

PHYSIOLOGICAL ASPECTS OF VEGETATIVE GROWTH OF MELON (*CUCUMIS MELO* L.) ON VARIOUS AIR SALINITY AND FOLIAR FLUSHING VOLUME IN COASTAL SANDY SOIL

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Abstract. Melon (*Cucumis melo* L.) has good economic prospects in Indonesia but is still faced with low production continuity due to productivity in coastal areas related to the specific agro-climate of strong salinity winds in certain seasons. This study aims to explain the physiological aspects of vegetative growth of melon plants at various air salinities, flushing volumes, and the interaction between air salinity and leaf flushing volume. The study was conducted using a Split Plot Design with air salinity as the main plot consisting of 0, 12, and 24 mS/cm and flushing volumes as subplots consisting of 0, 3.5, and 7 mm. The results showed that 0 mS/cm salinity produced the highest vegetative chlorophyll content (16.91 mg/L). The 7 mm flushing volume produced the highest number of leaves (11.5 leaves), fresh plant weight (70 g), and vegetative chlorophyll content (16.97 mg/L). An air salinity of 0 mS/cm and a flushing volume of 7 mm resulted in a high number of branches (14.33 branches), a high vegetative stomatal density (234 stomata/mm²), and a high number of flowers (2.33 flowers). The highest root fresh weight, 2.81 g, occurred at a salinity of 24 mS/cm and a flushing volume of 3.5 mm. A salinity of 12 mS/cm with a flushing volume of 7 mm resulted in the highest vegetative proline content, 24.24 μ mol/g.

Keywords: melon, air salinity, foliar flushing, vegetative physiology

1. Introduction

Melon (*Cucumis melo* L.) is a popular horticultural crop in Indonesia, offering potential for widespread cultivation. Melon production declined by 73,451 tons, from 192,147 tons in 2021 to 118,696 tons in 2022 (1). This decline in production is due to the conversion of agricultural land to non-agricultural use, coupled with Indonesia's increasing population.

Utilizing marginal land is expected to maintain and increase the productivity of horticultural crops such as melons. Coastal sandy soils have the potential to be developed as a cultivation medium. Indonesia's numerous islands provide extensive coastal sandy soils that need to be utilized.

Melon plants generally grow in sandy clay soils enriched with organic matter with a pH of 6.0–6.8 (2). This plant grows well at an altitude of 250–700 m above sea level with an environmental temperature between 18–28°C (3). Suitable rainfall for optimal growth is 1,500–2,000 mm (4) with 10–12 hours of sunlight per day (5).

Melon cultivation has not been widely practiced on marginal land such as coastal sandy soils. This soil consists of 95% sand (6), is nutrient-poor, easily loses water, has a low cation exchange capacity (CEC), and contains little organic matter (7). Coastal sandy soils are often exposed to salt solutions, both in the soil and carried by wind through the air. Soil salinity

results from high dissolved salt content, while air salinity is caused by sea breezes carrying saltwater vapor. These two factors are obstacles to melon cultivation on coastal sands. A solution is needed to reduce the impact of salinity on plants, namely by leaching them using water that does not contain salt stress. The objectives of this study were to determine the effect of air salinity on melon plant growth and yield, the effect of leaching volume on melon plant growth and yield, and the interaction of air salinity and volume on melon plant growth and yield.

The other references can come from textbooks, proceedings, or other valid scientific sources. Information sources that come from online sites (internet) are allowed if the sources are trustful and accountable, such as research institution sites, universities, and governments. Private sites (blogs or the likes) are not allowed as references.

