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Yield comparison of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems

Abstract. Melon is one of the horticultural commodities with considerable economic potential. Cultivation through hydroponic systems can provide efficiency and increase production if complemented by superior varieties. This study aims to identify the best hydroponic system and melon variety combination with the highest yield. The research was conducted from November 2023 to April 2024 at the screen house in Pasir Kulon Village, Karanglewas District, Banyumas Regency, at 110 m above sea level. The study used a split-plot factorial design with a basic design of a Completely Randomized Block Design. The first factor was the hydroponic system, consisting of S1 = Dutch bucket and S2 = drip irrigation. The second factor was the variety, consisting of V1 = Golden Aroma, V2 = Rangipo, and V3 = Sweet Net. The results showed that the best yield was found in the Dutch bucket system and the Golden Aroma variety, with a fruit flesh thickness of 3.3 cm and a total soluble solids content of 17.18 °Brix.

Keywords: Dutch bucket system · Drip irrigation · Melon · Superior varieties

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Introduction

Horticulture is one of the new sources of agricultural growth expected to support national economic development. One of the horticultural products with potential is melon, or *Cucumis melo* L. Melon is an annual fruit plant that belongs to the gourd family or *Cucurbitaceae*. The fluctuating production of melon in Indonesia is one of the limiting factors; during the harvest season, the product is available in abundance, while outside the harvest season, it is scarce in the market, leading to price increases (Trisnawati *et al*., 2018). Sustainable production must be increased through hydroponics and superior varieties to meet the demand for melons.

The Dutch bucket system (DBS) is a hydroponic method that uses buckets connected to a drip irrigation system. According to Bhat *et al*. (2023), this system utilizes individual containers filled with inert growing mediums, ensuring stability and aeration. The drip irrigation delivers precise amounts of water and nutrient solutions directly to plant roots, re-circulating excess solutions to minimize waste.

The principle of drip irrigation is to provide water and nutrients through drops that drip periodically according to the plant's needs through a PE pipe with the help of a pressure pump (Sumarni *et al*., 2023). According to Wang *et al*., (2020), a drip irrigation system can save water use due to evapotranspiration reduction. Droplets on the system are directed right at the plant's root area so that the plant can directly absorb the water and nutrients provided. Drip irrigation systems can be divided into recirculating and nonrecirculating drip irrigation. Recirculating drip irrigation is a system that utilizes runoff nutrient solutions to be reused as nutrients for plants. Meanwhile, nonrecirculating drip irrigation is a system that does not reuse runoff solutions as plant nutrients.

To enhance production, selecting the right varieties is crucial. Variety plays an important role in producing yield because different varieties respond differently regarding genotypic characteristics, input requirements, growth processes, and the prevailing environment during the growing season (Rahman *et al*., 2010). The superior melon varieties Golden Aroma, Rangipo, and Sweet Net were selected for their distinct characteristics and benefits, including fruit appearance, weight, texture, and sweetness. This experiment tested two hydroponic systems, Dutch bucket and drip irrigation, on three melon varieties: Golden Aroma, Rangipo, and Sweet Net. The goals were to identify the best hydroponic system for melon growth and yield, determine the top-performing variety, and find the optimal combination of system and variety.

Material and Methods

The materials used were melon seeds (Golden Aroma, Rangipo, Sweet Net), rock wool, water, AB Mix, cocopeat, pesticide, and polybags. The equipment comprised the Dutch bucket and drip irrigation systems, net pots, seedling trays, TDS meter, measuring tape, refractometer, pruning shears, digital scale, string, sprayer, and thermohygrometer. The research occurred in a screen house in Pasir Kulon Village, Karanglewas District, Banyumas Regency, 110 meters above sea level, from November 2023 to April 2024. A split-plot factorial design with a Randomized Complete Block Design (RCBD) was used. The first factor was the hydroponic system (S1 = Dutch bucket, S2 = drip irrigation), and the second was the variety (V1 = Golden Aroma, V2 = Rangipo, V3 = Sweet Net). This design resulted in 6 treatment combinations, each replicated 4 times.

