantitatively. The "Glamour" variety, with its high flesh thickness, correlates well with the fruit diameter. This observation aligns with several research findings. Thicker fruit flesh tends to increase the fruit diameter value due to the overall increase in fruit size, encompassing both fruit length and diameter. Khumaero et al. (2014) reported that commercial melon varieties generally have a flesh thickness exceeding 29-32 mm, with thicker-fleshed melons being preferred by consumers due to their larger edible portions.

Watering volume of 250 ml per plant for each variety demonstrated a significant influence on the fruit flesh thickness. Water sufficiency during the generative phase, which includes fruit formation, is crucial for fruit development. Insufficient water availability during the generative phase can adversely affect both the quality and quantity of plants (Sari et al., 2013). Watering at 250 ml per plant seems to have adequately meet the plant's requirement during fruit formation until harvest. In addition to genetic and environmental factors, topping can also enhance fruit development. Topping entails the removal of apical shoots, which can inhibit upward plant growth. Consequently, more assimilates are diverted into the fruit as food reserves, derived from the photosynthesis (Meliawati, 2014).

One of the critical determinants of fruit quality is the total soluble solids (TSS) value, which serves as an indicator of sweetness, taste, and maturity level. Park et al. (2018) emphasized that fruit sweetness significantly influences consumer preferences and

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Table 3. Qualitative characteristics of melon fruits at the two levels of watering volume and topping treatments.

Treatment	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit rind thickness (mm)
"Alisha"				
250ml per plant	827.13 ± 31.56	19.79 ± 0.26	36.58 ± 0.43	29.16 ± 0.60
285ml per plant	892.75 ± 66.60	19.94 ± 0.60	36.94 ± 0.78	29.72 ± 0.82
Topping	919.00 ± 44.00	20.96 ± 0.49	37.94 ± 0.71	30.89 ± 0.99
No topping	892.75 ± 72.23	19.94 ± 0.48	36.94 ± 0.65	29.72 ± 0.59
"Glamour"				
250ml per plant	1420.79 ± 69.70	23.42 ± 0.42	44.91 ± 0.62 [a]	0.72 ± 0.03
285ml per plant	1255.96 ± 69.42	22.25 ± 0.61	42.71 ± 1.19 [b]	0.69 ± 0.02
Topping	1299.75 ± 81.52	22.44 ± 0.60	43.64 ± 0.80	0.70 ± 0.03
No topping	1377.00 ± 67.42	23.23 ± 0.50	43.98 ± 1.22	0.71 ± 0.03

Note: the mean value followed by the same letter in each water volume or topping treatment shows significant difference based on the Duncan Multiple Range Test (DMRT) at α=0.05.

overall fruit quality. Higher sweetness levels are generally associated with superior fruit performance (Sari et al., 2019). However, in the current study, the sweetness levels of both "Alisha" and "Glamour" varieties were not significantly affected by the topping treatment or watering volume (Table 4). Several factors can influence the TSS content (°Brix) of fruits, including fruit maturity at harvest, plant spacing, fertilizer type, and fertilization timing (Makhful et al., 2017). Senesi et al. (2005) highlighted differences in °Brix values across various maturity stages of melons, ranging from immature to overripe stages. Additionally, low °Brix values may result from a low concentration of substances within the fruit. Typically, melon fruits exhibit °Brix values ranging from 9.3 to 16.0, with sweetness attributed to sucrose accumulation through photosynthesis. Genotype and environmental factors play crucial roles in sucrose accumulation, sweetness due to high sucrose accumulation is related to the genotypes, while environmental conditions influence sucrose accumulation during the growth phase (Daryono and Nofriarno, 2018). Water content in the media by watering practices before and during harvest significantly impacts the °Brix value of harvested fruits. Adjusting watering volume according to the plant's growth phase can optimize the °Brix value. Brix values can also be affected by rain (Barbagallo et al., 2012), harvesting age, and planting distance. Peirce (1987) demonstrated that soluble solids concentration varies with fruit maturity level, with fruits harvested at full maturity typically exhibiting higher TSS compositions. Fertilizer choice can also influence the °Brix value; Tang et al. (2012) found that potassium enhances total dissolved solids in melons, while Castellanos et al. (2011) noted that excessive nitrogen can reduce fruit quality by decreasing °Brix values and increasing fruit cavities.