2. Methods

This research was conducted from September 2024 to December 2024 at the Screenhouse Experimental Farm, Faculty of Agriculture, Universitas Jenderal Soedirman. This study used Madesta F1 melon seeds. The method used was a Split Plot Design (RPT) with a Completely Randomized Block Design (RAKL) consisting of 2 factors: air salinity as the main plot consisting of 3 levels, namely, 0 mS/cm (S₀), 12 mS/cm (S₁), 24 mS/cm (S₂) and flushing volume as a subplot consisting of 3 levels, namely 0 mm (V₀), 3.5 mm (V₁), and 7 mm (V₂). This study had 9 treatment combinations and was repeated 3 times to obtain 27 units and was repeated 3 times to obtain 81 polybags. The distance between polybags was 40 cm × 50 cm. Flushing was carried out 45 minutes after the salinity treatment was given. The observed variables were growth, physiology, and yield of melon plants. Growth variables included plant height, number of branches, number of leaves, leaf area, root fresh weight, branches fresh weight, leaf fresh weight, plant fresh weight, root dry weight, branches dry weight, leaf dry weight, and plant dry weight. Physiological variables included chlorophyll content, leaf greenness, proline content, stomatal aperture, and stomatal density. Yield variables included number of flowers, percentage of mature flowers, number of fruits, percentage of mature fruits, fruit diameter, fruit volume, fruit fresh weight, fruit dry weight, and crop yield.

3. Results And Discussion

Several variables were affected by air salinity treatment and flushing volume. The effect of air salinity treatment and flushing volume on each observed variable can be seen in Tables 1, 2, and 3.

Table 1. Mean values and DMRT test results for growth variables

Treatment	PH (cm)	NB	NL	LA (cm ²)	FWR (g)	FWB (g)	FWL (g)	FWP (g)	DWR (g)	DWB (g)	DWL (g)	DWP (g)
Air Salinity (S)												
0 mS/cm (S ₀)	63,35	10,22 b	10,56	702,09	1,51	15,39	6,93	57,32	0,46 b	2,69	2,61	22,07
12 mS/cm (S ₁)	50,31	8,15 a	8,8	603,16	1,12	10,43	5,65	49,33	0,26 a	2,66	2,55	23,41
24 mS/cm (S ₂)	41,94	6,83 a	8,89	530,04	1,83	18,47	10,8	62,51	0,50 b	2,78	2,99	24,71
CV (%)	18,89	18,11	16,15	16,01	23,83	16,54	27,18	14,63	2,47	13,72	26,67	12,85
Flushing volume (V)												
0 mm (V ₁)	42,77	6,83 a	8,06 a	467,92	1,3	12,37	6,75	50,11 a	0,24	2,13	2,65	21,42
3,5 mm (V ₂)	52,35	6,83 a	8,69 a	568,69	1,48	14,96	7,32	49,05 a	0,52	2,88	3,00	20,29
7 mm (V ₃)	60,48	9,17 b	11,5 b	798,68	1,67	16,97	9,31	70,00 b	0,46	3,12	2,50	28,48
CV (%)	17,57	7,59	9,66	25,66	13,44	10,5	21,5	11,73	12,68	19,89	20,46	18,16

Annotation: PH=plant height; NB=number of branches; NL=number of leaves; LA=leaf area; FWR=fresh weight of root; FWB=fresh weight of branches; FWL=fresh weight of leaves; FWP=fresh weight of plant; DWR=dry weight of root; DWB=dry weight of branches; DWL=dry weight of leaves; DWP=dry weight of plant.

Table 2. Mean values and DMRT test results for physiological variables

Treatment	VCC (mg/L)	GCC (mg/L)	GVL (unit)	GGL (unit)	VP (μ mol/g)	GP (μ mol/g)	VSO (μ m)	GSO (μ m)	VSD (stom/mm ²)	GSD (stom/mm ²)
Air Salinity (S)										
0 mS/cm (S ₀)	16,91 b	13,11	53,91	60,76	5,09 a	23,05	5,32	4,07	204,93	189,71 b
12 mS/cm (S ₁)	16,68 b	16,11	47,88	55,6	14,67 b	3,81	4,51	4,24	191,69	170,10 a
24 mS/cm (S ₂)	13,11 a	12,42	54,37	53,16	14,75 b	11,52	4,38	4,46	200,15	192,02 b
CV (%)	12,83	15,61	23,04	15,62	24,7	14,73	19,78	26,8	8,80	8,60
Flushing volume (V)										
0 mm (V ₁)	13,26 a	13,74	46,99	57,2	7,67 a	23,05	5,00	3,93	178,44	175,99
3,5 mm (V ₂)	16,46 b	14,77	55,26	57,79	9,47 b	3,81	5,04	3,86	207,87	183,00
7 mm (V ₃)	16,97 c	13,13	53,91	54,52	17,36 c	11,52	4,17	4,97	210,45	192,24
CV (%)	19,51	12,83	19,17	11,01	15,68	11,49	12,32	28,53	9,53	7,41

