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INFLUENCE OF SOILLESS POTTING MEDIA ON GROWTH AND VEGETATIVE TRAITS OF IMMATURE RUBBER (*HEVEA BRASILIENSIS* MÜLL. ARG.)

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Abstract

The resuts assessed growth and vegetative traits of rubber based on physic-chemical properties of newly produced soilless potting media. The treatments consisted of three soilless potting mixes coded as M1, M2 newly produced, a commercial-based medium M3 and soil-based M4 as a control. The treatment (M2) that contained coconut husk 15%, empty fruit bunch (EFB) 15%, sugarcane bagasse 15%, urea-N 10% and proportions of other materials noticeably showed the highest and significant N concentration. It significantly increased growth traits; scions stem diameter, the number of leaves, leaf area and leaf area index. Other vegetative traits such as total fresh weights and total dry weights are significantly improved. Most of the root morphological traits on the M2 was significantly higher when compared to the other media. Materials used in its preparation relatively induced rootstocks of the seedlings due to their water and nutrient absorptive capacity and could be an alternative to many poor soils when establishing rubber nursery.

Introduction

Soilless potting media or soilless technique is widely adopted and practice for crop production due to unfavorable growth conditions created by many soils, coupled with disease contamination even after series of efforts (Verhagen 2009). Girardi *et al.* (2005) have reported effectiveness of potting mixes for nursery trees in containers. It enhances plant growth than soil due to better pore distribution (Rodriguez *et al.* 2006). In order to achieve better root growth or another aspect of plant biomass than those planted in soils, the right materials must be used alone as a substrate or mixed well with other processed or organic materials (Noto 1993). It reduces some of the problems like pests and diseases associated with the use of soil and reduced use of soil fumigants is equally possible Salisu *et al.* (2016). Water and nutrient use efficiency are among many advantages of soilless medium due to a high cation exchange capacity and water holding capacity. Soil fumigant use equally reduced due to the reduction of soil-borne pests (Cantliffe *et al.* 2007). A good soilless media is said to possess some qualities such as low bulk density, light weight, friability, and slight acidity in addition to fungal free spores, weed seeds, insects (Meadn *et al.* 1998) and cost (Del and Gomez 2009).

These could not be found in topsoil used in rubber nursery, leading to poor growth and development of plant parts especially lateral roots (Khedkar and Subramanian 1997). This is due to lack of essential plant nutrient as some of these soils lack organic matter, which supplies the nutrient (Salisu and Noordin 2016).

Materials commonly used alone or combined with potting mix includes vermiculite, perlite, rock wool, rice hull, peat moss, coconut coir, burn rice husk and other locally available materials (Surrage *et al.* 2010). These materials like perlite improve drainage, aeration, nutrients and retain moisture due to the high porosity (Grillas *et al.* 2001).

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Coconut fibers having better bio-stability (92.2%), porosity (98%) and significant amount of P and K (Guerinet *et al.* 2001), sugarcane fibre (Josiah and Jones 1992). Vermiculite equally increases water-holding capacity, it is 3 - 4 times its weight of water, and holds positively charged nutrients such as K, Mg and Ca (Handreck and Black 2005). High buffering capacity and neutral reaction (pH 7) also make it a desirable material for plant growth, especially at seedling stage. The combination of vermiculite and perlite in soilless medium enhances plant growth traits such as height, the number of leaves and it equally promotes root system (Azadi *et al.* 2013).

Soilless medium containing both peat moss and perlite equally increases the amount of air (oxygen) and water. There are practically essential component in the potting mix, which successfully promotes growth of rubber seedlings. The objective of this study was to evaluate the effect of the different soilless potting mixes on vegetative growth and root morphology of rubber (*Hevea brasiliensis* Müll. Arg., Fam.: Euphorbiaceae) budded stumps.

