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Effect of Different Growing Media on Growth Performance of Liberica Coffee Rootstock

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Abstract

Liberica coffee is a hardy perennial crop grown by smallholders as a monocrop or intercrop with coconut or other fruit trees. The current propagation method of Liberica coffee clones is based on grafting, which requires 7-8 months for rootstock to mature and another 7-8 months for planting. The current production manual suggests using a 1:1 ratio of soil to sand to produce matured Liberica coffee rootstock. Studies have shown that using a combination of planting media, such as rice husk charcoal and compost, can result in higher plant height, number of leaves, internodes, and leaf area. A combination of leaf manure, silt, straw, peat moss, and soil performed better than 100% soil due to better nutrients, water, and anchorage provision. Consequently, a study to assess the impacts of growing media on MKL 1 polyhybrid as rootstock was carried out. The experimental design used was Randomized Complete Block Design (RCBD) with 4 replications. Treatment consist of T1 = soil + sand (1:1), T2 = soil + cocopeat (1:1), T3 = soil + peat moss + sand + cocopeat (1:1:1:1), T4 = soil + peat moss + cocopeat (2:1:1), T5 = soil + peat moss (3:1), T6 = soil + chicken manure (3:1) and T7 = soil + CIRP (10:1). Parameters evaluated in this study include plant height, leaves number, stem girth, SPAD, fresh root weight and dried root weight. The findings indicate that the treatments had a significant impact on girth, SPAD, and root fresh weight and these three parameters share significant positive association with one another. Girth performed best under T4 although fresh root weight and SPAD performed noticeably better under T3. Current recommended protocol for media performed significantly lower compared to other

media. This study offers a new outlook on how to improve current protocol on Liberica coffee rootstock preparations.

1. Introduction

Liberica coffee is a hardy perennial crop planted commercially grown by smallholders either as a monocrop or intercrop with coconut or other fruit trees and the green beans harvested are usually roasted, powdered before packaged into final beverage products [1]. Back in the 1990s, most coffee growers use unverified planting materials which result in lower yield and high variability [2]. In betterment of national coffee production, MARDI has introduced several sets of Liberica coffee clones known as MKL 2, MKL 3, MKL 4 back in 1995 and MKL 5, MKL 6 and MKL 7 in 2008 [3]. Recently, MARDI has again introduced the latest set of clones known as MKL 8, 9 and 10 in June 2023 [4].

As of now, the current propagation method of Liberica coffee clones is solely based on grafting [5]. In this method, a polyhybrid Liberica coffee MKL 1 is used as rootstock and grafted with scion of desired planting materials and hence known as clone [6]. The main disadvantage of this method is that rootstock requires 7-8 months before it is mature enough to be grafted and upon grafting it would require another 7-8 months for it to be ready to be planted at the field. In other words, it would require a total of 14-16 months to produce a matured planting material [7]. Providing better quality rootstock planting materials either through media manipulation or coffee accessions could enhance the performance of overall Liberica coffee performance since Myers et al. (2020) found out that Liberica coffee accessions Arnoldiana, Dewevrei and Fukunaga was a superior compared to non-grafted Kona Typica [8]. Another study by Magesa et al. (2018) suggest that red soil proved to provide the rooting percentage of selected hybrid coffee varieties [9].

Current protocol by MARDI suggests using 1:1 of soil to sand to produce matured Liberica coffee rootstock. According to Ghawas [5], using combination of planting media consisting of rice husk charcoal and compost resulted in significantly higher plant height, number of leaves, internodes, and leaf area. They attributed this result due to higher content of N in both charcoal rice husk and compost compared to 100% soil. Study showed that growing media red soil was the best followed by sawdust in contributing better rooting system. They attributed their findings due to red soil having significantly better chemical and physical properties. However, this study was carried out using coffee varieties outside Malaysia.

Another recommendation by MARDI suggests the combination of soil, peat moss and sand with ratio of 3:2:1 respectively as media for coffee rootstock [10]. They emphasized that this approach was the best to minimize root damage during transplanting. Another study pointed out that growing media of soil, sand and with ratio of 6:2:1 respectively contributed to significantly higher germination, seedling vigor, plant height, leaves number, leaf area index, girth, seedlings fresh weight and seedlings dried weight. Based on previous studies, different planting media can help to improve overall rootstock performance on coffee rootstock.