Annotation: VCC=vegetative chlorophyll content; GCC=generative chlorophyll content; GVL=greenish vegetative leaves; GGL= greenish generative leaves; VP=vegetative proline; GP=generative proline; VSO=vegetative stomatal opening; GSO=generative stomatal opening; VSD=vegetative stomatal density; GSD=generative stomatal density

Table 3. Mean values and DMRT test results for yield variables

Treatment	NF	PFF (%)	NFS	PHF (%)	FD (cm)	FV (cm ³)	FWF	DWF	CY (ton/h)
Air Salinity (S)									
0 mS/cm (S ₀)	1,78	0,95	1,44	0,74	4,75 b	65,37	15,64	13,11	13,11
12 mS/cm (S ₁)	2,11	0,64	1,22	0,87	5,27 b	84,42	17,96	16,11	16,11
24 mS/cm (S ₂)	1,93	0,64	1,15	0,90	3,92 a	37,09	18,73	12,42	12,42
CV (%)	13,49	10,84	24,65	18,88	11,11	3,37	12,92	15,61	15,61
Flushing volume (V)									
0 mm (V ₁)	1,67	0,90	1,22	0,87	4,88	77,12	15,55	13,74	13,74
3,5 mm (V ₂)	2,02	0,68	1,31	0,79	4,37	49,90	19,30	14,77	14,77
7 mm (V ₃)	2,13	0,65	1,28	0,85	4,68	59,87	17,47	13,13	13,13
CV (%)	9,12	11,81	27,92	22,77	15,53	23,32	24,89	12,83	12,83

Annotation: NF=number of flower; PFF=percentage of flower formed; NFS=number of fruith; PHF=percentage of harvested fruit; FD=fruith diameter; FV=fruith volume; FWF=fresh weight of fruith; DWF=dry weight of fruith; CY=crop yield

3.1. Air Salinity

Air salinity affected root dry weight, vegetative chlorophyll content, generative stomatal density, fruit diameter, and fruit volume. Air salinity at 12 mS/cm (S₁) produced the lowest values for root dry weight and generative stomatal density, with values of 0.26 g and 170 stomata/mm², respectively. Meanwhile, air salinity at 24 mS/cm (S₂) produced the highest values, with values of 0.5 and 192.02 stomata/mm², respectively. Other variables, such as vegetative chlorophyll content, fruit diameter, and fruit volume, had the lowest values in the S₂ treatment, with values of 13.11 mg/L, 3.92 cm, and 37.09 cm³, respectively.

Plants sprayed with high levels of air salinity were able to activate defense mechanisms through the production of secondary metabolites such as proline. Proline production in plants can help reduce osmotic stress, allowing plants to continue growing and forming cells and other growth tissues (8). The decrease in values for other variables is thought to be due to proline

production in plants stressed by high salinity no longer contributing to improved plant growth. Other growth, physiological, and yield variables were unaffected by air salinity spraying.

3.2. Flushing volume

Flushing volume affected the number of leaves, fresh weight of plants, vegetative chlorophyll content, and generative proline. Plants treated with a control treatment with a volume of 0 mm (V₀) produced the lowest fresh weight and vegetative chlorophyll content, namely 8.06 g and 13.26 mg/L, while a flushing volume of 7 mm (V₂) produced the highest number of leaves and vegetative chlorophyll content with values of 11.5 leaves and 16.97 mg/L. In contrast, fresh plant weight and generative proline had the lowest values when treated with a 3.5 mm (V₁) rinse, with values of 49.05 g and 3.81 µmol/g, respectively. However, increasing the rinse volume to 7 mm (V₂) significantly increased fresh plant weight to 70 g, while generative proline increased only from 7.71 µmol/g to 11.81 µmol/g.