The water volume and topping treatment did not significantly affect the firmness of the melon fruits. This lack of effect could be attributed to the fruit's age at harvest, which directly influences its firmness. Generally, as fruits mature, they tend to become softer due to increased water content and physiological ripening processes. Miccolis and Saltveit (1991) study of seven melon varieties reported a decline in fruit flesh firmness throughout the fruit development period, aligning with the findings of this research. Guo et al. (2015) provided insight into the mechanisms underlying fruit softening and texture changes during ripening, i.e., it is primarily due to the depolymerization and dissolution of cell walls, as well as the loss of cell structure due to reduced adhesion between cell walls. These physiological processes contribute to the overall softening of the fruit as it ripens.

The watering volume and topping treatments in this study did not significantly influence the position of the fruit formation in the plant, which is intricately linked to the success rate of flower pollination. While fruit can potentially appear on every plant segment, the quality of such fruit may not be optimal due to limitations in the plant's ability to allocate resources effectively between different plant organs. Fruit appearing on segments below the 9^{th} node may suffer from inadequate leaf support for optimal growth. Conversely, the presence of flowers in the first segment can impact the growth of upper plant parts. Therefore, the optimal position for fruit development is typically in the 9^{th} to 13^{th} segments. Pruning unnecessary lateral branches from the first to 8^{th} segments allows for better resource allocation,

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Table 4. Melon physical fruit quality at two levels of watering volume and topping treatments.

Treatment	Fruit flesh thickness (mm)	Total soluble solid (°Brix)	Fruit rind firmness (mm.kg^{-1}.5s^{-1})	Fruit position (segment)
"Alisha"				
250ml per plant	37.32 ± 1.59 [a]	9.92 ± 0.45	14.30 ± 0.43	10.46 ± 0.45
285ml per plant	36.35 ± 1.45 [b]	10.33 ± 0.39	14.90 ± 0.24	12.25 ± 0.39
Topping	39.17 ± 1.39	10.46 ± 0.37	14.55 ± 0.50	9.92 ± 0.37
No topping	34.50 ± 1.09	9.79 ± 0.45	14.65 ± 0.16	10.33 ± 0.45
"Glamour"				
250ml per plant	39.17 ± 1.39 [a]	13.15 ± 0.46	12.29 ± 0.59	11.42 ± 0.52
285ml per plant	34.50 ± 1.09 [b]	13.50 ± 0.44	10.96 ± 0.55	11.83 ± 0.70
Topping	37.32 ± 1.59	12.95 ± 0.42	11.42 ± 0.52	12.29 ± 0.59
No topping	36.35 ± 1.45	13.70 ± 0.45	11.83 ± 0.70	10.96 ± 0.55

Note: the mean value followed by the same letter in each water volume or topping treatment shows significant difference based on the Duncan Multiple Range Test (DMRT) at α=0.05.

while maintaining the 9th to 13th segments supports optimal fruit growth until harvest. Determining the ideal segment for fruit placement can be based on factors such as stem diameter and leaf distribution. The 10th or 11th segments are often preferred due to their optimal conditions for fruit formation, including a large stem diameter and the presence of adequate foliage. Fruits that are formed above the 13th node is considered risky due to the plant's advanced age and increased susceptibility to disease. Similarly, fruit positioned too close to the base of the stem may experience suboptimal development, resulting in smaller size, poor shape, and abnormal skin patterning. Proper positioning of fruit within the 10th to 13th segments ensures optimal growth conditions and good fruit quality.

Conclusion

Providing a watering volume of 250 ml per plant until harvest was the best treatment in terms of plant height, stem diameter, number of leaves, leaf area, the time to form hermaphrodite flower, fruit diameter, and fruit flesh thickness of "Glamour". The topping treatment only showed a significant effect on the number of internodes in 'Alisha" at 6 WAP. The increase in melon height was positively correlated with the increase in the number of leaves, number of segments, and fruit weight, but not correlated with the level of °Brix of the fruits.

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