The present protocol for Liberica coffee rootstock was established back in 2005 and it has been more than 17 years since the new set of coffee Liberica coffee clones were introduced. Therefore, there is a need to improve current protocol by evaluating the effect of several planting media on the performance of Liberica coffee rootstock.

2. Methodology

The trial was carried out in Ladang 1, Nurseri Kopi Pusat Tanaman Industri, MARDI Kluang from January to October 2023. In order to evaluate the effect of different planting media on Liberica coffee rootstock, a total of 350 seeds of polyhybrid MKL 1 were collected and germinated in germinating beds. The germinating beds with the size of 4 m (width) x 3 m (length) x 1.5 m (height) filled with sand were used to germinate MKL 1 polyhybrid seedlings. The plantlets were left to reach true leaf stage before it is transplanted into polybag with the size of 6’ x 9; [5] with different planting media. The treatments media consist of T1 = soil + sand (1:1), T2 = soil + cocopeat (1:1), T3 = soil + peat moss + sand + cocopeat (1:1:1:1), T4 = soil + peat moss + cocopeat (2:1:1), T5 = soil + peat moss (3:1), T6 = soil + chicken manure (3:1) and T7 = soil + Christmas Island Rock Phosphate (CIRP) (10:1). The experimental design used in this study was randomized complete block design (RCBD) with 4 replications. A total of 28 experimental units consisted of 4 polybags per experimental unit. The polybags were harvested 7 months after transplant. Evaluated parameters in this study were plant height, leaves number, girth, SPAD chlorophyll reading, root fresh weight and dried root weight [9]. Height was measured using ruler, (Vu et al.) [28] chlorophyll was measured using SPAD chlorophyll meter (Vu et al.) [28] whereby random 3 leaves selected for each seedling, and girth was measured 5 cm above ground using caliper [20]. All the polybags were harvested and washed carefully to avoid damage to the roots.

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3. Result and Discussion

ANOVA analysis pointed out that only plant girth and SPAD chlorophyll and fresh root weight reading were significantly affected by treatments (Table 1). The parameters of plant height, leaves number, and dried root weight were not significantly affected.

Table 1 *Mean square ANOVA analysis effect on different growing media on Liberica coffee rootstock*

Source of variance	Parameters					
	Height	Leaf number	Girth	SPAD	Fresh root weight	Dried root weight
Treatments	4.78	2.67	0.17*	62.24*	0.42*	0.06
Rep	3.78	5.94	0.25	52.89	0.03	0.004
Grand mean	11.89	5.25	2.21	46.18	1.77	1.31
C.V.	12.34	20.7	11.26	10.32	21.68	11.44

Note: mean followed by * indicates significant difference at 0.05

3.1 Girth

Analysis suggests that T3 with combination of soil + peat moss + sand + cocopeat (1:1:1:1) contributed a higher and significant reading compared to the rest of treatments (Figure 1). The difference between T3 and second highest reading (T4) was 17.78%. This may be attributed to properties of cocopeat to retain moisture while sand in planting media which act to provide better soil texture and porosity of seedlings growth [11] Another study found out that planting media combination topsoil + sandy soil contributed to highest significant reading on stem of Arabica coffee seedlings [23]. They postulate that the rice husk that was used as growing media in their study contains a lot of ash and may have impacted the bacterial decomposition and significantly has lower N which resulted poor growth for Liberica coffee rootstock. The current protocol represented by T1 = soil + sand recorded a significantly lower reading and was the lowest among all treatments. The difference in observation compared to other studies maybe due to planting materials used and climate since those study was carried outside Malaysia.