The Dutch bucket and drip irrigation systems had PVC pipes spaced 50 cm x 50 cm between each bucket/polybag. The Dutch bucket system used a nutrient solution, while the drip irrigation system employed cocopeat soaked in pond water for 2 weeks to reduce tannin levels. Melon seeds were germinated for 12 days before being transplanted into the hydroponic systems. Plant care involved tying plants to strings, pruning non-fruit-bearing lateral shoots and tips, pollination, fruit selection, sanitation, and pest and disease control. Fruits were harvested when physiologically ripe approximately 80 to 95 days after transplanting following seed producer recommendations.

Nutrient levels were monitored using a TDS meter, and the solution was adjusted based on plant needs and growth stage. Measured variables included plant height, number of leaves, leaf area, flowering age (male and female), fresh fruit weight, fruit diameter, fruit flesh thickness, total dissolved solids, root length, fresh root weight, and dry root weight. Data analysis was conducted using an Analysis of Variance (ANOVA) at a 5% significance level, with further analysis by Duncan's Multiple Range Test (DMRT) if significant variance was found.

Result and Discussion

General Condition. The screen house's daily temperature and humidity were recorded from 11:00 AM to 1:00 PM WIB, showing an average temperature of 33.5°C (range: 29 – 37.7°C) and humidity of 59.96% (range: 38 – 84%). These conditions are unsuitable for optimal melon production, which thrives at 20 – 30°C and humidity levels of 70 – 80% (Bambang *et al*., 2021). Such unfavorable conditions can hinder growth and yield. The site, located approximately 110 meters above sea level, has a climatic context affecting these levels.

Plant Height. The hydroponic system showed no significant difference in plant height 8 weeks after planting. Average plant height growth is detailed in Table 3. Differences in plant height are primarily attributed to genetic variations among the three melon varieties, which affect their growth ability. According to Lenroot & Giedd (2011), these genetic differences lead to varied responses to environmental conditions, resulting in different growth outcomes.

Number of Leaves. Significant variations in the number of leaves at 8 weeks after planting were observed due to differences in hydroponic systems and varieties. The highest average number of leaves was recorded with the drip irrigation treatment (33.17 leaves) and the Rangipo variety (32.96 leaves) (Table 3). Genetic variations among varieties likely contributed to differences in leaf number. The drip irrigation system was most effective, likely because the nitrogen-rich cocopeat medium promoted vegetative growth. Drip irrigation enhances nutrient supply and plant needs in melon cultivation; according to Cabello et al. (2009), relationships between crop yield and water supply allow field quantification of water use efficiency in a given environment and can be assessed by developing local crop yield/water production functions.

Leaf Area per Leaf Blade. The hydroponic system treatments did not significantly affect leaf area, but there were significant differences among varieties at 8 WAP. The Sweet Net variety had the largest leaf area (274 cm^2), while the Rangipo variety had the smallest (209.43 cm^2) (Table 3). The lack of significant difference between hydroponic systems is likely due to genetic factors and environmental conditions, such as sunlight. According to Rezai *et al*. (2018), shade plants develop larger and thinner leaves to increase light harvest.

Flowering Age. The hydroponic system did not significantly affect flowering age, but significant differences were observed among varieties. The Rangipo variety had the earliest male (14.75 days after planting) and female (21.31 days after planting) flowering, followed by Golden Aroma, and the Sweet Net variety flowering the last (Table 4). Varietal differences lead to differences in flowering time. The duration of flowering time and genome size are positively correlated (Bilinski et al., 2018). Flowering speed is influenced by variety and genetic factors. Attribute differences in flowering age to genetic influences and environmental conditions. According to Takeno (2016), many types of stress factors have been reported to induce flowering. These include high or low light intensity, UV light, high or low temperature, poor nutrition, nitrogen deficiency, drought, low oxygen, crowding, root removal, and mechanical stimulation. The average temperature during the experiment was 33.5°C, higher than the optimal 20 – 30°C, which likely accelerated flowering. Higher temperatures speed up flowering, while unsuitable temperatures can reduce enzyme activity involved in flowering; the rate of every biochemical reaction depends on it; ambient temperature also accelerates or delays flowering time (Takeno, 2016).

