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Influence of Composition of Soilless Substrates Monitored with Iot Sensor Nodes on the Growth, Nutrient and Fruit Quality of Rockmelons (*Cucumis melo* Var. Cantalupensis)

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ABSTRACT

Background: Coconut coir dust (CD) is commonly used for growing selected fruit and vegetables. It is a soilless medium with excellent drainage and high-water holding capacity; free from infestations of weeds and pathogens. However, plant growth is adversely affected due to its high salinity, potassium and low pH.

Methods: A greenhouse experiment was conducted to investigate the influence of different soilless media on rock melon's growth, nutrient and fruit quality. Five soilless media were prepared including CD as control. A customised portable IoT system was deployed to monitor and collect relevant real-time agronomic data.

Result: Plant height, yield, leaf area, total fresh fruit weight and soluble solids content (sweetness) of rock melon were significantly affected by the growing medium. Among the five media used, the growth and quality characteristics were highest in M2 followed by M3. It was found that a combination of burnt rice husk (BRH) and perlite with CD remarkably improved the growth of fruit quality of rock melon.

Key words: Coconut coir dust, Fruit quality, IoT Sensor nodes, Rock melon, Soilless media.

INTRODUCTION

Human health, growing environmental concerns and restrictions on fumigant use make it extremely difficult to control soil-borne pathogens. The alternate strategy is to use soilless medium to grow fruits and vegetables (Wang *et al*., 2016). The ability of soilless culture techniques to allow effective and intensive plant production has gained recognition on a global scale (Barrett *et al*., 2016). Effective soilless growing medium healthy root development (Rahil *et al*., 2021). Soilless systems use water and nutrients more efficiently than standard soil-based medium and offer high yields (Raviv *et al*., 2002). Plant morphological and physiological processes like transpiration can be greatly offered by the physical characteristics of the substrate (Handreck and Black, 2002).

The essential requirement of a growing medium is the availability of nutrients and water which affects shoot and root growth in plants (Leskovar and Othman, 2016). The traditional and popular growing medium, *i.e.*, CD is not very rich in nutrients and water availability. This is why several researchers have added various organic and inorganic materials to CD, all of which have affected plant growth and yield. Integration of organic and inorganic helps to achieve high yield (Dadiga *et al*., 2015). For instance, Ebrahimi *et al*., (2012) reported that strawberry plants grown in coconut coir dust and perlite (1:1 v/v) substrate had the highest levels of content. Salisu *et al*., (2020) observed that soilless media containing vermiculite, perlite and BRH significantly influenced the number of leaves and leaf area in rubber seedlings.

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Rock melon is widely grown in soilless CD. Rock melon (*Cucumis melo* L.) is one of the key economic crops of Malaysia and neighbouring countries, providing farmers with significant revenue (Ismail *et al*., 2021). However, there have been recent fluctuations in the production of this fruit. This could be due to a variety of circumstances among which poor soilless media might be one of the reasons (Muhammed *et al*., 2017). As such, despite the deficiencies reported, there exists scanty research evaluating mixtures of organic or inorganic materials as well as monitoring them with the internet of thing (IoT) sensor nodes to ensure optimum fruit yield.

An IoT-based monitoring system aims to gauge the moisture content, EC and nutrients and transmit the results to the user via the Firebase IoT platform (Noar and Kamal, 2017). The study reported the influence of different soilless media on growth, nutrients and rock melon fruit.

MATERIALS AND METHODS

Preparation of soilless media

Four newly prepared soilless media and commonly used coconut coir dust as a control were used to grow rock melon. The selection of the materials was based on a suggestion by Miller and Jones, (1995) as contained in the World Bank technical paper on viable materials for the constitution of growing media for greenhouse crops. Each of the soilless media contains proportions of the materials as shown in Table 1. The soilless media are coded as M1, M2, M3, M4 and M5. Berkeley method was adopted for soilless media preparation (Rakocy *et al*., 2009; Adekunle, 2017). The proximate analysis of the chemical and physical properties of soilless media material compositions is shown in (Table 2).