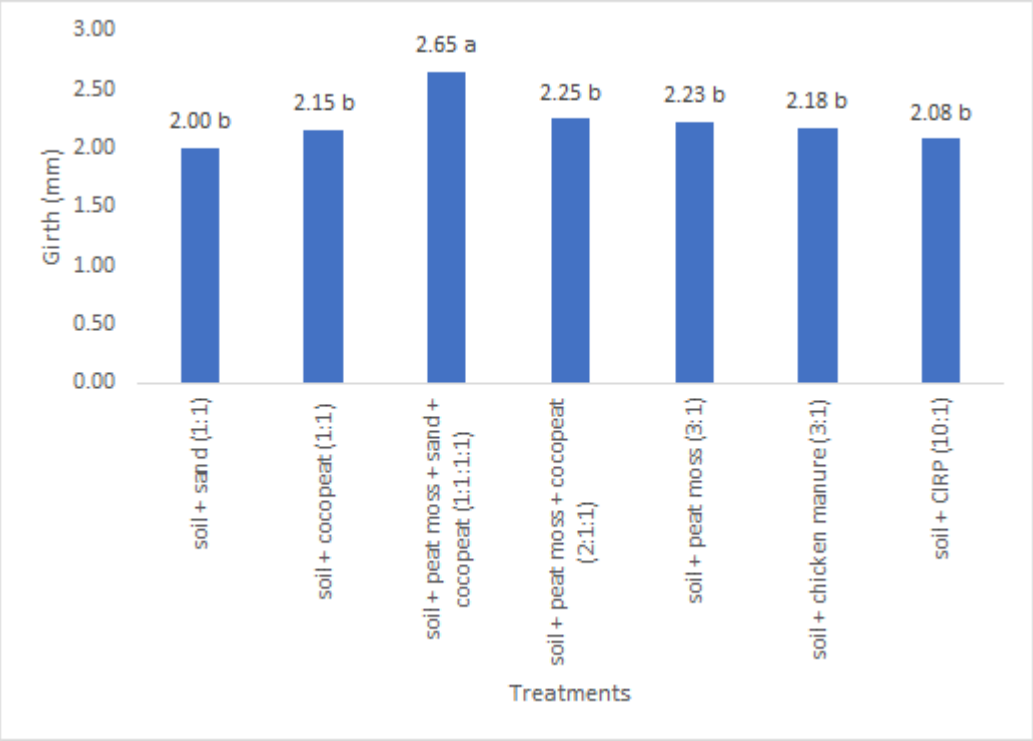

Fig. 1 *Effect of growing media on girth reading of Liberica coffee rootstock*

3.2 SPAD

Analysis suggests that T4 = soil + peat moss + cocopeat (2:1:1) recorded the highest significant reading which T1 was notably lowest which suggests the lack of N content within that media (Figure 2). The difference between T4 and T1 was 24.95%. Lee et al. (2019) and Jiang et al. (2017) have concluded that SPAD chlorophyll meter can be used in a rapid non-destructive reliable leaf N assessment in plants [16] [17]. Present study indicates that all combinations of soil with either cocopeat T2 or peat moss T5 exhibits statistical parity with T4 which has the highest girth reading. This may point out that the current protocol T1 may need improvement since it only comprises sand and soil (1:1).