Table 1. Comparison of quantitative phenotypic characteristics among three melon varieties.

Parameter Description of Varieties	Measurement Results		
	Golden Aroma	Rangipo	Sweet Net
Leaf length (cm)	7.7 – 17.5	8.7 – 15.6	12.1 – 14.7
Leaf width (cm)	10.2 – 22.5	12.2 – 22	16.6 – 20.5
Male flowering age (days after planting)	14 – 18	12 – 16	15 – 20
Female flowering age (days after planting)	18 – 25	16 – 24	20 – 26
Weight per fruit (g)	913.3 – 1963	683.3 – 991.3	812.3 – 973.7
Horizontal fruit diameter (cm)	12.63 – 15.57	11.25 – 13.42	10.96 – 12.45
Vertical fruit circumference (cm)	37 – 53	32 – 44.7	36 – 45.5
Horizontal fruit circumference (cm)	42.4 – 50.3	31.5 – 42.5	33.5 – 39
Fruit rind thickness (cm)	0.2 – 0.4	0.2 – 0.3	0.1 – 0.2
Fruit flesh thickness (cm)	3 – 3.3	3.2 – 3.23	2.8 – 3
Total soluble solids (°Brix)	15 – 17	14– 15	14 – 16

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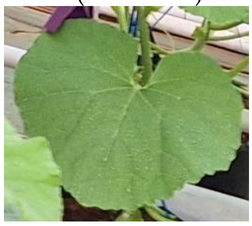
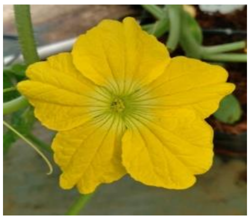
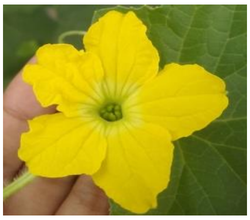
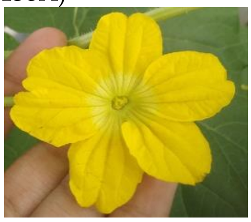
Table 2. Comparison of Qualitative Phenotypic Characteristics among Three Melon Varieties

Parameter Description of Varieties		Golden Aroma	Rangipo	Sweet Net
Stem	Shape	Cylinder	Cylinder	Cylinder
	Color	Green (RHS N144C)	Green (RHS 145A)	Green (RHS 145B)
Leaf				
	Shape	Triangular shape (triangularis)	Triangular shape (triangularis)	Triangular shape (triangularis)
	Color	Dark green (RHS 138B)	Dark green (RHS 137A)	Dark green (RHS 138A)
Flower				
	Shape	Rotate	Rotate	Rotate
	Flower petal color	Yellow (RHS 12A)	Yellow (RHS 12B)	Yellow (RHS 12B)
Fruit				
				
	Shape	Round/Globular	Round/Globular	Elongated/Oval
	Fruit skin color	Dark green (RHS 137A)	Light green (RHS 192D)	Yellow (20D)
	Surface texture	Dense netting present	Dense netting present	Sporadic netting
	Fruit flesh color	Orange (RHS 28D)	Orange (RHS 29C)	Orange (RHS 29B)
	Fruit flesh crispness	Crisp	Crisp	Crisp
Seed	Shape	Ellipse	Ellipse	Ellipse
	Color	Yellow (RHS 18C)	Yellow (RHS 18C)	Yellow (RHS 18C)

Note: Classification based on Daryono & Nofriarno (2018).

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Table 3. Average plant height, number of leaves, and leaf area of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Growth Variables at 8 Weeks After Planting (WAP)		
	Plant height (cm)	Number of leaves	Leaf area (cm^2)
Hydroponic system			
S1 (*Dutch bucket*)	246.92	29.69 b	236.10
S2 (Drip irrigation)	253.16	33.17 a	256.77
Varieties			
V1 (Golden Aroma)	249.86	32.08 b	255.76 b
V2 (Rangipo)	246.03	32.96 a	210.22 c
V3 (Sweet Net)	254.23	29.25 c	273.33 a
C.V. (%)	3.68	6.62	15.79

Note: Numbers followed by different letters in the same column indicate significant differences at the 5% DMRT.