Rock melon seeds were planted following the recommendation of Zulkarami *et al*., (2010). Thereafter, uniformly-sized seedlings were transferred into plastic bags filled with newly prepared soilless media, namely M1, M2, M3 and M4 and M5. A randomised complete block design with five replications was used for the experimental layout. The experiment was conducted at Farm B Sultan Idris Education University, Malaysia between 2021 and 2022. The rock melon was grown for ten weeks and irrigated with 1 litre of water twice daily using a drip system. Data were collected at 3, 6, 9 and 10 weeks after transplanting. Data were taken on plant height, number of leaves, total leaf area, fruit size, weight and sweetness (Brix) of fruit. A customised portable IoT system (Fig 1) developed by RED tone International Bhd-Broadband providers in Malaysia was used to monitor the quality of the soilless media.

The IoT system has all the requisite inbuilt components and functions for real-time data collection. The components of the IoT smart farming system were described by Labib Sharrar *et al*., (2021). This in turn enables farmers to conveniently store the data collected from sensor nodes using the cloud platform. The system was able to measure on-site while keeping track of electrical conductivity (EC), total dissolved solids (TDS) of nutrients, moisture content and pH using a cloud database as shown in Fig 2. The influence of different soilless media on the growth of rock melon is shown in Fig 3. The collected data were analysed using SAS System for Windows 9. A Least Significant Difference (LSD) was used to compare variations among the treatments.

RESULTS AND DISCUSSION

With the aid of the portable IoT system, the reading of the nutrient concentration and EC was collected periodically from the sensor nodes and a Tx LoRa transceiver through the cloud servers. The results are presented in Fig 4a, b and 4c. Soilless medium M2 and M3 showed the highest nitrogen content and significantly differed from M1, M4 and M5. However, M5 (control) performed better than M1. The high N concentration in M2 and M3 could have been due to the addition of BRH and perlite. BRH possesses a high silica concentration which makes it a good additive since it increases soil fertility. BRH also enhances nutrient retention when combined with materials like coconut coir dust (Kulkarni *et al*., 2014).

Perlite increases the porosity of soilless media and helps to maintain nutrient of the media however, excessive use of perlite is discouraged because it create a rapid drainage of water, which will be harmful to plants (Kingston *et al*., 2020). Soilless media M2 and M3 recorded the highest levels of phosphorus concentration, followed by M4 which was significantly different from M1 and M5. As for the potassium concentration, M2 performed best and was significantly different from the rest of the soilless media, while M1 and M3 were significantly different from M4 and M5. The highest EC levels were observed in M2 and M3 with 1.29 dS/m and 1.28 dS/m respectively, followed by M1 and M5 with 1.16 dS/m and 1.02 dS/m respectively, all of which were significantly different from M4's 0.97 dS/m Fig 4d.

The highest plant height was recorded on soilless medium M2, followed by M3 and both were different from the rest of the soilless media as shown in Fig 5a. However, there were significant differences between M4, M1 and M5. The differences in height among growing media may be due to similar differences in their nutrient concentration. Soilless media containing BRH, due to its high silica content improves

Table 1: Composition of different newly prepared soilless media and Coconut coir dust (control).

Soilless media	Soilless formulations	% Components composition
M1	Coconut coir dust, burnt rice husk, perlite	75:15:10
M2	Coconut coir dust, burnt rice husk, perlite	75:20:5
M3	Coconut coir dust, vermiculite, perlite	75:15:10
M4	Coconut coir dust, perlite	75:25
M5	Coconut coir dust (CD)	100 (control)

nutrient uptake, turgidity and plant structure (Karam *et al*., 2021). In addition, soilless media containing burnt rice husk and perlite aid rapid plant growth which could easily be reflected in the plant canopy, plant stem and leaf number (Awang *et al*., 2010). Due to its high porosity, BRH largely possesses a skeletal structure. It prevents bacterial attack, regulates the pH of soilless media and permeates oxygen throughout root zones, making it an ideal soilless medium additive.

Noticeably, the highest number of leaves was recorded in the plants grown on soilless media M2 and M3, with 43.8 and 41.8 respectively and significantly different from the remaining media treatments Fig 5b. The comparatively high number of leaves recorded from M2 and M3 could have been due to their material composition and nutrient concentration. This is in agreement with the study conducted by Gonbad *et al*., (2013) who reported that a medium containing vermiculite and perlite increases the number of plant leaves and growth traits. Plants with a high concentration of P as shown in M2 and M3 produce the maximum number of leaves, especially when perlite is combined with edaphic factors like optimum moisture content, favourable pH and aeration (Kim and Li, 2016; Salisu *et al*., 2013).