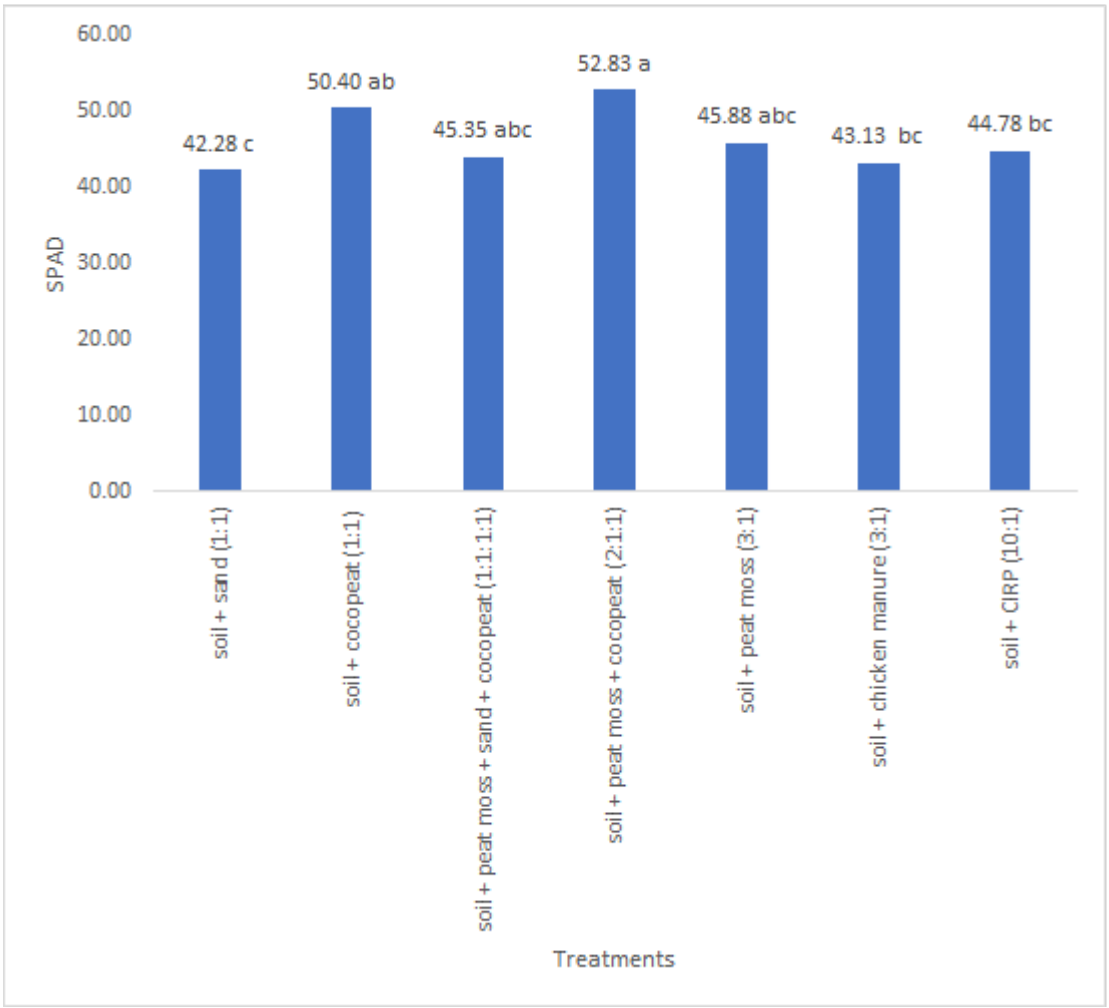

Fig. 2 *Relationship between treatments and SPAD*

3.3 Height and Leaf Number

Despite the difference in the observations, no significant impact was established for height and leaf number (Table 2). The highest observation for height was recorded under T3 while T5 was the lowest. According to Bertrand and Etienne (2001), Arabica coffee rootstock was significantly affected by interaction between scion and rootstock utilized [19]. Higher rootstock is more desirable since current protocol dictates that the specific region on rootstock to implement the grafting method should at least be 8-12 cm from rootstock soil surface [5]. Furthermore, they found out that higher height could have the potential to maintain stem vigor and the production cycle which desirable at field condition.

An approach to increase the rootstock's height of Liberica coffee is through the manipulation of fertilizer levels [20]. However, proper study needs to be carried out to determine the optimum nitrogen per polybag. Study by Madhavi et al. (2021) discovered that growing medium of Bio plus compost C:N ratio: 30:1 and Bio plus compost C:N ratio: 30:1 with Hoagland Solution contributed to higher height for strawberry both in vegetative and reproductive stage [21]. Their analysis suggests that bio plus compost could provide better nutrient retention and water holding capacity compared to soil (control). Growing media that lacks organic materials

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such as T1 could have the potential to negatively impact Liberica coffee rootstock height due to its lowest reading and this is not desirable at field stage.

For leaves number, both T1 = soil + sand (1:1) and T3 = soil + peat moss + sand + cocopeat (1:1:1:1) recorded the highest observation of leaves number while soil + peat moss recorded the lowest reading. Despite the difference in observation, no significant impact was established for leaves number. According Ogunrotimi and Kayode (2018), *Solanum macrocarpon* L. recorded highest leaf number under planting media topsoil and topsoil + river sand due to its properties to retain nutrients and it can be further improved with addition of organic manure [22].

Table 2 *Mean comparison of height and plant number*

Treatment	Height	Leaf number
soil + sand (1:1)	10.2 a	6.0a
soil + cocopeat (1:1)	12.2 a	5.5a
soil + peat moss + sand + cocopeat (1:1:1:1)	12.4a	6.0a
soil + peat moss + cocopeat (2:1:1)	13.3a	4.8a
soil + peat moss (3:1)	10.7a	3.8a
soil + chicken manure (3:1)	11.8a	5.0a
soil + CIRP (10:1)	12.6a	5.8a

3.4 Fresh Root Weight

The present study discovered that root fresh weight was under T3 = soil + peat moss + sand + cocopeat (1:1:1:1) and T7 = soil + CIRP (10:1) contributed to highest fresh root weight reading while T6 = soil + chicken manure (3:1) recorded lowest significant reading. The difference between T7 and T6 was 74.8% According to Bittenbender and Smith (2008), the most suitable media for growing coffee rootstock would be either soil or a mixture of vermiculite, perlite, and peat moss (1:1:1) [24]. Peat moss has texture and structure to provide space for roots to elongate and expand. Another study by Senthil et al. (2022) found out that use of cocopeat as a mixture of growing media for coffee rootstock contributed to higher root length [12]. Rock phosphate on the other hand contributed significant interaction with arbuscular mycorrhizal fungi which lead to improvement of Robusta coffee seedlings (Afrizal et al., 2023) and this may explain why T7 performed significantly well [25].

