Agrotrop : Journal on Agriculture Science, 16(2): 94-102 (2026)
ISSN: 2654-4008 (Online), 2088-155X (Print)
URL: https://ejournal2.unud.ac.id/index.php/agrotrop
DOI: https://doi.org/10.24843/AJoAS.2026.v16.i02.p03
Penerbit: Fakultas Pertanian, Universitas Udayana

Effects of Growing Media and AB Mix Nutrient Concentration in an NFT Hydroponic System on the Growth and Yield of Celery (Apium graveolens L.)

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ABSTRACT

Hydroponic cultivation is a soilless production system in which plant nutrient requirements are supplied through a nutrient solution. Growing medium and nutrient concentration are important factors determining the success of celery (Apium graveolens L.) cultivation in a Nutrient Film Technique (NFT) system. This study aimed to evaluate the effects of different growing media and AB Mix nutrient concentrations on the growth and yield of celery. The experiment was arranged in a factorial randomized complete block design with three replications. The first factor was growing medium, consisting of pumice, rice husk charcoal, and rockwool. The second factor was AB Mix nutrient concentration, consisting of K0 (125 ppm), K1 (900 ppm), K2 (1200 ppm), and K3 (1500 ppm). Observed variables included plant height, number of leaves, leaf color, root length, fresh weight, dry weight, and root volume. The results showed that growing medium and its interaction with nutrient concentration significantly affected plant height, number of leaves, leaf color, and dry weight. Rice husk charcoal consistently produced the best growth response, particularly at 1500 ppm AB Mix. The combination of rice husk charcoal and 1500 ppm AB Mix produced the highest plant height (15.43 cm), number of leaves (15.00 leaves), leaf color score (3.67), root length (7.63 cm), fresh weight (7.43 g), dry weight (2.13 g), and root volume (5.00 cm3). Therefore, rice husk charcoal combined with 1500 ppm AB Mix is recommended for improving celery growth and yield in NFT hydroponic cultivation.

Keywords: AB Mix, Apium graveolens, growing medium, hydroponics, nutrient concentration, rice husk charcoal

INTRODUCTION

The limitation of agricultural land, particularly in urban areas, has encouraged the development of efficient alternative cultivation systems. Hydroponics is one of the most widely applied soilless cultivation technologies because plant nutrient requirements can be supplied directly through nutrient solutions. Compared with conventional cultivation, hydroponic systems offer advantages in land and water use efficiency, crop uniformity, and production management.

The success of hydroponic production is strongly influenced by the growing medium and nutrient management. A growing medium provides physical support for roots and affects water retention, aeration, and oxygen availability in the root zone. In parallel, nutrient concentration determines nutrient uptake efficiency and plant physiological performance. Inadequate nutrient concentration may reduce growth, whereas excessive concentration may cause osmotic stress or nutrient toxicity.

Celery (Apium graveolens L.) is an economically important horticultural crop used as a vegetable, flavoring ingredient, and medicinal plant. Celery is suitable for hydroponic production because it has high market demand and can be cultivated intensively in limited areas. However, the suitability of different growing media and AB Mix nutrient concentrations for celery production in an NFT hydroponic system requires further evaluation. Therefore, this study was conducted to determine the effects of growing media and AB Mix nutrient concentration on the growth and yield of celery plants cultivated using an NFT hydroponic system.

MATERIALS AND METHODS

Time and location

The study was conducted at SMAN 7 Denpasar, Kamboja Street No. 9, Dangin Puri Kangin, North Denpasar District, Denpasar City, Bali, Indonesia, from April to June 2024.

Materials and equipment

The materials used in this study were AB Mix nutrient solution, celery (Apium graveolens L.) seedlings of the Amigo variety, and three types of growing media: pumice, rice husk charcoal, and rockwool (Figure 1). The equipment included an NFT hydroponic system, shade net, net pots, nutrient solution reservoirs, a water pump, plastic hoses, trays, a TDS meter, a pH meter, a ruler, a measuring tape, a digital scale, a camera, and supporting cultivation tools.

Experimental design and treatment structure

The experiment was arranged in a factorial randomized complete block design with three replications. The first factor was growing medium (M), consisting of pumice (Ma), rice husk charcoal (Ms), and rockwool (Mr). The second factor was AB Mix nutrient concentration (K), consisting of K0 (125 ppm, control/source water), K1 (900 ppm), K2 (1200 ppm), and K3 (1500 ppm) (Figure 2). The 3 x 4 treatment combinations were replicated three times, resulting in 36 experimental units. Healthy one-month-old celery seedlings with four leaves were transplanted into net pots according to the assigned treatments.