The leaf area of plants grown in M2 was significantly different at $p<0.05$ (971.37 cm^2/plant) from plants grown in M1 (722.55 cm^2/plant), M3 (717.23 cm^2/plant), M4 (694.38 cm^2/plant) and M5 (694.38 cm^2/plant) (Fig 5c). The nitrogen level was significantly higher in soilless medium M2 than those that were planted in other media. Leaf area is a key indicator of how efficiently nitrogen is used by plants and it has considerable impacts on growth parameters like plant height (Hirel *et al*., 2001).

Fruit length, diameter and fruit weight varied significantly among the new soilless media and the CD (Fig 6a). M2 plants had longer fruits, followed by M3 and M4, all three of which were comparatively longer than M1 and M5. Similarly,

Table 2: Proximate analysis of physicochemical properties of material composition and Coconut coir dust (control) of the soilless media.

Materials	Chemical properties (%)	Physical properties	Sources
Perlite	SiO_2=74.4		Terzić *et al*., (2020)
	Al_2O_3=15.4	Free moisture= 0.5%	Panuccio *et al*., (2009)
	Fe_2O_3=1.3	Specific gravity- 2.2= 2.4	Perlite institute, (2011)
	MgO=0.13	Refractive index- 1.5	
	K_2O=4.55	Expanded Bulk density= 2-25	
	P=3.5	lb/ft^3	
	Na_2O=3.38	Optimum water content= 2.09	
	O_2=47.5	Fineness (%)= 10.2	
	pH=7		
Vermiculite	SiO_2=41.2	Bulk density= 140 kg/m^3	Quintero *et al*., (2011)
	Al_2O_3=14.94	Water holding capacity= 240	Panuccio *et al*., (2009)
	CaO=3.95	wt%	Sutcu, (2015)
	Fe_2O_3=7.2		
	MgO=25.5		
	K_2O=5.1		
	TiO_2=1.4		
	pH=7		
Burnt Rice Husk	SiO_2=93.4	Bulk density (g/cc)= 0.353	Korotkova *et al*., (2016)
	Al_2O_3=0.05	Particle density (g/cc)= 0.410	Bishnoi *et al*., (2004)
	Fe_2O_3=0.06	Porosity (%)= 13.90	
	CaO=0.31		
	MgO=0.35		
	K_2O=1.4		
	Na_2O=0.1		
	P_2O_5=0.8		
	pH=6.5		
Coconut coir dust	N=0.39%	Bulk density (g cm^{-3})= 0.074	Asiah *et al*., (2004)
	P= 0.28-2.81 mol m $(^{-3})$	Particle density (g cm^{-3})= 0.758	Abad *et al*., (2002)
	K= 2.97-52.66 mol m (-3)	Total pore space (% vol)= 96.26	
	Ca^{2+}=0.18%		
	Mg^{2+}=0.11%		
	C/N= 31.7 to 95.4 cmol(c) kg$(^{-1})$		
	EC=1.96 dS m^{-1}		

Fig 1: The portable IoT smart farming system by RED tone international Bhd-Broadband providers in Malaysia.

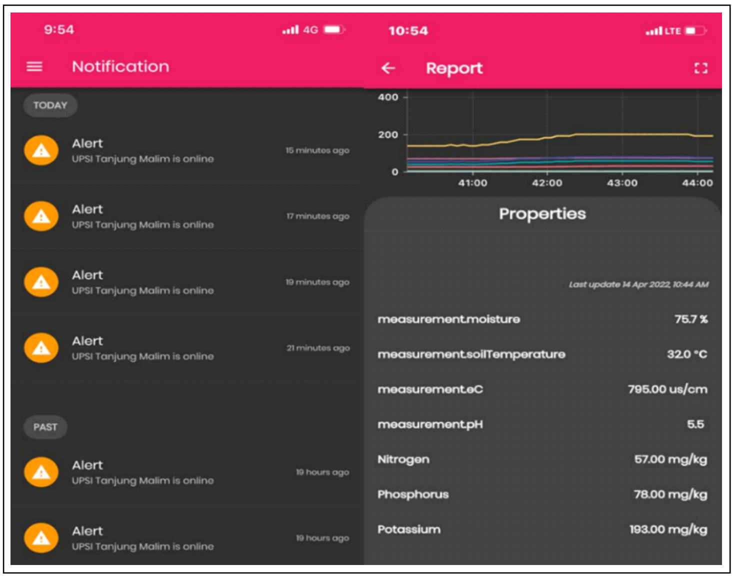

Fig 2: EC, moisture, pH and nutrients concentration readings from portable IoT smart farming system.

