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Combinatory effects of pineapple peel liquid organic fertilizer and rice husk charcoal on melon (*Cucumis melo* L.) growth and yield

Efek kombinasi pemberian pupuk organik cair kulit nanas dan arang sekam padi pada pertumbuhan dan hasil tanaman melon (*Cucumis melo* L.)

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ABSTRACT

The intensive use of synthetic fertilizers in melon cultivation can reduce soil organic matter and fertility, ultimately decreasing productivity. This situation necessitates the improvement of growing media to achieve production targets through the use of rice husk charcoal and liquid organic fertilizer (LOF) from pineapple peel. This study aims to determine the combinatory effects of pineapple peel LOF and rice husk charcoal media on the growth and yield of melon plants. The research employed a factorial randomized block design (RBD) with 6 treatment levels, and data were analyzed using ANOVA followed by an HSD test at the 5% significance level. The results showed an interaction between pineapple peel POC and rice husk charcoal media on the number of leaves variable. The P0M1 treatment (positive control and 50% rice husk charcoal : 50% soil) at 52 days after planting (DAP) produced the highest number of leaves, totaling 26. However, this increase in leaf number was not accompanied by an increase in fruit weight or brix levels. These findings open opportunities for further research to understand why the increase in leaf number did not translate to higher fruit weight or Brix levels, and to identify treatment combinations that can enhance both growth and yield.

ABSTRAK

Penggunaan pupuk sintetis secara intensif pada budidaya tanaman melon dapat menurunkan kandungan bahan organik dan kesuburan tanah, yang pada akhirnya dapat mengurangi produktivitas. Kondisi ini memerlukan perbaikan media tanam untuk mencapai target produksi melalui penggunaan arang sekam dan pupuk organik cair (POC) dari kulit nanas. Penelitian ini bertujuan untuk mengetahui efek kombinasi antara pemberian POC kulit nanas dan media arang sekam terhadap pertumbuhan dan hasil tanaman melon. Penelitian ini menggunakan rancangan acak kelompok (RAK) faktorial dengan 6 taraf perlakuan, dan data dianalisis menggunakan ANOVA yang dilanjutkan dengan uji BNJ taraf 5%. Hasil penelitian menunjukkan adanya interaksi antara POC kulit nanas dan media arang sekam pada variabel jumlah daun. Perlakuan P0M1 (kontrol positif dan arang sekam 50% : tanah 50%) pada umur 52 hari setelah tanam (HST) menghasilkan jumlah daun terbanyak sebesar 26 helai. Namun, peningkatan jumlah daun ini tidak diikuti oleh peningkatan bobot buah dan kadar Brix buah. Hasil ini membuka peluang penelitian lebih lanjut untuk memahami mengapa peningkatan jumlah daun tidak meningkatkan bobot buah serta kadar brix buah, dan mencari kombinasi perlakuan yang dapat meningkatkan pertumbuhan serta hasil.

INTRODUCTION

Melon (*Cucumis melo* L.) is a high-value horticultural commodity with significant economic potential and profitability for farmers (Haiqal et al., 2023). Initially imported to Indonesia in the 1980s, melon cultivation has since been developed locally, particularly through agribusiness enterprises in Bogor. By 1990, melon cultivation centers had been established

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across various regions in Indonesia, including Jakarta, West Java, Yogyakarta, Central Java, and East Java (Daryono and Maryanto, 2018).

Despite an average annual consumption of melon in Indonesia reaching 332,698 tons (Nurpanjawi et al., 2021), production in East Java, a major producer, experienced a significant decline in 2022. Data from the Central Statistics Agency (BPS) revealed a reduction in melon production from 68,527 tons in 2021 to 62,287 tons in 2022 (Badan Pusat Statistik, 2023). This decline is likely attributed to the excessive use of inorganic fertilizers, which has been a common practice in agriculture. The negative impacts of sustained synthetic fertilizer use include soil degradation and reduced plant growth (Hilman et al., 2018; Aulia and Aji, 2021).

