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Growth of PB 260 Clone (*Hevea brasiliensis* (Willd. ex A. Juss.) Muell-Arg.) in Different Potting Media and Fertilization Scheme

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ABSTRACT

Rubber is an important commodity for Indonesia. Currently, a problem encountered in the propagation of rubber planting materials is the availability of ideal soils with optimum nutrition as the planting medium. Peat can be used as a growing medium but it still has weaknesses such as high level of acidity and poor in nutrient content. This study was aimed to assess the performance of rubber budded stump grown on modified potting medium and applied with different forms and rates of fertilizers. The nursery experiment consisted of 17 treatments and arranged in a randomized complete block design. After rubber nursery stage, the performance of the rubber budded stump were also monitored in the field for 10 months. Results showed that mixture of peat and soil with the application of recommended rate of solid or liquid fertilizer produced rubber budded stump with bigger stem diameter and taller plants. The potting medium stimulated early root development which led to higher nutrient uptake. These budded stump also performed better in field, showed higher leaf nutrient concentration after 6 months and produced bigger stem diameter after 10 months.

Keywords: budded stump; inorganic and organic fertilizer; peat

INTRODUCTION

Natural rubber is a unique biopolymer that is important in the industrial sector, health care, and transportation. Most of the existing rubber plantations in Indonesia are managed by smallholders and productivity was recorded to be low (Setiawan & Andoko, 2005). Some efforts to improve smallholder's rubber production in Indonesia are made through renovation or expansion of new areas. Success key of these efforts came from the use of recommended rubber clones as the planting materials. Nowadays, the common rubber planting materials being used are budded stump and grafted seedlings in polybag.

Soil is one of the most important environmental factor in supporting growth and development of plants. At the present, the problem encountered in the preparation of rubber planting material is the limited availability of potting medium that can provide a suitable growing environment for root formation and early growth of the stump. The growing medium commonly used for rubber is top soil placed in a polybag. Several European countries have been using peat as a growing medium for breeding, especially for forest plants (Abdoellah, 1992).

Most of the rubber growing areas in South Sumatra are ultisols which are associated with low soil fertility. Rubber trees are now being planted in newly-converted fields, which are mostly histosols. In Indonesia, the area covered by peat soil or histosols is estimated to be 14,000,000 hectares of the total land area in Indonesia (Wahyunto, 2015) thus peat soils could be potentially useful as a potting medium for rubber. Another material that can be considered as a potting medium is compost from farm wastes of oil palm plantations. Compost is important to improve soil fertility properties in order to have a positive impact on the availability of nutrients in the soil. With the abundant source of raw materials, compost also have a great potential as a potting medium to improve the quality of rubber budded stump. Both peat and compost can be utilized as growing media for rubber in addition to the use of mineral soil.

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One of challenges about the supply of rubber planting material is the availability of potting medium which consists mostly of top soil. As the supply of good quality soil becomes gradually limited, it is vital to look for alternative growing medium that can support the growth of rubber budded stump. In South Sumatra, the use of peat soil and compost appear to be promising. The combination of various growing media is expected to give positive effects on plant growth. Further, to improve the growth of rubber stump, there is a need for an additional supply of plant nutrient through fertilization. Solid and liquid fertilizers can be applied at various rates to provide additional nutrients that will support the growth of the budded stump plant in the nursery and later in the field. This research was conducted to find out the fertilization scheme and potting media effect on the growth of rubber budded stump at nursery stage and assess performance of rubber budded stump grown on different potting media applied with different fertilizer material until 10 months after transplanting.

MATERIALS AND METHODS

This study was conducted at Sembawa Research Centre, Indonesian Rubber Research Institute in South Sumatra from July 2014 to August 2015.

Nursery Experiment

The nursery experiment consisted of 17 treatments involving different potting media which were arranged in a Randomized Complete Block Design. Treatments used in the nursery experiment are (T1) peat; (T2) soil; (T3) compost; (T4) peat+soil (1:1); (T5) compost+soil (1:1); (T6) peat+compost+soil (1:1:1); (T7) peat+soil+chicken manure (1:1:1); (T8) peat+soil+solid fertilizer rate 1; (T9) peat+soil+solid fertilizer rate 2; (T10) peat+soil+foliar fertilizer rate 1; (T11) peat+soil+foliar fertilizer rate 2; (T12) compost+soil+chicken manure (1:1:1); (T13) compost+soil+solid fertilizer rate 1; (T14) compost+soil+solid fertilizer rate 2; (T15) compost+soil+foliar fertilizer rate 1; (T16) compost+soil+foliar fertilizer rate 2; and (T17) normal practice (soil+soild fertilizer rate 1). Budded stump of PB 260 clone that has a high latex production (quick starter) characteristic was used. The different growing media were weighed in 25 x 40 cm polybags and planted with PB 260 budded stump. Solid fertilizer application was conducted once a month while foliar application was conducted once every 2 weeks based on the recommended level of fertilizer. Budded stumps were grown for 3 months or until the appearance of first whorl. Compost was made from the empty fruit bunches of palm oil and palm oil mill effluent with rapid composting technology (fast composting) under aerobic conditions at pH of 6.5-8.5. The peat used in this experiment was classified as sapric material which was obtained from Sungei Rengit district, South Sumatra, Indonesia.