Overall, flushing volume can improve several growth and physiological variables, indicating good plant growth. This is thought to be because flushing can reduce stress by breaking down dissolved salts into micronutrients Na⁺ and Cl⁻, which can be absorbed by plants to optimize growth (9). In contrast, generative proline increased with a 7 mm flush (V₂), presumably because flushing volume was no longer able to effectively reduce salinity stress, leaving the plants still stressed and producing proline to survive. Other growth, physiological, and yield variables were unaffected by the flushing volume.

3.3. Interaction between air salinity and flushing volume

Number of branches

The interaction between air salinity and flushing volume had a very significant effect on growth variables such as the number of branches (Table 4).

Table 4. Mean values and results of the DMRT test of the interaction between two factors on the number of branches

Treatment	0 mm (V ₀)	3,5 mm (V ₁)	7 mm (V ₂)
0 mS/cm (S ₀)	1,43 ABa	1,97 Ab	1,14 Aa
12 mS/cm (S ₁)	1,35 Ba	0,94 Aa	1,08 Aa
24 mS/cm (S ₂)	1,13 Aa	1,54 Ab	2,81 Bb

Note: Different lowercase letters in the same column indicate significant differences between treatments. Different uppercase letters in the same row indicate significant differences between treatments according to Duncan's test at a 5% error level.

Treatment without salinity and 7 mm flushing (S₀V₂) produced the highest number of branches, namely 14.33 branches. Environmental conditions without salinity and given additional water through flushing support more optimal plant growth because of minimal osmotic stress (Ismail et al., 2018). The salinity treatment of 24 mS/cm with 3.5 mm flushing (S₂V₁) produced the lowest number of branches, namely 5 branches. The salinity treatment of 24 mS/cm with 3.5 mm flushing (S₂V₁) can inhibit branch formation caused by the flushing volume is not enough to reduce high salt concentrations, so that photosynthesis efficiency is disrupted and there is a decrease in carbohydrate synthesis for plant tissue formation (10).

Root fresh weight

The interaction between air salinity treatment and flushing volume had a significant effect on root fresh weight (Table 5).

Table 5. Average values and results of the DMRT test of the interaction between two factors on root fresh weight

Treatment	0 mm (V ₀)	3,5 mm (V ₁)	7 mm (V ₂)
0 mS/cm (S ₀)	1,43 ABa	1,97 Ab	1,14 Aa
12 mS/cm (S ₁)	1,35 Ba	0,94 Aa	1,08 Aa
24 mS/cm (S ₂)	1,13 Aa	1,54 Ab	2,81 Bb

Note: Different lowercase letters in the same column indicate significant differences between treatments. Different uppercase letters in the same row indicate significant differences between treatments according to Duncan's test at a 5% error level.

Air salinity treatment with a concentration of 24 mS/cm accompanied by flushing at a volume of 7 mm (S2V1) produced the highest root fresh weight, namely 2.81 g. Although at high salinity (24 mS/cm) it causes stress, optimal flushing (7 mm) has the potential to reduce the effects of stress by maintaining root physiological function. Sufficient flushing volume can reduce Na⁺ and Cl⁻ levels so that toxicity does not occur and root tissue formation is not disturbed (11). In contrast, the treatment of 12 mS/cm salinity accompanied by a flushing volume of 3.5 mm (S1V1) on the root fresh weight produced the lowest value, namely 0.94 g. This is thought to be because flushing with this volume is not enough to reduce the stress of 12 mS/cm salinity, thus impacting the reduction of available water and nutrients (12).

Proline content

The interaction between air salinity treatment and flushing volume had a significant effect on vegetative proline content (Table 6).

Table 6. Mean values and results of the DMRT test of the interaction between two factors on vegetative proline content

Treatment	0 mm (V ₀)	3,5 mm (V ₁)	7 mm (V ₂)
0 mS/cm (S ₀)	5,99 Ba	3,5 Aa	5,77 Ba
12 mS/cm (S ₁)	7,33 Aa	12,44 Aa	24,24 Aa
24 mS/cm (S ₂)	9,69 Aa	12,48 Aa	22,08 Aa

Note: Different lowercase letters in the same column indicate significant differences between treatments. Different uppercase letters in the same row indicate significant differences between treatments according to Duncan's test at a 5% error level.