Materials and Methods

Different soilless potting mixes and soil-based media were used. Based on a suggestion by Miller and Jones (1995) as contain in the World Bank technical paper on materials for growing media for tree seedlings (Table 1). Newly formulated potting mixes used were: (codded M1) containing vermiculite, perlite, coconut husk, compost, peat moss, burn rice husk, rock phosphate and urea-N and (M2) vermiculite, perlite, EFB, coconut husk, peat moss, sugarcane bagasse and fortified with proportions of Christmas Island Rock Phosphate (CIRP) and Urea-N fertilizers (Miller and Jones 1995).

Table 1. Soilless formulations in different percentage composition used in the study.

Soilless/soil-based media	Soilless formulations	% components composition
M1	Vermiculite: perlite: coconut husk: EFB: Rock Phosphate (CIRP): peat moss: urea: burn rice husk	15 : 5 : 20 : 10 : 5 : 30 : 5 : 10
M2	Vermiculite: perlite: coconut husk: EFB: rock Phosphate: peat moss: urea: sugarcane bagasse	10 : 10 : 15 : 15 : 5 : 20:10:15
M3	Commercial soilless media	Commercial media
M4	Oxisol soil (Control)	100

A commercial potting mix as (M3) was included in the study and Oxisol soil as (M4) designated as control evaluation. It is a clayey soil containing a yellowish brown to strong brown color commonly used in rubber plantation (van Noordwijk *et al.* 1996, Paramananthan 2000). Physico-chemical properties were analyzed using a modified saturated medium extract (SME) with diethylenetriamine penta-acetic acid (DTPA) solution (Warncke 1990). Physical analysis performed according to method described by Teh and Jamal (2006). A nursery experiment conducted under a rain shelter with 50% light intensity at the field No. 2 Universiti Putra Malaysia (UPM). The experiment was conducted in containers (root trainers) size 26 cm length and 600 ml filled with 400 g of the soilless media and polybag size (20" × 12") filed with soil (4.5 kg).

Bare-root budded stumps of rubber planted according to technique described by Seneviratne (2001). To facilitate irrigation, the top 3 cm of the container was unfilled. The experiment was arranged in a RCBD with five replications under the rain shelter. Fertilizer solution combined with fungicide as foliar application done was based on Malaysia Rubber Board (2009).

Actual chlorophyll content was extracted, analyzed and determined using the described and published equation by Coombs *et al.* (1985). Plant growth and biomass traits were measured monthly after the emergence of leaves from the bear leaves green budded stumps. Number of leaves was counted following the method as described by Arbona *et al.* (2005) for budded seedlings. Plant height (cm) measured using a standard measuring tape. Stem diameter (mm) of the scions were measured using digital Veneer Caliper. Leaf area was equally measured using an LI-COR-3100 leaf area meter (LI-COR, Lincoln, NE, USA). Measurement of leaf area index (LAI) done and was calculated as follows:

$$\textbf{Mean LAI} = \frac{\left(\frac{LA1}{P1} + \frac{LA2}{P2}\right)}{2}$$

where LA is the total leaf area and P is the total ground area upon which crop stands. Foliar nutrients analysis carried out according to the rubber industry foliar techniques as described by Noordin (2012). For the biomass production, fresh and dry weights were collected and determined. Fresh biomass for leaves, stem and roots were weighed (g) to a constantweight 0.01 g.

For the dry matter (DM), plant tissues were oven-dried at 50°C for 48 - 72 and equally weighed (g). Root: shoot ratio was also determined using an equation proposed by Hunt (1978)

$$\text{RSR} = \left(\frac{\text{Total root dry weight (g)}}{\text{Total shoot dry weight (g)}}\right)$$

Root sampling was done and root morphological traits such as total length, average diameter, surface area, total root volume and a number of tips were were scanned using WinRHIZO pro software (Regent Instrument Inc.) root analysis equipment. All data were analyzed (ANOVA) using SAS statistical software Package (Version 9.1). The LSD was used to compare treatment means at the 0.01 and 0.05% probability levels DMRT.