Two rates of solid fertilizers were applied in this experiment. Rate 1 was the recommended rate of Urea (100 %) and rate 2 was 150 % of the urea recommended rate. Recommended fertilizer rate is urea (5 g per polybag), phosphate (6 g per polybag), kieserite (2 g per polybag) and MOP (2 g per polybag). Two rates of foliar fertilizer were also applied. Rate 1 (100 %) was the recommended rate of Bayfolan® and rate 2 was 150 % of the recommended rate. The recommended dosage of Bayfolan was 2 mL L^{-1}. Budded stump from three replications were harvested after three months for soil and tissue analysis. The remaining three budded stumps (from 3 replicates) were transplanted in the field. Various parameters that were determined for the potting medium namely pH, organic C, cation exchange capacity, total N, available P and exchangeable bases (K, Ca, Mg). Agronomic parameters such as stem diameter, plant height, and shoot and root dry weight were also determined. Nutrient uptake was determined after harvest.

Field Experiment

Based on soil profile characterization, the soil in field experiment was classified as Typic Tropoudults. Three budded stumps from the nursery experiment were planted in the field to determine if the composition of the growing media and fertilization scheme would affect the performance of PB 260 clone in the first ten (10) months of their growth in the field. Rubber plants were planted using 6 x 3 m spacing with three replications. Fertilizer application was conducted every 3 months with dosage i.e. urea (250 g t^{-1} per year), phosphate (150 g t^{-1} per year), MOP (100 g t^{-1} per year) and Kieserite (50 g t^{-1} per year). Agronomic parameters such as plant height and stem diameter were measured every month from 1 to 10 months after planted. Girth measurement was conducted at 1 meter above union. On the sixth month, leaf samples were collected and analyzed in laboratory to determine their nutrient concentrations such as nitrogen, phosphorus and potassium. Nitrogen was analyzed using Kjedhal distillation. Phosphorus was determined on the Spectrophotometry UV Visible Pharo 300 and potassium was detected using the Atomic Absorption Spectrophotometry Varian Spectra 55B.

Statistical Analysis

Experimental data were analyzed using SAS (version 9.0) and mean comparisons were performed using Tukey's Significant Difference Test at 95 % confidence interval.

RESULTS AND DISCUSSION

Nursery Experiment

The initial chemical characteristics of various potting mixtures presented in Table 1. pH of compost was strongly alkaline, while peat, soil, and mixture of peat and soil were strongly acidic. Cation exchange capacity (CEC) showed that peat has high CEC because largely pH dependent negative charge contributed by carboxyl with phenolic hydroxyl groups in lignin (Driessen & Soepraptohardjo, 1974). The highest organic matter (OM) content was obtained in peat treatment. The highest total N content was noted in compost+soil+chicken manure due to compost and chicken manure provided additional N. Organic fertilizer can be a source of nutrient for plant (Campiglia, Mancinelli, & Radicetti, 2011). Furthermore, Combination of chemical fertilizer with organic manure increased soil organic carbon on boro rice variety as much as 0.71 % (Saha et al., 2007). This is consistent with the findings of Sholikah, Suyono, & Wikandari (2013) that eggplant grown in a mixture of chicken manure had higher N content compared to other organic fertilizers. The highest available P content was noted in compost+soil treatment with 297.49 ppm and the lowest was soil (43.21 ppm). Soil used in this experiment was an Ultisol characterized by high soil acidity with a pH < 5, low SOM, N, P, K Ca and Mg and less than 24 cmol$_c$ kg^{-1} CEC (Hardjowigeno, 2003). Exchangeable cations concentration levels in all potting media were generally low.

The effect of potting media and fertilization scheme on growth parameters of PB 260 rubber clone at 12 weeks after planting (WAP) is presented in Table 2. Plant height was significantly affected by the composition of the potting media and fertilization scheme. Among the potting media, peat+soil had the highest plant height (33 cm) while compost had the lowest plant height (18.5 cm). Use of peat, soil, peat+soil and peat+compost+soil resulted in relatively higher plant height than the normal practice. This indicated that peat combination with soil can give metabolism support in nutrient supply to plant. Among the potting media used in the study, peat had the highest CEC and OM content. Available P was also high despite the low pH. The high level of available P in peat could have stimulated early root development of rubber stump. Combining peat with soil appear to have improved its physical characteristics and made it more favorable for the growth of rubber stump at an early stage. Treatment of peat and compost without soil combination still resulted in positive trend in plant height. When relay on soil chemical analysis, increasing plant height in this treatment due to higher organic matter content and P level. Cleveland, Reed, & Townsend (2006) stated that organic matter may influence of P availability in tropical rain forest soil due to leached of dissolved organic matter that enters the soil.