Table 4. Average flowering age of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Flowering Age (Days After Planting - DAP)	
	Male	Female
Hydroponic system		
S1 (*Dutch bucket*)	16,58	21,96
S2 (Drip irrigation)	16	22,29
Varieties		
V1 (Golden Aroma)	16.42 b	21.88 ab
V2 (Rangipo)	14.75 a	21.31 a
V3 (Sweet Net)	17.71 c	23.19 b
C.V. (%)	8.40	4.23

Note: Numbers followed by different letters in the same column indicate significant differences at the 5% DMRT.

Fresh Fruit Weight. The hydroponic system treatments did not significantly affect fresh fruit weight, but significant differences were observed among varieties. The Golden Aroma variety had the highest average fresh fruit weight at 1570.96 g, followed by Sweet Net and Rangipo (Table 6). Genetic factors influence variations in fresh fruit weight. Fresh fruit weight is also affected by plant organs, such as leaves. Leaf area influences photosynthesis and plant growth by determining light interception through the leaf surface, morphology, and orientation. This is particularly important in noncontinuous canopies (e.g., young plants), where the incident light is only partially intercepted, and photo-morphogenetic responses have a relevant impact on plant growth and productivity (Paradiso & Proietti, 2022). The fresh fruit weight also rises when plant height and leaf area increase. This is evident in the Rangipo variety, which has the smallest leaf area and lower fresh fruit weight. This is due to less effective sunlight absorption, reducing photosynthesis and photo-assimilate production.

The yield potential of each variety influences the difference in fruit weight across each variety. The Golden Aroma variety has the highest average weight of 1570.96 g, while the seed producer claims that the yield potential of the Golden Aroma variety can reach up to 2500 g. The Rangipo and Sweet Net varieties have average weights of 883.58 g and 898.75 g, respectively, with the seed producer claiming that the yield potential of the Rangipo variety can reach up to 2000 g. The yield potential of Golden Aroma, as claimed by the producer, is higher than that of Rangipo and Sweet Net.

The two hydroponic systems did not show significant differences in fresh fruit weight, likely because both systems provided similar and adequate nutrient supplies. Plants with adequate nutrients will grow well. Phosphorus (P) in hydroponic nutrients plays a role in plant growth. According to Shirko *et al.* (2018), phosphorus deficiency is not very common in hydroponic systems compared to N and K deficiencies; however, it can greatly reduce yield and plant growth. Syah & Yulia (2021) stated that optimal phosphorus uptake increases and multiplies ATP in plants, which is needed for cell division and enhances photosynthetic output, thus improving fresh fruit weight.

Fruit Diameter. The hydroponic system treatments did not show significant differences in melon fruit diameter, while different varieties showed significant differences. Table 5 shows that the Golden Aroma variety had the highest average diameter at 14.15 cm, followed by the Rangipo and Sweet Net varieties. Fruit diameter is closely related to fresh fruit weight; as weight increases, diameter also increases. Some important traits (fruit weight, diameter, and length) indicated that they were quantitative traits controlled by multiple nuclear genes (Lian *et al.*, 2021).

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Table 5. Average fresh fruit weight and fruit diameter of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Observation Variables	
	Fresh Fruit Weight (g)	Fruit Diameter (cm)
Hydroponic system		
S1 (*Dutch bucket*)	1125.05	12.69
S2 (Drip irrigation)	1110.47	12.51
Varieties		
V1 (Golden Aroma)	1570.96 a	14.15 a
V2 (Rangipo)	883.58 c	12.12 b
V3 (Sweet Net)	898.75 b	11.5 c
C.V. (%)	18.12	7.24

Note: Numbers followed by different letters in the same column indicate significant differences at the 5% DMRT.