Continuous use of chemical fertilizers can lead to soil nutrient depletion, compaction, and reduced soil porosity (Aulia and Aji, 2021). To address these issues, exploring alternative soil amendments and fertilizers is crucial. One such alternative is the use of rice husk charcoal and pineapple peels. Pineapple peels, an inedible organic waste from the fruit, can be utilized to produce liquid organic fertilizer (LOF) (Kartiko et al., 2021). Rice husk charcoal can enhance soil porosity, retain moisture, and support beneficial soil microorganisms (Dakiyo et al., 2022; Kusmarwiyah and Erni, 2023). The addition of rice husk charcoal during the early growth stages can also improve soil quality, which in turn positively impacts plant growth and yield (Mangiring et al., 2023). Pineapple peel LOF, rich in essential nutrients such as phosphorus, potassium, and nitrogen, can also improve plant growth and yield (Sriagtula and Sowmen, 2018; Susi et al., 2018).

However, despite the known benefits of rice husk charcoal and pineapple peel LOF, there is a lack of research specifically evaluating their combined effects on melon cultivation. This study aims to address this gap by investigating the combinatory effects of pineapple peel LOF and rice husk charcoal on melon growth and yield. Additionally, the study seeks to determine the optimal dosage of pineapple peel LOF across various concentrations of rice husk charcoal to enhance melon production effectively.

MATERIALS & METHODS

Study area conditions

This research was conducted from September to November 2023 at the Agricultural Technology Park (TTP) in Sukodono Village, Panceng District, Gresik Regency, East Java Province, Indonesia, which is located at 6°56'43.0"S 112°27'54.3"E. The study area had a temperature range of 25°C to 30°C at an elevation of 15 meters above sea level. Table 1 provides the average environmental conditions in Gresik Regency from September to November 2023.

Table 1. Average monthly climate data in Gresik Regency 2023

Month	Temperature (°C)		Humidity (%)	Rainfall (mm)	Sunlight duration (hours)	Wind speed (m/s)
	Min	Max				
Sep	26.71	31.00	76.40	0.00	10.05	3.63
Oct	25.86	31.24	73.90	0.00	9.10	3.03
Nov	26.53	33.43	78.56	1.04	9.17	1.61

Source: Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG), September-November 2023

Materials

The materials used in this study included Alina F1 melon seeds (PT. East West Seed Cap Panah Merah, Indonesia), rice husk charcoal obtained from a rice mill in Panceng District, and pineapple peels sourced from local vendors around Panceng District Market. The procedure for production of pineapple peel LOF followed the methodology of Susi et al. (2018).

Experimental design

This study employed a factorial randomized block design (RBD) with two factors: pineapple peel LOF and rice husk charcoal media. The pineapple peel LOF was tested at three levels: a positive control using NPK 16:16:16 at 3 g (P0), LOF at 65 ml per liter of water (P1), and LOF at 95 ml per liter of water (P2). The rice husk charcoal media was tested at two levels: a mixture of 50% rice husk charcoal and 50% soil (M1), and a mixture of 75% rice husk charcoal and 25% soil (M2). The study included six treatments, each replicated four times, resulting in 24 treatment combinations. Data were analyzed using analysis of variance (ANOVA), followed by a 5% honest significant difference (HSD) test and correlation analysis to determine relationships between two or more variables, as per Khomphet et al. (2022).

Sample collection was performed randomly based on the methodology of Lopez-Zaplana et al. (2022). Each plot consisted of five plants, with five observation samples taken. Observations were conducted weekly following the procedures outlined by Maharia et al. (2022). The variables observed in this study included the number of leaves, plant height, fresh and dry biomass weight, fruit weight, and fruit brix, as per the observation procedures of Lestari et al. (2019).

RESULTS & DISCUSSION

Plant height

The results of the 5% HSD test showed no significant interaction on plant height at each observation age. This may be due to nutrients not being optimally absorbed by the roots. Additionally, environmental factors, especially extreme temperatures, can influence evapotranspiration processes, leading to the loss of essential nutrients in the rice husk charcoal medium. Increased evapotranspiration results in significant water loss (Maryani, 2012). Moreover, the insufficient availability of essential nutrients required by plants for metabolism can cause growth disturbances, visibly manifesting as abnormalities (Lakitan, 2010).