Table 1. Initial chemical properties of the different potting media.

Treatments	pH	CEC (cmol$_c$ kg^{-1})	OM (%)	N (%)	Available P(ppm)	Exchangeable cation (cmol$_c$ kg^{-1})		
						K	Ca	Mg
Peat	4.62	28.94	18.95	0.51	295.23	0.07	0.25	0.08
Soil	5.03	9.86	5.21	0.19	43.21	0.03	0.12	0.02
Compost	7.80	17.92	18.00	1.32	249.31	2.38	2.72	1.18
Peat + Soil	4.74	18.56	16.95	0.37	178.02	0.03	0.07	0.03
Compost + Soil	7.28	18.89	16.06	0.98	297.49	2.13	1.77	0.92
Peat + Compost + Soil	6.36	21.18	17.63	0.77	287.07	1.72	1.30	0.75
Peat + Soil + Chicken Manure	7.25	20.29	18.16	1.23	239.51	2.19	4.86	1.19
Compost + Soil + Chicken Manure	7.55	19.62	14.17	1.54	268.87	2.26	3.34	1.23

Table 2. Plant height, stem diameter, root and shoot weight of PB 260 clone after 12 weeks as influenced by potting media and fertilization scheme

Treatments	Plant height (cm)	Stem diameter (mm)	Dry matter yield	
			Root (g)	Shoot (g)
Peat	33.33[bcd]	6.70[abcdef]	2.46[ab]	7.78[ab]
Soil	28.50[bcde]	6.24[abcdef]	1.73[abcd]	6.52[bcd]
Compost	22.00[cde]	5.17[f]	0.85[cde]	2.53[fg]
Peat + Soil	35.67[ab]	7.05[abcd]	2.06[abc]	5.74[bcde]
Compost + Soil	23.00[cde]	6.95[abcde]	0.53[de]	4.57[cdef]
Peat + Compost+ Soil	28.33[bcde]	5.92[bcdef]	1.15[bcde]	4.18[defg]
Peat + Soil + Chicken Manure	20.33[e]	5.71[cdef]	0.40[de]	2.56[fg]
Peat + Soil + Solid Fertilizer Rate 1	39.33[a]	7.32[abc]	2.63[a]	7.00[abc]
Peat + Soil + Solid Fertilizer Rate 2	32.17[abc]	7.48[ab]	0.92[cde]	5.69[bcde]
Peat + Soil + Foliar Fertilizer Rate 1	33.33[ab]	7.71[a]	2.90[a]	9.35[a]
Peat + Soil + Foliar Fertilizer Rate 2	29.67[bcde]	6.14[abcdef]	1.03[cde]	5.64[bcde]
Compost + Soil + Chicken Manure	27.00[cde]	5.67[def]	0.31[de]	3.73[efg]
Compost + Soil + Solid Fertilizer Rate 1	28.00[bcde]	5.25[ef]	0.99[cde]	3.84[efg]
Compost + Soil + Solid Fertilizer Rate 2	25.00[cde]	5.75[cdef]	0.18e	1.49[g]
Compost + Soil + Foliar Fertilizer Rate 1	22.33[cde]	6.16[abcdef]	0.76[cde]	3.31[efg]
Compost + Soil + Foliar Fertilizer Rate 2	26.00[de]	6.08[abcdef]	0.72[cde]	3.07[efg]
Normal Practice(Soil + Solid Fertilizer Rate 1)	26.33[bcde]	5.37[def]	0.65[cde]	2.80[fg]

Remarks: Values followed by the same letter in the column are not significantly different at 5 %