The treatment without salinity accompanied by a 3.5 mm flush (S0V1) produced the lowest vegetative proline content, at 3.5 µmol/g. This low proline value indicates that the plants are in a stress-free environment. This contrasts with the treatment with a salinity of 12 mS/cm accompanied by a 7 mm flush (S1V2), which produced the highest vegetative proline content, at 24.24 µmol/g. This is due to the plant's ability to adapt to salinity stress, which produces proline to maintain plant growth (8).

Vegetative stomatal density

The interaction between air salinity treatment and flushing volume had a significant effect on vegetative stomatal density (Table 7).

Table 7. Mean values and results of the DMRT test of two-factor interaction on vegetative stomatal density

Treatment	0 mm (V ₀)	3,5 mm (V ₁)	7 mm (V ₂)
0 mS/cm (S ₀)	163,36 Aa	217,44 Aa	234 Aa
12 mS/cm (S ₁)	168,87 Ba	205,3 Aa	200,88 Aa
24 mS/cm (S ₂)	203,09 Ca	200,88 Aa	196,47 Aa

Note: Different lowercase letters in the same column indicate significant differences between treatments. Different uppercase letters in the same row indicate significant differences between treatments according to Duncan's test at a 5% error level.

The treatment without salinity accompanied by 7 mm flushing (S0V2) produced the highest vegetative stomatal density, namely 234 stomata/mm², while the lowest vegetative stomatal density was produced by the control treatment (S0V0) with a value of 163.36 stomata/mm². High stomatal density indicates an increased number of stomata. This is because plants absorb water well in non-stressed conditions, so that plants grow optimally and increase the number of stomata followed by an increase in stomatal density (13).

Number of flowers

The interaction between air salinity and flushing volume had a significant effect on the number of flowers (Table 8).

Table 8. Mean value and results of the DMRT test of interaction between two factors on the number of flowers

Treatment	0 mm (V ₀)	3,5 mm (V ₁)	7 mm (V ₂)
0 mS/cm (S ₀)	1 Aa	2 Ba	2,33 Ba
12 mS/cm (S ₁)	2,33 Ac	1,83 Aa	2,17 Aa
24 mS/cm (S ₂)	1,67 Ab	2,22 Ba	1,89 ABa

Note: Different lowercase letters in the same column indicate significant differences between treatments. Different uppercase letters in the same row indicate significant differences between treatments according to Duncan's test at a 5% error level.

The control treatment (S₀V₀) had the lowest leaf count, with one flower. In contrast, the treatment without air salinity, which received a 7 mm flush, produced the highest number of flowers, with 2.33 flowers. The 7 mm flush increased the water volume available to the plants, allowing them to absorb more water for photosynthesis. The products of photosynthesis, carbohydrates, are needed by plants to produce flowers (14).

Other growth, physiological, and yield variables were not affected by the interaction between air salinity and flush volume.

4. Conclusion

The conclusions drawn from the research results are as follows:

The results showed that air salinity affected root dry weight, vegetative chlorophyll content, generative stomatal density, fruit diameter, and fruit volume. An air salinity of 24 mS/cm produced the highest values for root dry weight (0.5 g) and generative stomatal density (192.02 stomata/mm²). An air salinity of 12 mS/cm produced the highest values for fruit diameter (5.27 g) and fruit volume (84.42 cm³). A salinity of 0 mS/cm produced the highest value for vegetative chlorophyll content (16.91 mg/L).

A flushing volume of 7 mm (V₂) produced the highest values for the number of leaves (11.5), fresh plant weight (70 g), and vegetative chlorophyll content (16.97 mg/L), while a flushing volume of 0 mm produced the highest value for the generative proline variable (23.05 µmol/g).

The interaction between air salinity and flushing volume significantly affected the number of branches, fresh root weight, vegetative proline content, vegetative stomatal density, and number of flowers. A salinity of 0 mS/cm² combined with a flushing volume of 7 mm produced the highest values for the number of branches (14.33 branches), vegetative stomatal density (234 stomata/mm²), and number of flowers (2.33 flowers). A salinity of 24 mS/cm² combined with a flushing volume of 3.5 mm produced the highest value for fresh root weight (2.81 g). Air salinity of 12 mS/cm accompanied by a flushing volume of 7 mm produced the highest value in vegetative proline levels (24.24 µmol/g).

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