Table 2. Plant height (cm) for combinatory effect of LOF and rice husk charcoal (n = 4)

Treatment	Plant height (cm)		
	45 DAP	52 DAP	59 DAP
P_0M_1	146.25	162.45	183.20
P_0M_2	153.25	171.20	213.80
P_1M_1	93.50	102.25	104.85
P_1M_2	92.50	105.85	110.20
P_2M_1	86.50	95.45	99.60
P_2M_2	89.25	96.35	102.30
5% HSD	ns	ns	ns

Note: Values followed by the same letters are not significantly different based on the 5% HSD test; DAP: days after planting; ns: no significant difference; *: significant difference; **: highly significant difference.

Plants supplied with essential nutrients in adequate amounts can maximize their growth support (Asp and Bergstrand, 2024). When plants receive sufficient nutrients, their metabolic processes improve (Lingga and Marsono, 2001). This enhances cell division, elongation, and tissue maturation more optimally and rapidly, thus accelerating the increase in plant volume, time, and weight, ultimately leading to better growth and development (Gusnawan et al., 2021). Melon plants require nitrogen (N) during the vegetative phase, especially for height growth. Nitrogen is crucial for the development of branches, leaves, and stems during this phase (Parnata, 2004). When provided in the correct amount and at the right time, essential nutrients can cause plants to grow and develop optimally (Jumini et al., 2012). When melon plants absorb nutrients well, they exhibit optimal growth. Table 2 shows the average plant height values for the interaction treatments of pineapple peel LOF and rice husk charcoal medium. The observations indicate no significant difference in plant height based on the 5% HSD test.

Number of leaves

The analysis of the number of leaves revealed a significant interaction at 52 days after planting (DAP) as indicated by the 5% HSD test, though no significant differences were observed at 45 and 59 DAP. Among the treatments, P0M1 yielded the highest average number of leaves at 26, closely followed by P0M2 with 24 leaves. These findings suggest that a combination of 3 g of NPK and a medium consisting of 50% rice husk charcoal and 50% soil provides optimal conditions for root development. This medium facilitates the rapid conversion of nutrients into ions and cations, which are crucial for plant growth. The enhanced cation exchange capacity allows the soil to retain and release more nutrients, supporting vigorous leaf growth during the vegetative phase (Veranika et al., 2019).

Table 3. Number of leaves for combinatory effect of LOF and rice husk charcoal (n = 4)

Treatment	Number of leaves (leaves)		
	45 DAP	52 DAP	59 DAP
P_0M_1	22.25	26.00ef	31.50
P_0M_2	21.75	24.75e	28.75
P_1M_1	16.50	19.50cd	19.75
P_1M_2	15.50	17.25a	18.75
P_2M_1	15.25	17.75ab	18.25
P_2M_2	17.00	19.25c	21.25
5% HSD	ns	*	ns

Note: Values followed by the same letters are not significantly different based on the 5% HSD test; DAP: days after planting; ns: no significant difference; *: significant difference; **: highly significant difference.

As shown in Table 3, the interaction between pineapple peel LOF and rice husk charcoal medium did not result in significant differences in leaf count at 45 and 59 DAP. According to Yadi et al. (2012), the number of leaves is influenced by the growing environment and nutrient availability. Elevated light intensity and air temperature can lead to nutrient evaporation, particularly in liquid organic fertilizers. These fertilizers, which contain volatile compounds such as ammonia, tend to evaporate easily (Nugroho et al., 2020). High light intensity also increases photorespiration rates in C3 plants like melons, thereby reducing the efficiency of nutrient use (Surtinah, 2017). Efficient nitrogen uptake is vital for optimal melon growth and yield. Nitrogen plays a key role in cell growth and photosynthesis, especially in the development of young leaves (Hartati et al., 2019). Adequate nitrogen availability is essential for chlorophyll formation, which is crucial for the photosynthetic process (Akbar et al., 2019).