Stem diameter also markedly varied between potting media, type and rate of fertilization. Combination of peat+soil resulted in bigger stem diameter (7.05 mm) followed by compost+soil (6.95 mm), peat (6.70 mm) and soil (6.24 mm). Use of compost resulted in significantly smaller stem diameter (5.17 mm). In peat+soil mixtures, application of recommended rate of foliar fertilizer resulted in bigger stem diameter (7.71 mm) followed by the application of solid fertilizer rate 2 (7.48 mm), solid fertilizer rate 1 (7.32 mm), and foliar fertilizer rate 2 (6.14 mm). Application of chicken manure resulted a significantly smaller stem diameter (5.71 mm). Foliar fertilizer is one economical way of providing nutrients to the plants (Girma et al., 2007; Fageria, Filho, Moreira, & Guimaraes, 2009). Although the compost used in this study contained high amount of nutrients, it was better to mix it with soil rather than just compost alone as a potting medium. Peat+soil treatment resulted in higher stem girth and plant height with plant height result. This condition related to the availability of nutrient in this combination can support plant growth even without fertilizer application. Compared to normal practice, stem girth was improved by all the treatments except by the use of compost and compost+soil+solid fertilizer rate 1. Factors affecting the girth development of the plant are the availability of water and light as well as optimum air temperature and humidity. If these factors are favorable, growth of plants through division and cell elongation are being stimulated. Furthermore, even other planting media combination did not give higher stem girth, soil chemical analysis showed that there was an improvement in term of nutrient content which can improve stem girth. Compost treatment applied alone resulted in the lowest stem girth growth because pH in pure compost was slightly alkaline. Decreasing soil pH draws in many positive effects for plant growth such as increasing plant nutrient availability and negative charges on colloid surfaces caused by the pH dependent charges. Presence of negative charges in the soil enabled the soil to store nutrients, specifically the positively charged ions (Cosico, 2005). The cations were adsorbed and kept from being washed away by water passing through the soil column. If the cations are not adsorbed, soils will not be able to maintain their fertility level because the constant passage of water depleted the soil of its nutrients.

The effect of potting media and fertilization scheme on root and shoot weight is shown in Table 2. Higher root dry weights were obtained in peat+soil mixtures applied with recommended rate of foliar fertilizer (2.90 g) and recommended rate of solid fertilizer (2.63 g) which were comparable with root weights obtained in peat (2.46 g), peat+soil (2.06 g) and soil (1.73 g). Lowest root weight was noted in compost+soil+solid fertilizer rate 2 (0.18 g). Only the use of compost+soil (0.53 g), compost+soil+chicken manure (0.31 g) and compost+soil+solid fertilizer rate 2 (0.18 g) resulted in lower root weight than normal practice (0.65 g). Christensen & Jackson (1981) reported that nutrient uptake by roots, leaves and total top of corn increased as concentration of nutrient in soil solution increased. It is believed that using fertilizer as addition nutrient for plant could make metabolism of plant growth more effective. Chicken manure application of 3.125 t ha^{-1} gave significantly higher fresh root yield of cassava compare to the control (Chaisri et al., 2013).

Similar trend was observed with shoot weight. Higher shoot dry weights were obtained in peat+soil+recommended rate of foliar fertilizer (9.35 g), peat (7.78 g) and peat+soil+recommended rate of solid fertilizer (7.00 g). The lowest shoot weight was noted in compost+soil+solid fertilizer rate 2 (1.49 g). Only the use of compost (2.53 g), peat+soil+chicken manure (2.56 g) and compost+soil+solid fertilizer rate 2 (1.49 g) resulted in lower shoot weights compared to the normal practice (2.80 g). Nutrient availability during the growing period of plants generally affects plant growth. By providing additional nutrient requirements, the nutrient contents of the different potting media particularly peat+soil was improved. Root biomass determined the capacity of the crop to protect itself from water and nutrient stress and soil-borne pathogens that caused diseases and infections (Farhad, Saleem, Cheema, & Hammad, 2009).

As shown in Table 3, N root uptake reaches the highest in peat+soil+foliar fertilizer rate 1 (80.11 mg pot^{-1}), while the lowest was noted in peat+compost+soil (6.97 mg pot^{-1}). Comparing the different potting media, higher N uptake was obtained in peat (55.45 mg pot^{-1}), soil (49.20 mg pot^{-1}) and peat+soil (41.12 mg pot^{-1}). Njogu, Kariuki, Kamau, & Wachira (2014) stated that by applying the fertilizer through the leaves has significant possitive effect on the overall quality tea experiment. For micro-nutrients, foliar fertilization is also more efficient and practical. Furthermore, nutrient availability during the growing period of plants generally affects plant growth. By providing the additional nutrient, the soil nutrient contents were increased. Peat treatment when relay on N nutrient concentration of shoot and root was quite high due to higher in organic matter. Addition of organic matter increased soil pH and might have accelerated the N mineralization which then promoted the uptake of nitrogen. In addition, improved Nitrogen uptake may also be attributed to enhance Nitrogen fixation (Ranjit, Dasog, & Patil, 2007). Furthermore, organic fertilizer application in Nigeria with rate 5 t ha^{-1} increased in maize and cowpea grain yields (Adediran, Taiwo, Akande, Sobulo, & Idowu, 2005).