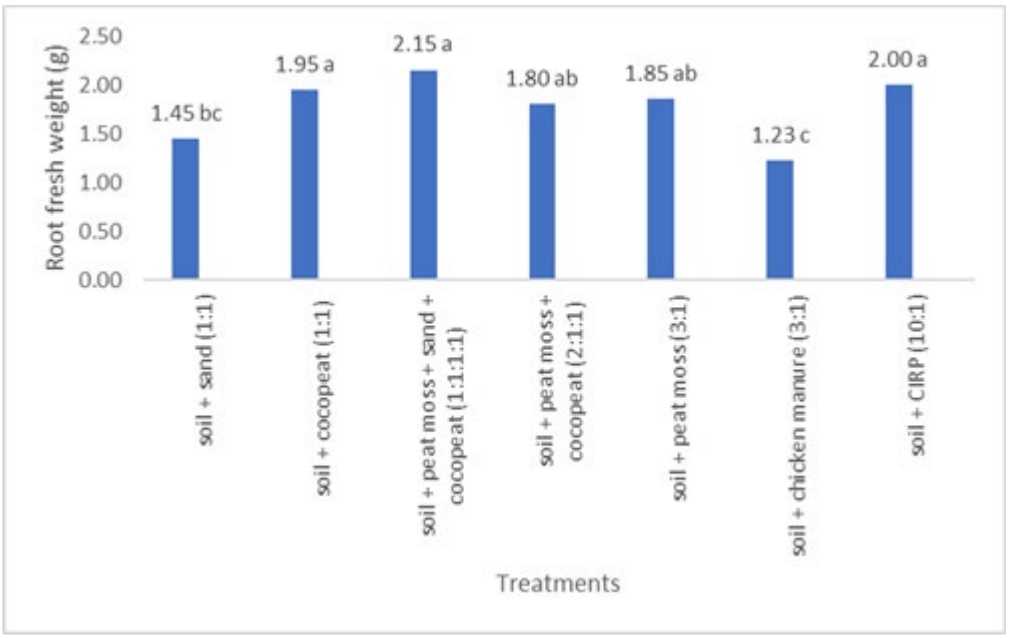

Fig. 3 *Relationship between treatments fresh root weight*

3.5 Dried Root Weight

Highest dried root weight was recorded under T7 = soil + CIRP 10:1 while T5 = soil + peat moss 3:1 was the lowest. Despite the differences in observations, no significant impact was established. T7 = soil + CIRP 10:1 for both fresh and dried root weight recorded highest reading. Study of different phosphate source on coffee tree formation suggest that organomineral phosphate contributed to higher root fresh weight reading compared to rock phosphate such as Christmas Island Rock Phosphate [29]. However, a similar insignificant impact on root

dry weight was observed. Nevertheless, aside from organic components such as peat moss and cocopeat, the role of phosphate in developing root of arabica coffee was instrumental as according to Melo et al. (2016) [27]. They pointed out that simple rock phosphate performed significantly better compared to magnesium – thermophosphate. Phosphate is indeed an essential nutrient in promoting root development in coffee seedlings.

Table 3 *Mean comparison of root dry weight*

Treatment	Root dry weight	
soil + sand (1:1)	0.43	a
soil + cocopeat (1:1)	0.50	a
soil + peat moss + sand + cocopeat (1:1:1:1)	0.45	a
soil + peat moss + cocopeat (2:1:1)	0.40	a
soil + peat moss (3:1)	0.38	a
soil + chicken manure (3:1)	0.40	a
soil + CIRP (10:1)	0.55	a

3.6 Correlation Analysis

Analysis suggests that SPAD, girth and root fresh weight were significantly affected by treatments and at the same time share significant positive association among each other (Table 4). This implies that if any of the positively correlated parameters were to be negatively impaired it could significantly impair the other in a negative manner. Therefore, steps should be taken to further develop these three parameters. Furthermore, even though minimum impact of treatments on height, this parameter shares a significant positive association with root fresh weight. In other words, height may have an impact on root fresh weight. According to correlation analysis, R2 value between height with root fresh weight is 0.46 and this implies any increment on root fresh weight could potentially increase height in positive manner. As mentioned earlier in Section 3.3, height can be further improved with manipulation of fertilizer rate. Fertilizer trial could be another way forward to improve Liberica coffee seedlings performance.