Plant fresh and dry weight

There was no significant interaction observed between the treatments on plant fresh weight and dry weight across the different observation periods. Treatment P0M2 exhibited the highest fresh weight at 487.60 g and dry weight at 106.50 g. The addition of 75% rice husk charcoal mixed with 25% soil appears to enhance growth and reduce the need for fertilizer application, aligning with findings from previous research (Lestari et al., 2019). The lack of significant interaction in treatment P0M2 may be due to suboptimal nutrient absorption, which is crucial in the nutrient release process (Trinh and Kushari, 2016). Extreme air temperatures can also lead to nutrient loss. Additionally, the low Cation Exchange Capacity (CEC) of the rice husk charcoal medium can hinder nutrient retention. Rice husk charcoal has a low CEC, increasing the risk of nutrient loss through leaching and evaporation, and also has low Electrical Conductivity (EC) (Ezperanza et al., 2023). Improving CEC and the availability of nutrients can enhance the vegetative phase of plants (Girsang et al., 2020).

High light intensity may also contribute to the lack of significant interaction, leading to evapotranspiration of nutrients and water. Light intensity plays a significant role in the photosynthesis process and melon fruit growth (Minarni and Ulinnuha, 2023). Excessive light intensity can result in nutrient loss and reduced chlorophyll in leaves. During the dry season, intense sunlight can decrease chlorophyll levels in leaves due to high light intensity (Pratiwi et al., 2023). High light intensity causes leaf temperatures to rise, leading to stomatal closure and photodestruction of some chlorophyll (Rohman et al., 2018). High air temperatures prevent the optimal absorption of nitrogen-containing nutrients from the LOF, resulting in suboptimal vegetative growth (Rahayu et al., 2023). The precise use of nitrogen fertilizers is crucial to balance agricultural yield increases while maintaining fruit quality (Cai et al., 2023).

Table 4. Plant fresh and dry weight (g) for combinatory effect of LOF and rice husk charcoal (n = 4)

Treatment	Plant fresh and dry weight (g)	
	Plant fresh weight (g)	Plant dry weight (g)
	45 HSP	52 HSP
P_0M_1	276.85	84.25
P_0M_2	487.60	106.50
P_1M_1	109.55	33.00
P_1M_2	114.10	32.25
P_2M_1	90.25	22.25
P_2M_2	104.25	30.75
HSD 5%	ns	ns

Note: Values followed by the same letters are not significantly different based on the 5% HSD test; DAP: days after planting; ns: no significant difference; *: significant difference; **: highly significant difference.

Fruit weight and Brix

The 5% HSD test results indicated no significant interaction between treatments for fruit weight at any observation period. The analysis revealed that treatments P0M1 and P0M2 had similar outcomes, demonstrating that the addition of 75% rice husk charcoal did not significantly affect fruit weight, consistent with previous research (Aini and Muzakiyah, 2023). The absence of interaction between treatments may be attributed to high light intensity causing strong evapotranspiration of nutrients in the plant medium within polybags. Bazaz et al. (2022) noted that plants grown in polybags have limited root systems due to restricted growing space, relying heavily on provided water and nutrients during extreme weather, particularly high temperatures. The cultivation method using polybags or pots, combined with adequate watering, significantly impacts melon growth and production (Carsidi et al., 2021). The plant roots depend on the water and nutrients available within the polybag or pot. Adequate availability of nutrients, especially phosphorus (P) and potassium (K), in balance with the plant's needs, can result in optimal fruit weight (Asri and Syam, 2021). Vegetables, fruits, and ornamental plants thrive when essential nutrients are sufficiently and evenly supplied, with P and K playing active roles in flower and fruit formation (Topan et al., 2017). Thus, adequate nutrient provision leads to high-quality and optimal fruit yields.

Similarly, the 5% HSD test indicated no significant interaction for fruit brix at any observation period, with treatment P0M2 producing the highest brix value at 9%. This outcome is attributed to the 75% rice husk charcoal medium, which contains absorbable potassium (K) (Lestari et al., 2019). Rice husk charcoal, although low in nutrients, provides additional nutrients when used in large quantities. It contains SiO_2 (52%), C (31%), K (0.3%), N (0.18%), F (0.08%), and Ca (0.145%), along with trace amounts of Fe_2O_3, K_2O, MgO, Cu, and other organic materials (Mauliyandani et al., 2022). Rice husk charcoal enhances soil fertility due to its high K content, aiding in K absorption and root growth (Mauliyandani et al., 2022).