No significant difference was observed on P uptake in root (Table 3). However, the highest P uptake was observed in peat+soil+solid fertilizer rate 1 (8.44 mg pot^{-1}) and the lowest P uptake was showed in normal practice (0.91 mg pot^{-1}). Highest K root uptake was noted in peat+soil+foliar fertilizer rate 1 (69.81 mg pot^{-1}) and lowest in compost+soil+solid fertilizer rate 2 (4.11 mg pot^{-1}). Application of fertilizer did not give significant effects on root uptake in peat+soil potting mixtures while application of foliar fertilizers improved K uptake in compost+soil potting mixtures. Root nutrient uptake was positively correlated with the amount of roots present in the planting medium. Based on Armstrong, Griffin, & Danner (1999) research nitrogen and phosphorus were both involved in vital functions for plant growth metabolism. On the other hand, Phosphorus and Potassium are both essential for stress tolerance and photosynthesis.

Furthermore, N uptake in shoot was the highest in peat+soil+foliar fertilizer rate 1 (312.07 mg pot^{-1}) and the lowest in compost+soil+solid fertilizer rate 2 (41.40 mg pot^{-1}). Application of recommended rate of foliar fertilizer significantly increased N uptake in peat+soil mixtures. Application of chicken manure and recommended rate of solid and foliar fertilizers improved N uptake in compost+soil potting mixtures. Highest P uptake was also noted in peat+soil+foliar fertilizer rate 1 (29.28 mg pot^{-1}), although not it was significantly different with peat alone (28.93 mg pot^{-1}) and peat+soil+solid fertilizer rate 1 (18.27 mg pot^{-1}). The lowest P uptake was obtained in compost+soil+solid fertilizer rate 2 treatment with 5.62 mg pot^{-1}. Highest K uptake was also found in peat+soil+foliar fertilizer rate 1 treatment with 232.11 mg pot^{-1} and the lowest was noted in compost+soil+solid fertilizer rate 2 with 45.51 mg pot^{-1}. Foliar fertilizer rate 1 gave faster impact on plant growth due to the nutrient that was quickly absorbed by the plant thus provided greater root and shoot dry weight than solid fertilizer. The effectiveness of foliar fertilizer directly improved in photosynthetic metabolism and resulted in higher root and shoot dry weight.

Table 3. Nutrient uptake in PB 260 clone root and shoot at 12 WAP as influenced by different potting media and fertilization scheme

Treatments	Root			Shoot		
	N (mg pot^{-1})	P (mg pot^{-1})	K (mg pot^{-1})	N (mg pot^{-1})	P (mg pot^{-1})	K (mg pot^{-1})
Peat	55.45^{ab}	5.89	87.00^{a}	237.85^{bc}	28.93^{ab}	117.19^{bc}
Soil	49.20^{abc}	5.60	42.04^{abcd}	192.80^{bcde}	19.23^{bc}	145.81^{abc}
Compost	18.24^{bcd}	4.79	34.58^{bcd}	76.44^{de}	8.06^{c}	60.47^{c}
Peat + Soil	41.12^{bcd}	5.69	68.78^{ab}	195.53^{bcd}	13.45^{bc}	114.72^{bc}
Compost + Soil	7.71^{cd}	2.21	21.86^{bcd}	64.09^{de}	9.73^{bc}	127.48^{bc}
Peat + Compost+ Soil	6.97^{d}	3.93	20.37^{bcd}	115.51^{cde}	15.05^{bc}	87.65^{bc}
Peat + Soil + Chicken Manure	12.67^{cd}	3.02	11.42^{cd}	69.79^{de}	9.35^{bc}	53.37^{c}
Peat + Soil + Solid Fertilizer Rate 1	58.90^{ab}	8.44	54.32^{abc}	178.79^{b}	18.27^{abc}	188.11^{ab}
Peat + Soil + Solid Fertilizer Rate 2	37.31^{bcd}	2.28	17.59^{cd}	193.70^{bcd}	16.23^{bc}	93.96^{bc}
Peat + Soil + Foliar Fertilizer Rate 1	80.11^{a}	4.62	69.81^{ab}	312.07^{a}	29.28^{a}	232.11^{a}
Peat + Soil + Foliar Fertilizer Rate 2	38.96^{bcd}	1.77	34.22^{bcd}	176.07^{bcde}	12.56^{bc}	99.56^{bc}
Compost + Soil + Chicken Manure	10.62^{cd}	3.52	12.00^{cd}	138.53^{bcde}	14.47^{bc}	77.04^{c}
Compost + Soil + Solid Fertilizer Rate 1	10.27^{cd}	3.15	12.40^{cd}	114.99^{cde}	12.09^{bc}	110.26^{bc}
Compost + Soil + Solid Fertilizer Rate 2	7.66^{cd}	1.28	4.11^{d}	41.40^{e}	5.62^{c}	45.51^{c}
Compost + Soil + Foliar Fertilizer Rate 1	23.33^{bcd}	2.54	37.16^{bcd}	94.92^{cde}	9.10^{bc}	83.28^{bc}
Compost + Soil + Foliar Fertilizer Rate 2	8.49^{cd}	2.66	30.88^{bcd}	67.53^{de}	8.49^{bc}	74.60^{c}
Normal Practice (Soil + Solid Fertilizer Rate 1)	20.30^{bcd}	0.91	12.61^{cd}	92.34^{cde}	7.66^{c}	57.67^{c}

Remarks: Values followed by the same letter in the column are not significantly different at 5 %

Table 4. Soil profile description of the experimental area.