Preparation of the NFT system and nutrient solution

A shading structure was prepared to reduce excessive light exposure and pest disturbance. Four NFT hydroponic installations were assembled using PVC pipes with a diameter of 2.5 inches and a length of 1 m. Planting holes were spaced 10 cm apart, and each installation was connected to a nutrient reservoir using a circulation pump. The AB Mix nutrient solution was prepared using source water with an initial concentration of 125 ppm. The required amounts of AB Mix to obtain 900, 1200, and 1500 ppm were 3.875 g, 5.375 g, and 6.875 g per 5 L of water, respectively.

Celery seeds were germinated on moistened rockwool in plastic trays, with five seeds per hole. Seedlings were maintained for 21-25 days before transplanting (Figure 3). Pumice and rice husk charcoal were washed, moistened, and placed into 5 cm net pots before transplanting. Nutrient solution was added to each reservoir according to the assigned treatment concentration. The pH of the nutrient solution was maintained at 6.0-7.0 and adjusted when necessary. Total dissolved solids (TDS) and pH were measured weekly, while air temperature and relative humidity were recorded daily.

Observation variables and data analysis

The observed variables were plant height, number of leaves, leaf color, root length, fresh weight, dry weight, and root volume. Plant height and root length were measured in centimeters using a ruler. Leaf color was determined using a leaf color chart by observing the uppermost fully expanded leaf (Figure 4). Fresh weight was measured immediately after harvest using a digital scale. Dry weight was obtained after oven-drying at 40°C until the sample reached approximately 10% moisture content. Root volume was measured using the water displacement method in a graduated cylinder. Data were analyzed using analysis of variance according to the factorial randomized complete block design, and significant treatment effects were further separated using the least significant difference (LSD) test at the 5% level.

Figure 1. Sowing and transplanting of celery seedlings

Figure 2. Celery yield under AB Mix nutrient concentrations of 900 ppm, 1200 ppm, and 1500 ppm

Figure 3. Celery plants grown in different growing media at 22 days after transplanting

Figure 4. Observation and measurement procedures: (1) leaf color measurement, (2) fresh weight measurement, (3) dry weight measurement, and (4) root volume measurement

RESULTS AND DISCUSSION

The analysis of variance showed that growing medium and the interaction between growing medium and nutrient concentration had highly significant effects on plant height, number of leaves, leaf color, and dry weight (Table 1). Nutrient concentration had a significant to highly significant effect on all observed variables. These results indicate that celery growth in the NFT system was determined not only by nutrient concentration but also by the physical characteristics of the growing medium.

Rice husk charcoal produced the highest plant height across nutrient concentrations. Plant height in rice husk charcoal increased from 11.33 cm at K0 to 15.43 cm at K3 (Table 2). Rockwool produced intermediate plant height values, whereas pumice produced the lowest values. This result suggests that rice husk charcoal provided better aeration and moisture retention, which supported root activity and vegetative growth. Adequate water and oxygen availability in the root zone are important for cell elongation, nutrient uptake, and photosynthetic activity.

A similar pattern was observed for the number of leaves. Rice husk charcoal resulted in the highest number of leaves at all nutrient levels, increasing from 11.67 leaves at K0 to 15.00 leaves at K2 and K3 (Table 3). Leaf formation is closely related to nutrient availability, particularly nitrogen, which supports vegetative growth and chlorophyll formation. The combination of adequate nutrient concentration and favorable root-zone conditions likely improved leaf initiation and expansion.

Leaf color was also affected by growing medium and nutrient concentration. Rice husk charcoal and rockwool produced greener leaves than pumice. The highest leaf color score (3.67) was observed at K3 in rice husk charcoal and rockwool (Table 4). Greener leaves generally indicate higher chlorophyll content and improved nitrogen status, which are associated with better photosynthetic capacity.

Root length and root volume were significantly influenced by nutrient concentration, whereas the single effect of growing medium and the interaction effect were not significant. Nevertheless, rice husk charcoal tended to produce longer roots and greater root volume than the other media. The longest root (7.63 cm) and the largest root volume (5.00 cm3) were observed under rice husk charcoal at 1500 ppm (Table 5). These results suggest that higher nutrient concentration, when supported by a suitable growing medium, can stimulate root development and improve nutrient absorption.

Fresh weight was significantly affected by nutrient concentration but not by growing medium or the interaction between growing medium and nutrient concentration. The highest fresh weight (7.43 g) was obtained from rice husk charcoal at 1500 ppm (Table 6). Fresh weight reflects both biomass accumulation and tissue water content. Therefore, sufficient nutrient availability and favorable water retention in the root zone likely contributed to higher fresh biomass.

Dry weight was significantly affected by growing medium, nutrient concentration, and their interaction. Rice husk charcoal produced the highest dry weight, reaching 2.13 g at both 1200 and 1500 ppm (Table 7). Dry weight reflects the accumulation of photosynthetic assimilates in plant tissues. The higher dry weight observed in rice husk charcoal indicates that this medium supported more efficient photosynthesis and biomass accumulation than pumice and rockwool under the conditions of this study.