Fig 3: Influence of different soilless media on the growth of Rock Melon.

fruit diameters were comparatively wider in plants grown in M2 and M3 and significantly different from plants grown in M1, M4 and M5 (Fig 6b). The results revealed that total fresh fruit weights were significantly greater in soilless media M2 and M3 and significantly different from plants grown in M1, M4 and M5. This could have been due to the soilless nutrient concentration. There is a significant and positive correlation between nutrients and fruit quality (Sharma and Kumawat, 2019).

Noticeably, CD recorded the lowest total fruit fresh weight after M1 (Fig 6c). The sweetness of the rock melon from different soilless media is presented in Fig 6d. The highest soluble solids content 18.4% was recorded in soilless medium M2 and significantly different from the rest of the soilless media. The M3 media were solids content 14.72% higher followed by M2 and is also significantly different from plants grown in M1, M4 and M5. The sweetness of the fruits was related to the soilless media,

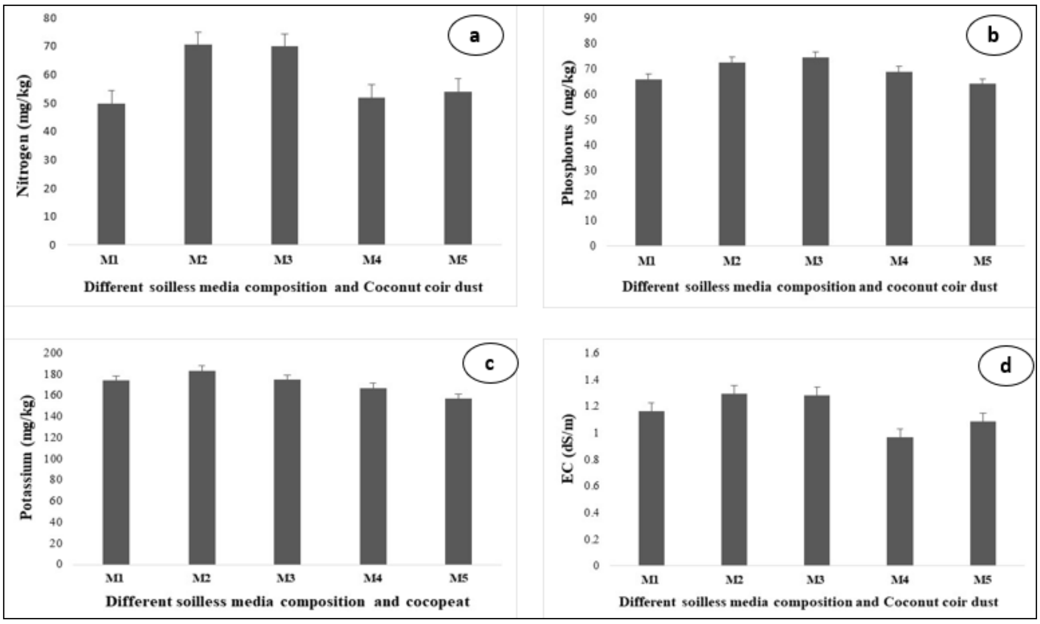

Fig 4: a,b and c. nutrient concentration and d. EC levels of different soilless media for rockmelon growth and fruit quality.