Results and Discussion

Growing medium composition M2 showed the highest scion stem diameter (6.26 mm) ranking as the significantly best medium for growth of *Hevea*. Plants grown in the same medium composition, M2 equally recorded the highest (32.0) number of leaves Table 2. Highest value (8.37 cm^2) of leaf area was recorded in media composition M2 followed by composition medium, M3 (5.12 cm^2) though not varied significantly. This have been contributed by urea-N (10 %) used for the media preparation. This soilless medium resulted in highly significant ($p \leq 0.001$) foliar nitrogen content in plants grown on it contributing to the increase in scion stem diameter and other vegetative attributes (Chen *et al*. 1988).

Significant differences of leaf area index (LAI) was observed among plants that were grown in various media but medium composition M1 and M2 recorded the highest values (21.87) and (18.22) while lowest (10.17) yield was recorded in medium composition M3. Leaf growth such as leaf area and leaf area index may be greatly influenced by N (Engels and Marschner 1995). This is because the size and number of vegetative and reproductive storage organs largely influenced by N due to the photosynthetic rate per leaf, which controls photosynthetic products including the production of carbohydrates. Plants biomass recorded in all the media showed significant differences (Table 3). Highest root fresh weight (RFW) of plants was recorded in medium composition M2 (13.52 g) followed by M3 (12.62 g) while the lowest (4.65 g) was observed in M4 soil-based medium.

Medium composition of M2 profoundly and significantly influenced shoot fresh and dry weights of *Hevea* to 27.75 and 9.36 g, respectively. Total fresh and dry weights of the plants in the same medium 24.71 and 11.43 g were significantly promoted and were different from other media.

Table 2. Effect of soil-based and soilless media on plants growth traits of *Hevea brasiliensis.*

Treatments	Plant height (cm)	Stem diameter (mm)	Number of leaves	Leaf area (cm^2/plant)	Leaf area index (cm^2/plant)	Chlorophyll (Mv)
M1	14.0	3.67b	14.4c	3.14b	21.87a	475.9
M2	17.8	6.26a	32.0a	8.37a	18.22a	475.9
M3	15.6	4.19b	24.4b	5.12ab	10.17b	432.8
M4	11.6	4.42b	24.2b	1.850b	15.36ab	345.2
LSD $_{\%5}$	5.33	1.11	7.13	4.6135	74.191	545.96
p > F	ns	0.002	0.002	0.05	0.05	ns

Mean values followed by the same letter within the same column are not significantly different at $p < 0.05$, based on a least significant difference test (LSD).

However, root dry weight and root: shoot ratio of the plants grown in the respective media also significantly improved. However no significant changes was observed in total dry weights achieved from plants grown in M 3 and M 4 growing media though growth was slightly better in M 3 medium (Table 3). Ratio : shoot ratio varied not significantly among the plants grown in the media.

Table 3. Effects of soil-based and soilless media on vegetative traits of *Hevea brasiliensis.*

Treatments	RFW(g)	RDW	SFW	SDW	TFW	TDW	RSR
M1	6.28bc	0.85	9.80b	3.04b	10.17bc	3.89b	3.52
M2	13.52a	1.83	27.75a	9.36a	24.71a	11.43a	7.55
M3	12.62ab	1.86	11.40b	4.22b	18.7ab	5.84b	2.60
M4	4.65c	0.71	10.50b	3.37b	8.733c	4.08b	4.45
LSD $_{\%5}$	7.17	1.05	7.45	3.96	8.58	3.91	5.06
p > F	0.05	ns	0.003	0.025	0.012	0.0112	ns

Mean values followed by the same letter within the same column are not significantly different at $p < 0.05$, based on a least significant difference test (LSD). SFW: shoot fresh weight, RFW. root fresh weight, SDW: shoot dry weight, RDW: root dry weight, TFW: total fresh weight, TDW: total dry weight, RSR. root: shoot ratio.

The performance of the media composition M2 could have been due to the combination of the materials used which include coconut coir (20%) and sugarcane bagasse (15%). Both materials aid water retention of the media. Haman and Izuno (2003) reported that plant yields such as biomass production could positively affected depending on the specific combination of potting mix and water retention capacity and container height are important factors. Proportions of sugarcane bagasse in media may significantly influence plant growth and overall biomass production of plant at both fresh and dry weight depending on the percentage added to the media (Webber *et al*. 2015). As such, inclusion of sugarcane bagasse in M2 had significantly affected plant growth and biomass yield and could be considered suitable for potting mix combinations.