Using soil with low permeability and high sunlight intensity can cause rapid evaporation of liquid organic fertilizer (LOF), hindering its absorption by plants (Afifudin et al., 2024). High light intensity increases nutrient evaporation in the medium. Melon plants require K for fruit formation and quality. Parmila et al. (2019) stated that K significantly increases sugar levels in fruits, positively impacting various quality aspects, including size, color, appearance, soluble solids concentration, acidity, and vitamin content (Ates et al., 2022). Adequate K availability enhances melon fruit sweetness, with sufficient K levels increasing fruit sugar content, contributing to a sweeter taste (Ayu et al., 2019).

Table 5. Fruit weight (kg) and Brix (%) for combinatory effect of LOF and rice husk charcoal (n = 4)

Treatment	Results	
	1 DAH fruite weight (kg)	3 DAH fruit Brix (%)
P_0M_1	1.36	8.3
P_0M_2	1.36	9.0
P_1M_1	0.65	8.6
P_1M_2	0.67	9.1
P_2M_1	0.53	8.3
P_2M_2	0.56	8.6
HSD 5%	ns	Ns

Note: Values followed by the same letters are not significantly different based on the 5% HSD test; DAH: days after harvest; ns: no significant difference; *: significant difference; **: highly significant difference.

Table 6. Correlation test results for combinatory effect of LOF and rice husk charcoal on variable relationship strength

Parameter correlation	JD 52 DAP	TT 52 DAP	FWB 1 DAH	FWD 4 DAH	FW
TT 52 DAP	0.897 10.590				
FWB 1 DAH	0.893 10.444	0.953 15.480			
FWD 4 DAH	0.848 8.852	0.922 12.089	0.985 26.846		
FW	0.918 11.755	0.959 16.500	0.948 14.773	0.901 10.817	
BRIX	-.057 4.698	115 4.721	0.248 4.841	0.319 4.948	0.081 4.706

Note: (+): positive correlation; (-): negative correlation; **: significant; TT 52 DAP: plant height at 52 days after planting (cm); JD 52 DAP: number of leaves at 52 days after planting (leaves); FWB 1 DAH: fresh weight biomass at 1 day after harvest (g); FWD 4 DAH: fresh weight dry at 4 days after harvest (g); FW: fruit weight (kg); BRIX: sweetness (%).

Correlation test

The number of leaves (JD) shows a positive but not significant correlation with plant height (TT) (r=0.897, p>10.590), fresh weight biomass (FWB) (r=0.893, p>10.444), fresh weight dry (FWD) (r=0.848, p>8.852), and fruit weight (FW) (r=0.918, p>11.755), but a negative and not significant correlation with BRIX (r=-0.057, p>4.698). The negative correlation between JD and BRIX might be due to pest attacks on the leaves, which disrupt photosynthesis and nutrient transport. Pests not only interfere with photosynthesis but can also cause plant damage and death due to viruses they carry. Pathogens and viruses can be transmitted by insect vectors, which serve as intermediaries in disease transmission (Sholihatin et al., 2020). The analysis results are summarized in Table 6.

Plant height (TT) shows a positive but not significant correlation with FWB (r=0.953, p>15.480), FWD (r=0.922, p>12.089), FW (r=0.959, p>16.500), and BRIX (r=0.115, p>4.721). Fresh weight biomass (FWB) shows a positive but not significant correlation with FWD (r=0.985, p>26.846), FW (r=0.948, p>14.773), and BRIX (r=0.248, p>4.841). Fresh weight dry (FWD) shows a positive but not significant correlation with FW (r=0.901, p>10.817), and BRIX (r=0.319, p>4.948). Fruit weight (FW) shows a positive but not significant correlation with BRIX (r=0.081, p>4.706).

CONCLUSIONS

This study investigated the effects of different liquid organic fertilizers, specifically those based on pineapple peel and rice husk charcoal, on melon plant growth and fruit quality. The results demonstrated that the application of 75% rice husk charcoal significantly improved both wet and dry biomass as well as fruit sweetness. The findings underscore the importance of optimizing fertilizer composition to enhance plant growth and fruit quality. By selecting the appropriate fertilizer, melon cultivation can be optimized to achieve better yields and higher-quality fruit. This study provides valuable insights for future research and practical applications in agricultural practices, suggesting that further exploration of various fertilizer blends could lead to even more significant improvements in melon production.

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