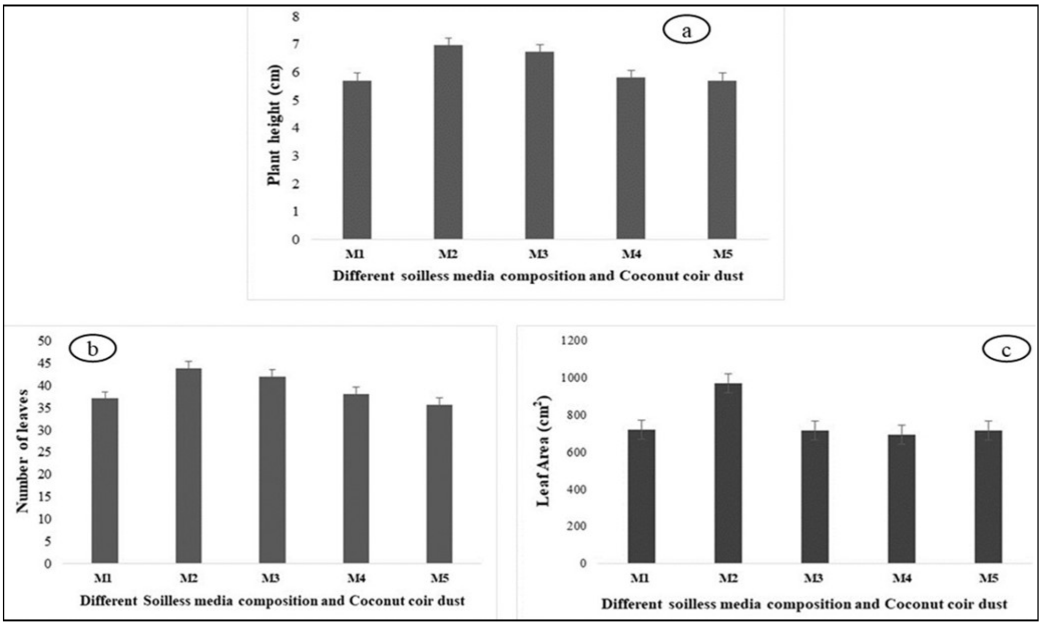

Fig 5: a. Effect of different soilless media on the plant height of rock melon b. Number of leaves of rock melon c. Leaf area of rock melon.

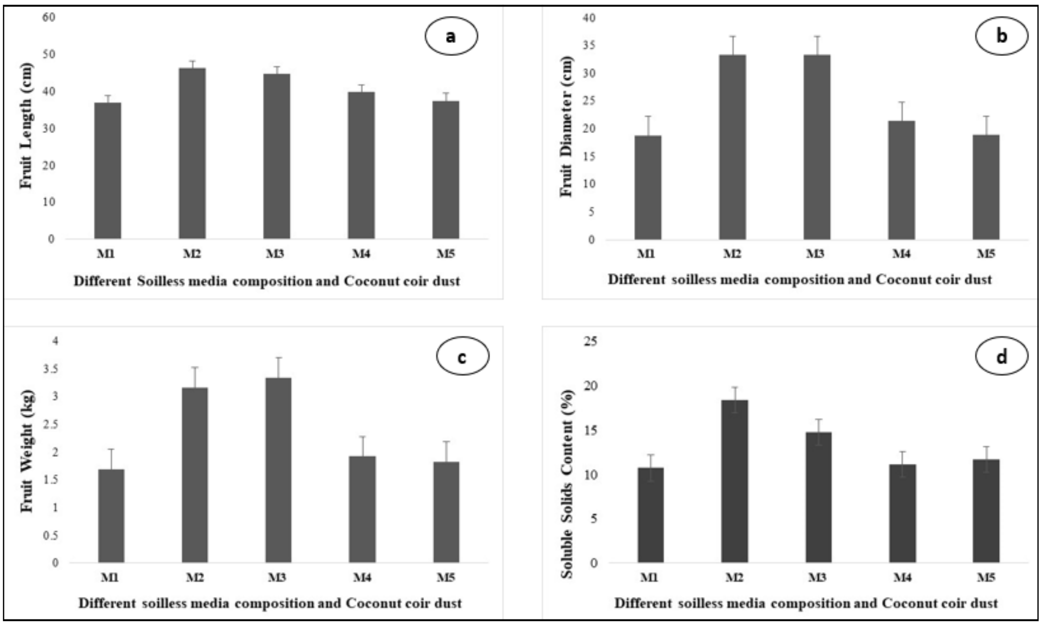

Fig 6: a. Effect of different soilless media on the fruit length, b. Fruit diameter, c. Fruit weight and d. Soluble solids content of rock melon.

especially fruits harvested from M2 was remarkable. This could have been due to the EC levels which ranged from 0.9 dS/m to 1.5.

CONCLUSION

It may be concluded that EC level and the combination of BRH and perlite in the soilless media improve the growth and fruit quality of rock melon.

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Conflict of interest: None.

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