Horizon	Depth (cm)	Description
Ap1	0-9	Dark brown (7.5 YR 3/4) moist, clay loam; weak medium sub-angular blocky structure; many very fine pores, few fine pores; many very fine roots, few fine roots; clear smooth boundary; pH 4.3.
Ap2	9-29	Strong brown (7.5 YR 5/8) moist, clay; weak coarse sub-angular blocky structure; very few fine pores; very few fine roots; clear smooth boundary; pH 4.3.
Bt1	29-54	Strong brown (7.5 YR 5/8) moist, clay; moderate medium sub-angular blocky structure; no pores; no roots; clear smooth boundary; pH 5.0.
Bt2	54-73	Yellowish red (5 YR 5/8) moist, clay; prismatic breaking into weak fine sub-angular blocky structure; no pores; no roots; clear smooth boundary; pH 5.0.
BC	73-91	Yellowish red (5 YR 5/8) moist, clay; moderate prismatic structure; no pores; no roots; clear smooth boundary; pH 5.0;
C	91 below	Reddish yellow (5 YR 6/8) moist, clay; massive; no pores; no roots; pH 4.9.

Table 5. Leaf nutrient concentration of PB 260 clone 6 months after transplanting as affected by the different potting media and fertilization scheme

Treatments	Leaf nutrient concentration (%)		
	N	P	K
Peat	2.28 a	0.18 a	1.01 a
Soil	2.04 a	0.21 a	1.11 a
Compost	2.14 a	0.18 a	1.16 a
Peat + Soil	2.73 a	0.19 a	1.04 a
Compost + Soil	2.66 a	0.19 a	1.09 a
Peat + Compost+ Soil	3.18 a	0.18 a	1.36 a
Peat + Soil + Chicken Manure	2.65 a	0.20 a	0.99 a
Peat + Soil + Solid Fertilizer Rate 1	2.88 a	0.19 a	1.15 a
Peat + Soil + Solid Fertilizer Rate 2	3.20 a	0.19 a	0.99 a
Peat + Soil + Foliar Fertilizer Rate 1	3.00 a	0.19 a	1.07 a
Peat + Soil + Foliar Fertilizer Rate 2	3.35 a	0.19 a	1.11 a
Compost + Soil + Chicken Manure	2.74 a	0.16 a	1.06 a
Compost + Soil + Solid Fertilizer Rate 1	2.55 a	0.19 a	1.60 a
Compost + Soil + Solid Fertilizer Rate 2	2.85 a	0.18 a	1.09 a
Compost + Soil + Foliar Fertilizer Rate 1	2.92 a	0.18 a	1.18 a
Compost + Soil + Foliar Fertilizer Rate 2	3.04 a	0.17 a	1.26 a
Normal Practice (Soil + Solid Fertilizer Rate 1)	2.65 a	0.18 a	1.23 a

Remarks: Values followed by the same letter in the column are not significantly different at 5 %

Field Experiment (Site Characterization)

The experimental area was subjected to soil profile evaluation to determine the capability of the soil to sustain rubber growth. Soil in the experimental area belongs to the order of Ultisol which covers the widest part of the dry land in Indonesia (about 25 % of the total Indonesian land area). Based on soil profile characterization, the soil is classified as Typic Tropoudults (Table 4). Based on the presence of roots, effective rooting depth is only down to 29 cm. Subsoil yellowish red color is an indicator of low fertility level of the soil. Ultisols are characterized with low organic matter, low base saturation, high Al content, low productivity levels and has clay to sandy clay texture. It has also acidic pH and bulk density of 1.3 to 1.5 g cm^{-3} (Hardjowigeno, 2003).

There was no significant difference observed in leaf nutrient concentrations of rubber 6 months after transplanting but relatively higher leaf N concentrations were noted with the application of higher rate of solid and foliar fertilizer in the nursery stage (Table 5). Higher leaf N content was noted in peat+soil+foliar fertilizer rate 2 (3.35 %), peat+soil+solid fertilizer rate 2 (3.20 %) and compost+soil+foliar fertilizer rate 2

(3.04 %). Lower leaf N concentration was recorded in soil alone (2.04 %). The highest P content was found in treatment with soil alone (0.21 %) and the lowest was recorded in compost+soil+chicken manure (0.16 %). For K content, the highest was noted in peat+compost+soil (1.36 %) and lowest in peat+soil+chicken manure (0.99 %). According to Suwandi (2009), additional macro nutrients could cause more rapid development of leaf surface and also played a role in supporting the growth of leaf.