Table 4 *Correlation analysis among parameters*

	Height	**Leaves number**	**Stem girth**	**SPAD**	**Root fresh weight**	**Root dry weight**
Height	1	0.26 ns	0.50 **	0.41 **	0.46 **	0.54 **
Leaf number		1	0.16 ns	-0.25 ns	0.25 ns	0.50 **
Stem girth			1	0.07 ns	0.46 **	0.25 ns
SPAD				1	0.38 *	0.17 ns
Root fresh weight					1	0.60 **
Root dry weight						1

Note: mean followed by * indicates significant difference at 0.05
mean followed by ** indicates significant difference at 0.01

4. Conclusion

Three major parameters within this study which are root fresh weight, SPAD and stem girth were found to be vital as benchmark for coffee rootstock growth performance. These 3 parameters were responsive to treatments applied and are sensitive to one another. As a way forward studies need to be carried out to improve these parameters and protect it from plummeting either from pests and disease or environmental stress. Another aspect of this study is that it serves as reference for researchers who are trying to improve the coffee production in Malaysia. This result could also be implemented in the current protocol for rootstock preparations.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: Ahmad Arif Ismail and Muhammad Naim Fadzli, A.R;* ***data collection****: Ahmad Arif Ismail, Furzani Pa'ee;* ***analysis and interpretation****: Ahmad Arif Ismail and Azlan Azizi M.N.;* ***draft manuscript preparation****: Zafrul Arif Radhi and Khairol Ismail. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Lim, D (1980) Review of Coffee in West Malaysia, *Dept. of Agric. Bulletin, 152:62*
[2] Muhamad Ghawas M. & Wan Rubiah A. (1988) Variations in Fruit and Bean Characters in Seedling Progenies of Robusta and Liberica Types Coffee, *MARDI Research Journal, 16(2)*, 97-101
[3] MARDI (2007). Klon Kopi Baru (MKL 5, MKL 6 dan MKL 7). MARDI
[4] Kementerian Pertanian dan Keterjaminan Makanan. (2023, 29 August). *Majlis Pelancaran Klon dan Inovasi Kopi Liberica Baharu MARDI.* www.moa.gov.my/documents/20182/544835/18-min.pdf/e9d14205-8485-4036-af26-e9c35fb467e9
[5] Ghawas, M.M. (2005). Manual Penanaman Kopi Liberica Berhasil Tinggi. MARDI.
[6] Ulum, Y.B., Rahayu, A. and Mulyaningsih, Y. (2020) Effects of Various Planting Media on Growth Performance of Melon Plants Grafted with Squash Rootstock, *Journal of Innovative Sciences, 6(2)*, 206-213
[7] Ghawas, M.M. and Wan Rubiah, A. (1991) Yield Performance and Selection of Coffee Liberica Progenitors. *MARDI Research Journal, 19(2),*177-182
[8] Myers, R., Kawabata, A., Cho, A., Nakamoto, S. T., (2020) Grafted Coffee Increases Yield and Survivability, *Horttechnology 30(3),* 428 - 432
[9] Magesa, J.M., Msogya, T.J., Rewyemanu, C.L. (2018) Effects of Growing Media on Rooting of Stem Cuttings of Hybrid Coffee Varieties, *African Journal of Agricultural Research 13(2)*, 41-46
[10] Yau, P.Y. (1991). Pembiakan dan Amalan Semaian In Azmil, A.R. (Ed), *Laporan Khas Pengeluaran Kopi* (pp. 15-18). Malaysian Agricultural Research and Development Institute (MARDI).
[11] Yahya, A., Safie, H. and Kahar, S.A. (1997). Properties of Cocopeat-Based Growing Media and Their Effects on Two Annual Ornaments, *Journal of Tropical Agriculture and Food Science*, *25 (2)*, 151-157
[12] Senthil, R., R., Manonmani V., Renganayaki, P. Jeyakumar, P., Thangaselva, B and Ragupathi, K.P. (2022). Effect of Different Growing Media for Elite Seedlings Production in Arabica Coffee (*Coffea arabica* L.), *The Pharma Innovation Journal*, *11(1)*, 1502-1505