Several studies about the effect of pruning on carbohydrate content in peaches and cherries have been carried out and report similar findings (Clair-Maczulajtys *et al*., 1994; Ikinci, 2014). The study pointed out that this practice reduced shoot length, stimulated shoot diameter enlargement, decreased fruit yield, and increased fruit weight; in addition, if applied, this technique increased significantly fruit soluble solids content (SSC). The increase in fruit size and quality has been attributed to higher photosynthate availability in the fruit of pruned trees due both to the increment in photosynthetic photon flux density (PPFD) and to the elimination of competing sinks, i.e., watersprouts. The improved light exposure, in turn, may increase fruit sink activity, thus positively affecting fruit size (Falchi *et al*., 2020).

Fruit Flesh Thickness. The analysis of variance results shows that both hydroponic system treatments and different varieties resulted in significant differences in fruit flesh thickness, as presented in Table 6. The table shows that the best fruit flesh thickness, 3.3 cm, was achieved with the Dutch bucket system and Golden Aroma variety. This combination does not significantly differ from the Dutch bucket system with Rangipo or the drip irrigation system with Rangipo, but it does differ significantly from other treatments. The lowest flesh thickness, 2.83 cm, was found with the Dutch bucket system and Sweet Net variety. Fruit diameter and weight are closely related to flesh thickness, with larger fruit size corresponding to thicker flesh as assimilates are stored as food reserves in the fruit.

The formation of melon flesh is influenced by nutrients absorbed by the plants and transported by roots to all the plant organs. Some nutrients will also be transferred to developing fruit so that it will supply nutrients to produce fruit with optimal quality and quantity. The optimal supply of nutrients that are balanced from all nutrients guarantees the quantity and quality of the fruit to be harvested. The flesh thickness can also be influenced by sugar content, aroma, taste, fruit weight, and fruit volume (Sugiartini *et al*., 20022).

Total Soluble Solids. The analysis of variance indicates significant effects of both hydroponic system treatments and variety differences on the total soluble solids in melon fruit, as presented in Table 7. The Dutch bucket system and Golden Aroma variety produced the highest total soluble solids at 17.18 °Brix. This was followed by the Dutch bucket system with the Sweet Net variety and the drip irrigation system with Golden Aroma, which were not significantly different. The lowest total soluble solids, 14.83 °Brix, were observed with the Dutch bucket system and Rangipo variety. The combination of the Dutch bucket system and Golden Aroma variety is optimal for total soluble solids, likely due to the variety's superior genetic traits and the consistent nutrient supply from the system, enhancing leaf area and photosynthesis and thus increasing sugar accumulation in the fruit. The differences in observational variables between melon varieties are more directed to the genetic factors of the varieties tested against a wide genetic diversity so that they have different variations, including fruit diameter, wet weight, and fruit sweetness level (Aragao *et al*., 2013)

According to Falchi *et al*. (2020), thinning induces a transient accumulation of soluble sugars in the leaves, leading to reduced photosynthesis and stomatal closure without significantly impacting the final fruit size. The results indicate the influence of crop load on fruit-water relationships, possibly improved by frequent irrigation in un-thinned plants, allowing the fruit to reach its maximum potential (Andreade *et al*., 2019).

Table 6. Interaction effect on fruit flesh thickness of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Fruit flesh thickness (cm)		
	V1 (Golden Aroma)	V2 (Rangipo)	V3 (Sweet Net)
S1 (*Dutch bucket*)	3.3 x	3.2 x	2.83 y
	a	a	b
S2 (Drip irrigation)	3 y	3.23 x	3 y
	b	a	a

Note: Numbers followed by the same letters in rows (x, y, z) and columns (a, b) indicate no significant differences at the 5% DMRT.

Table 7. Interaction effect on total soluble solids of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Total soluble solids (°Brix)		
	V1 (Golden Aroma)	V2 (Rangipo)	V3 (Sweet Net)
S1 (*Dutch bucket*)	17.18 x	14.83 z	16.73 y
	a	b	a
S2 (Drip irrigation)	16.13 x	15.08 z	15.4 y
	b	a	b

Note: Numbers followed by the same letters in rows (x, y, z) and columns (a, b) indicate no significant differences at the 5% DMRT.