There is a significant difference in plant height 6 months after transplanting (Table 6). The highest was obtained in peat+soil+solid fertilizer rate 1, but the value was comparable with the other peat+soil treatment combinations. Compost+soil applied with inorganic fertilizers (solid and foliar) and the potting medium (soil, peat, compost) alone and their combinations were comparable with the normal practice. It was in line with Harjadi (1979) research that inorganic fertilizers are materials that can provide nutrients to the plants. Individual peat, soil and compost treatment did not give a significant effect but tended toincrease stem girth due to root growth of rubber in 10 months and search nutrient from surrounding planting area due to the spreading root adsorb more nutrient for photosynthetic metabolism.

Significant differences were observed in stem diameter of rubber after 10 months (Table 7). The highest stem diameter was obtained in treatments peat+soil combined with inorganic fertilizers (solid and foliar). Compost+soil treatment combined with foliar fertilizer rate 2 showed the lowest value for stem diameter. This can be related to nutrient contents of peat+soil in nursery experiment has higher in CEC compared to others. CEC will make nutrient in field become more available for plant growth. Higher CEC's of planting media indicated a high plant nutrient storage capacity. While relay in leaf nutrient concentration on 6 months shows peat+soil+foliar fertilizer is higher in N leaf nutrient content. Nitrogen has an important function in photosynthetic and cell growth. Landon (1991) stated that the Nitrogen compounds arranged 40 % to 50 % of the dry matter of protoplasm. Appreciable and normal growth was impossible unless an adequate supply of this element is provided to plants.

Table 6. Initial plant height of PB 260 clone and 6 months after transplanting as influenced by different nursery practices

Treatments	Initial plant height (cm)	Plant height at 6 months (cm)	Increase in plant height (cm)
Peat	35.83[abcde]	169.72[ab]	133.89
Soil	32.22[bcdef]	175.78[ab]	143.56
Compost	20.00[cdefgh]	131.50[abc]	111.50
Peat + Soil	34.22[abcdef]	170.56[ab]	136.34
Compost + Soil	17.06[cdefgh]	129.56[abc]	112.50
Peat + Compost+ Soil	21.83[fgh]	130.83[abc]	109.00
Peat + Soil + Chicken Manure	29.50[bcdefgh]	163.17[abc]	133.67
Peat + Soil + Solid Fertilizer Rate 1	51.20[a]	191.70[a]	140.50
Peat + Soil + Solid Fertilizer Rate 2	38.00[abc]	168.33[ab]	130.33
Peat + Soil + Foliar Fertilizer Rate 1	41.78[ab]	183.33[a]	141.55
Peat + Soil + Foliar Fertilizer Rate 2	34.33[abcdef]	183.78[a]	149.45
Compost + Soil + Chicken Manure	17.50[efgh]	130.50[abc]	113.00
Compost + Soil + Solid Fertilizer Rate 1	24.50[bcdefgh]	110.00[bc]	85.50
Compost + Soil + Solid Fertilizer Rate 2	13.25[gh]	125.00[abc]	111.75
Compost + Soil + Foliar Fertilizer Rate 1	15.69[h]	124.33[abc]	108.64
Compost + Soil + Foliar Fertilizer Rate 2	18.83[defgh]	100.00[c]	81.17
Normal Practice (Soil + Solid Fertilizer Rate 1)	36.89[abcd]	171.11[ab]	134.22

Remarks: Values followed by the same letter in the column are not significantly different at 5 %

Table 7. Initial stem diameter and stem diameter of PB 260 clone and 10 months after transplanting as influenced by different nursery practices

Treatments	Initial stem diameter (mm)	Stem diameter on 10 months (mm)	Increase in stem diameter (mm)
Peat	8.38[ab]	24.67[a]	16.29
Soil	7.66[abc]	23.21[ab]	15.55
Compost	7.04[abc]	20.19[ab]	13.15
Peat + Soil	8.07[ab]	23.41[a]	15.34
Compost + Soil	5.88[bc]	19.13[ab]	13.25
Peat + Compost+ Soil	6.86[abc]	19.73[ab]	12.87
Peat + Soil + Chicken Manure	8.36[ab]	22.94[ab]	14.58
Peat + Soil + Inorganic Fertilizer Rate 1	9.33[a]	25.62[a]	16.29
Peat + Soil + Inorganic Fertilizer Rate 2	6.84[abc]	24.96[a]	18.12
Peat + Soil + Foliar Fertilizer Rate 1	8.13[ab]	24.81[a]	16.68
Peat + Soil + Foliar Fertilizer Rate 2	7.63[abc]	23.24[ab]	15.61
Compost + Soil + Chicken Manure	5.39[c]	20.78[ab]	15.39
Compost + Soil + Inorganic Fertilizer Rate 1	7.77[abc]	22.22[ab]	14.45
Compost + Soil + Inorganic Fertilizer Rate 2	6.17[bc]	25.32[a]	19.15
Compost + Soil + Foliar Fertilizer Rate 1	5.80[bc]	18.62[ab]	12.82
Compost + Soil + Foliar Fertilizer Rate 2	6.13[bc]	17.92[b]	11.79
Normal Practice (Soil + Solid Fertilizer Rate 1)	6.69[bc]	23.70[a]	17.01