Overall, the combination of rice husk charcoal and 1500 ppm AB Mix nutrient concentration produced the best growth and yield response for celery in the NFT hydroponic system (Table 8). Rice husk charcoal likely provided a favorable balance between aeration and water-holding capacity, enabling celery roots to use the nutrient solution more efficiently. However, the study was conducted at a single location and used one celery variety; therefore, further research across different environmental conditions, cultivars, and production scales is recommended before broader application.

Table 1. Significance of the effects of growing medium (M), AB Mix nutrient concentration (K), and their interaction on celery growth and yield

No.	Variable	M	K	M x K
1	Plant height	**	*	**
2	Number of leaves	**	*	**
3	Leaf color	**	*	**
4	Root length	NS	**	NS
5	Fresh weight	NS	**	NS
6	Dry weight	**	**	**
7	Root volume	NS	**	NS

Note: NS = not significant ($P > 0.05$); * = significant ($P < 0.05$); ** = highly significant ($P < 0.01$).

Table 2. Interaction of growing medium and AB Mix nutrient concentration on celery plant height (cm)

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	9.13 a	11.33 d	11.63 a
K1	9.53 a	12.60 c	12.13 a
K2	10.27 a	14.10 b	12.27 a
K3	10.33 a	15.43 a	12.37 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 2.1003.

Table 3. Interaction of growing medium and AB Mix nutrient concentration on the number of celery leaves.

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	10.00 a	11.67 d	11.67 a
K1	10.76 a	14.67 c	11.33 a
K2	11.00 a	15.00 a	12.33 a
K3	11.00 a	15.00 a	12.67 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 1.2237.

Table 4. Interaction of growing medium and AB Mix nutrient concentration on celery leaf color score

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	2.00 a	3.00 c	3.00 b
K1	2.00 a	3.00 c	3.00 b
K2	2.00 a	3.33 b	3.00 b
K3	2.00 a	3.67 a	3.67 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 0.2645.

Table 5. Interaction of growing medium and AB Mix nutrient concentration on celery root length (cm)

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	4.47 cd	4.73 c	4.33 c
K1	5.00 bc	4.83 c	4.50 c
K2	5.20 b	5.97 b	4.87 b
K3	5.87 a	7.63 a	6.80 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 0.3271.

Table 6. Interaction of growing medium and AB Mix nutrient concentration on celery fresh weight (g)

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	3.27 a	3.53 d	4.50 a
K1	3.37 a	4.57 c	4.53 a
K2	3.43 a	5.97 b	5.00 a
K3	3.43 a	7.43 a	4.93 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 0.6671.

Table 7. Interaction of growing medium and AB Mix nutrient concentration on celery dry weight (g)

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	1.30 a	1.40 c	1.77 a
K1	1.30 a	1.80 b	1.83 a
K2	1.33 a	2.13 a	2.00 a
K3	1.33 a	2.13 a	1.97 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 0.1276.

Table 8. Interaction of growing medium and AB Mix nutrient concentration on celery root volume (cm3)

Nutrient concentration	Pumice	Rice husk charcoal	Rockwool
K0	3.60 a	3.77 c	3.63 b
K1	3.80 a	4.20 b	3.50 c
K2	3.87 a	4.20 b	3.73 b
K3	3.77 a	5.00 a	4.20 a

Note: Values followed by the same letter within the same column are not significantly different based on the LSD test at 5%; LSD (5%) = 0.2759.

CONCLUSION

Growing medium and AB Mix nutrient concentration significantly influenced the growth and yield of celery plants cultivated in an NFT hydroponic system. Rice husk charcoal was the most suitable growing medium compared with pumice and rockwool, as it produced the highest values for plant height, number of leaves, leaf color, fresh weight, dry weight, root length, and root volume. The best overall treatment combination was rice husk charcoal with 1500 ppm AB Mix nutrient concentration, which produced plant height of 15.43 cm, 15.00 leaves, leaf color score of 3.67, root length of 7.63 cm, fresh weight of 7.43 g, dry weight of 2.13 g, and root volume of 5.00 cm3. Therefore, rice husk charcoal combined with 1500 ppm AB Mix is recommended for improving celery production in NFT hydroponic systems.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Prof. Dr. Ir. I Gusti Ngurah Santosa, M.S., IPU., ASEAN Eng., as Supervisor I, and Dr. Anak Agung Gede Sugiarta, S.P., M.Si., as Supervisor II, for their guidance and support throughout the research process. The authors also thank Dr. Ida Ayu Putri Darmawati, S.P., M.Si., and Yuyun Fitriani, S.P., M.P., as examiners, for their constructive suggestions and valuable input. Appreciation is also extended to all parties who supported the completion of this study.

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