Table 8. Average root length, fresh root weight, and dry root weight of three melon (*Cucumis melo* L.) varieties cultivated with dutch bucket and drip irrigation systems.

Treatments	Observation variables		
	Root lenght (cm)	Fresh root weight (g)	Dry root weight (g)
Hydroponic system			
S1 (*Dutch bucket*)	26.71 b	131.43 a	11.14 a
S2 (Drip irrigation)	39.88 a	28.98 b	3.36 b
Varieties			
V1 (Golden Aroma)	31.44	61.95 c	7.12
V2 (Rangipo)	34.94	65 b	6.7
V3 (Sweet Net)	33.5	113.65 a	7.95
C.V. (%)	12.26	41.02	67.27

Note: Numbers followed by different letters in the same column indicate significant differences at the 5% DMRT.

Root Length. The hydroponic system treatments showed significant differences in root length, whereas the different varieties did not show significant differences. Table 8 illustrates significant differences in root length between the two systems due to the different growing media used. The drip irrigation system produced the longest roots to the Dutch bucket system. The growing media is closely related to its support for root growth. The Dutch bucket system, with the medium filled with water to the height of the bucket, can influence the resulting root length. Pratiwi (2021), states that the height of the container can affect root growth; taller containers allow roots to grow longer in search of the nutrients and water required by the plants the plants require. The drip irrigation system with cocopeat media likely provides better oxygen circulation in the root area due to its air-filled pores, resulting in better root development and unimpeded plant growth. According to Phogat *et al*. (2015), a constant supply of O_2 is essential, and its concentration should be at least 10% for the plants to grow normally. A lack of O2 is more injurious to plants than an excess of CO2 within reasonable limits (<20%). An excess of O_2 is also undesirable because it oxidizes the organic matter rapidly and dries the soil quickly.

Cocopeat media contains many additional nutrients besides regular nutrient applications. These nutrients are crucial for plant growth and development, including macro and micronutrients such as potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), sodium, and other minerals that support root elongation. Nurifah & Fajarfika (2020) state that cocopeat contains micro-nutrients

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like copper (Cu), which plays a role in electron transport during photosynthesis and root formation, and zinc (Zn), which supports root growth and leaf expansion.

Fresh Root Weight. The hydroponic system treatments and varieties resulted in significant differences in fresh root weight. Table 8 shows that the Dutch bucket system produced higher fresh root weights than the drip irrigation system. This is likely due to the abundant nutrient supply in the Dutch bucket system, which provides ample nutrients to the roots, promoting rapid development of lateral roots and thus increasing fresh root weight. The Sweet Net variety showed significantly higher fresh root weight than other varieties. Manuhuttu *et al*. (2014), explain that root system development is primarily controlled by the plant's genetic traits and the growing media conditions.

Dry Root Weight. The hydroponic system treatments showed significant differences in dry root weight, while the different varieties did not show significant differences. Table 8 indicates that the Dutch bucket system resulted in the highest dry root weight, significantly different from the drip irrigation system. This is suspected because dry root weight is proportional to fresh root weight. Manuhuttu *et al*. (2014), state that plants with higher fresh root weights also have higher dry root weights and root volumes, indicating that these plants are well-supplied with photosynthates. However, each variety has a different root water uptake rate that is genetically influenced. The BmBm gene controls the rate of water uptake from the soil and the incoming radiation so that the transpiration rate can be controlled (Aqil & Bunyamin, 2013).

Conclusion

The Dutch bucket system yielded the best results for total soluble solids, fresh root weight, and dry root weight. The drip irrigation system excelled in leaf number and root length. The Golden Aroma variety achieved the highest fruit weight and total soluble solids. The Rangipo variety showed superior growth in leaf number, flowering age, and fruit flesh thickness, while the Sweet Net variety excelled in leaf area and fresh root weight. The Dutch bucket system with the Golden Aroma variety was the best combination for fruit flesh thickness (3.3 cm) and total soluble solids (17.18 °Brix).

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