The result in comparison to M1, showed a significantly ($p \leq 0.001$) higher foliar nitrogen content of *Hevea* seedlings grown in medium composition M2 followed by that grown in M4 soil-based medium though not significant (Table 4). An increase of urea-N, EFB compost (15%) and other materials combinations could have contributed to the significant difference. The inclusion of compost such as sugarcane trash in soilless gives necessary nutrients, especially N and P and these greatly promoted the vegetative growth of plants (Jayasinghe *et al.* 2010).

Table 4. Effects of soil-based and soilless media on foliar nutrients concentration of *Hevea brasiliensis.*

Treatments	N (mg/g)	P (mg/g)	K (mg/g)	Ca (mg/g)	Mg (mg/g)
M1	1.93c	1.06	0.59	0.18	0.15
M2	3.39a	1.19	0.8	0.46	0.14
M3	2.66b	1.1	0.62	0.3	0.16
M4	3.04ab	1.0	0.58	0.29	0.19
LSD $_{\%5}$	0.58	0.16	0.21	0.21	0.083
p > F	0.001	ns	ns	ns	ns

Mean values followed by the same letter within the same column are not significantly different at $p < 0.05$, based on a least significant difference test (LSD).

The rest of the nutrients (N, P, K, Ca and Mg) showed no significant differences among the plants (Table 4). Medium composition of M1 recorded the lowest percentage of nitrogen. Root morphology of rubber like total average diameter (TAD) of seedlings of rubber *Hevea* varied significantly from 0.31 to 0.56 mm (Table 5). Root of plants grown in medium composition M2 were significantly increased ($p \leq 0.05$) and record the highest total average diameter (Table 5). A similar scenario was found where plants grown in M2 also recorded the highest root surface area (570.60 cm^2) followed by those planted in commercial-based medium M3 (439.99 cm^2) and was statistically identical.

Table 5. Effect of soil-based and soilless media on root morphological traits of *Hevea brasiliensis.*

Treatments	Root length (cm)	Root volume (cm^3)	Average diam. (mm)	Surface area (cm^2)	Number of tips
M1	2215.1	2.88	0.39b	387.10b	50486c
M2	4198.1	6.26	0.56a	570.60a	95986a
M3	2350.5	3.93	0.31b	439.99ab	78354ab
M4	2751.0	3.85	0.43b	159.73c	56830bc
LSD $_{\%5}$	2213	3.02	0.11	146.23	24715
p > F	ns	ns	0.045	0.003	0.014

A number of root tips were equally significantly ($p \leq 0.05$) influenced by the medium composition M2 followed by those planted in M3 and was not statistically different. The available N and plants absorption ability could have contributed to the performance of M2, which greatly influenced most of the root traits. Shinano *et al.* (1994) reported that plants experience an increase in root size and other biomasses such as dry weight due to photosynthetic activities and plant nitrogen absorption rate. In addition, Stoffell *et al.* (1996) observed that soilless amended with sugarcane fiber as in M2 in this study, significantly aid plant growth such as seedlings height and overall root growth than those planted in 100% compost. Consequently, M2 could be an ideal growing medium for rubber seedlings.

The results reveal that using soilless potting mix would greatly enhance growth of rubber and serve as an alternative to poor soils. It equally identified materials that absorb more water and provides adequate nutrient for enhancement of vegetative traits and root growth of *Hevea* and locally cheap available materials like EFB that could serve as constituents of affordable medium for the production of seedling rootstocks. This study affirms a relationship between scion stem diameter and number of leaves with respect to the effect of N on both traits. For maximum growth of rubber tree, including increasing stem diameter which is essential in rubber growth and the combination of suitable materials are strongly correspond to the root systems of the rubber tree. Sugarcane bagasse should be included in soilless preparation for the improvement of medium and inducement of rootstocks due to its absorptive capacity for a better rubber nursery.

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