[13] Ghawas, M.M. (2006). Yield Performance and Selection of F_1 Hybrid Liberica Coffee, *Journal of Tropical Agriculture and Food Science*, *31(2)*, 165-170
[14] Ghawas, M.M. (1993) Kebun Benih dan Pengeluaran Biji Kopi Polihibrid, *Teknologi Pelbagai Tanaman MARDI*, *9*, 5-9
[15] Rusli, Heryana, N. dan Saefudin. (2014). Rootstock Growth and Green Budding Success of Rubber Plant in Different Sizes of Polybag and Growing Media, *Jurnal Tanaman Industri dan Penyegar*, *1(3)*, 141-148
[16] Lee, Y., Kweon, H.J., Park, M.Y. and Lee, D. (2019). Field Assessment of Macronutrients and Nitrogen in Apple Leaves Using a Chlorophyll Meter, *Horttechnology, 29(3)*, 300-307
[17] Jiang, C., Johkan, M., Hohjo,M., Tsukagoshi, S. and Maruo, T. (2017) A Correlation Analysis on Chlorophyll and SPAD Value in Tomato Leaves, *HortResearch, 71,* 37-42
[18] Ismail-Embong, N., Manan, N.A., Md Salleh, N.A., Pa'ee, F. (2021). The Effect of Different Growing Media on Growth Performance of *Clinacanthus nutans*, *IOP Conference Series: Earth and Environmental Science*, *736*, 012026
[19] Bertrand, B., Etienne, H. (2001). Growth, Production, and Bean Quality of *Coffea arabica* as Affected by Interspecific Grafting: Consequences for Rootstock Breeding, *Hortscience, 36(2)*, 269-273.
[20] Chemura, A. (2014). The Growth Response of Coffee (*Coffea arabica* L) Plants to Organic Manure, Inorganic Fertilizers and Irrigated Soil Fertility Management Under Different Irrigation Water Supply Levels, *International Journal of Recycling Organic Waste in Agriculture*, *3,* 59.
[21] Madhavi, B.G.K., Khan,F., Bhujel, A., Jaihuni, M., Kim, N.E., Moon, B.E. and Kim, H.T. (2021) Influence of Different Growing Media on the Growth and Development of Strawberry Plants, *Heliyon*, *7*, e07170
[22] Ogunrotimi, D.G., Kayode, J. (2018). Influence of Potting Media on Growth and Development of *Solanum macrocarpon* L. *World Scientific News*, *111*, 159-166
[23] Ala, A., Musa, Y. and Kadola, L. Effect of Compost Enrichment with *Trichoderma* sp. on the Growth of Arabica Coffee Seedlings, *IOP Conference Series: Earth and Environmental Science, 575,* 012145
[24] Bittenbender, H.C. and Smith, V.E. (2008). *Growing Coffee in Hawaii*. University of Hawaii.
[25] Afrizal, A., Sufardi, S., Syakar, S. (2023). Improving the Quality of Media and Robusta Coffee Seedlings with Mycorrhizal (AMF) and Rock Phosphate, *IOP Conference Series : Earth and Environmental Science, 1183,* 012028

[26] Mukharib, D.S., Rudragouda, Babou, C., Govindappa, R., Gokavi, N., Mote, K., Manjunath, A.N. and Raghuramalu (2018). Establishment of Coffee Seedlings as Influenced by Planting Pit Size and Rock Phosphate along with Plant Growth Promoting Rhizobacteria Inocualtions, *International Journal of Plant & Soil Sciences*, *21(3)*, 1-5
[27] Melo, B.D., Mendes, A.N.G., Guimaraes, P.T.G., Dias, F.P. (2016). Substrate Sources and Doses of P_2O_5 in Production of Coffee Seedlings, *Bioscience Journal, 19 (2)*, 35-44
[28] Vu, N.T., Park, J.M., Nguyen, N.Q., Son Nguyen, T.T., Kim, I.S. and Jang, D.C. (2021). Enhanced Drought Tolerance of Arabica Coffee (*Coffea arabica* L.) by Grafting Method, *Sains Malaysiana*, *50 (11)*, 3219-3229
[29] Amaral, G.S., Junior, K.S.F., Brigante, G.P. and Souza Dias, M. (2022), Different sources of phosphorus in coffee tree formation, *Brazilian Journal of Biosystems Engineering*, *16,* 1063