Remarks: Values followed by the same letter in the column are not significantly different at 5 %

CONCLUSION

The best planting medium in nursery would be the combination of peat and soil with additional nutrients from inorganic foliar fertilizer. Application of recommended rate (rate 1) of solid or foliar fertilizer gave a better effect than rate 2. There was no significant benefit from increasing rate of inorganic fertilizer application. Peat could be a good component of a potting medium for rubber. Field experiment showed that growing rubber stump of PB260 clone in peat+soil potting mixture combined with recommended rate of inorganic foliar fertilizer resulteda better performance in the field.

REFERENCES

Abdoellah, S. (1992). Pertumbuhan bibit kakao pada medium gambut dengan berbagai kondisi lengas dan pengapuran [The growth of cocoa seedlings in peat medium with various moisture conditions and liming]. *Pelita Perkebunan, 8*(1), 6-11.

Adediran, J. A., Taiwo, L. B., Akande, M. O., Sobulo, R. A., & Idowu, O. J. (2005). Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria. *Journal of Plant Nutrition*, *27*(7), 1163–1181. http://doi.org/10.1081/PLN-12 0038542

Armstrong, D. L., Griffin, K. P., & Danner, M. (Eds.). (1999). Phosphorus for agriculture. *Better Crops with Plant Food, 83*(1), 3-40. Retrieved from http://www.ipni.net/publication/bettercrops.nsf/0/8E2921B2D5FB31B085257980007CD130/$FILE/Better%20Crops%201999-1%20(lo%20res).pdf

Campiglia, E., Mancinelli, R., & Radicetti, E. (2011). Influence of no-tillage and organic mulching on tomato (*Solanum Lycopersicum* L.) production and nitrogen use in the mediterranean environment of central Italy. *Scientia Horticulturae*, *130*(3), 588–598. http://doi.org/10.1016/j.scienta.2011.08.012

Chaisri, S., Panitnok, K., Sarobol, E., Thongpae, S., Chaisri, P., Ngamprasitthi, S., Boonsri, N. (2013). Effects of chicken manure and chemical fertilizer management on yield of cassava grown on map bon, coarse-loamy variant soil. *Communications in Soil Science and Plant Analysis, 44*(1-4), 347-355. http://doi.org/10.1080/00103624.2013.742004

Christensen, N. W., & Jackson, T. L. (1981). Potential for phosphorus toxicity in zinc-stressed corn and potato. *Soil Science Society of America Journal, 45*(5), 904-909. http://doi.org/10.2136/sssaj 1981.0361599 5004500050017x

Cleveland, C. C., Reed, S. C., & Townsend, A. R. (2006). Nutrient regulation of organic mater decomposition in a tropical rain forest. *Ecology, 87*(2), 492-503. http://doi.org/10.1890/05-0525

Cosico, W. C. (2005). *Primer on Soil Science*. Laguna, PH: University of the Philippines Los Baños College.

Driessen, P. M., & Soepraptohardjo. (1974). Organic soils. In Soils for agricultural expansion in Indonesia. *Soil Research Bulletin, 1*, 8-13. Bogor, ID: Soil Research Institute.

Fageria, N. K., Filho, M. P. B., Moreira, A., & Guimarães, C. M. (2009). Foliar fertilization of crop plants. *Journal of Plant Nutrition*, *32*(6), 1044–1064. http://doi.org/ 10.1080/01904160902872826

Farhad, W., Saleem, M. F., Cheema, M. A., & Hammad, H. M. (2009). Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). *The Journal of Animal and Plant Sciences, 19*(3), 122–125. Retrieved from http://www.thejaps.org.pk/docs/19-no-3-2009/09-961.pdf

Girma, K., Martin, K. L., Freeman, K. W., Mosali, J., Teal, R. K., Raun, W. R., and Arnall, D. B. (2007). Determination of optimum rate and growth stage for foliar applied phosphorus in corn. *Communications in Soil Science and Plant Analysis*, *38*(9–10), 1137–1154. http://doi.org/10.1080/00103620701328016

Hardjowigeno, S. (2003). Ilmu tanah. [Soil science]. Jakarta, ID: Akademika Pressindo.

Harjadi, S. S. (1979). *Pengantar agronomi* [Introduction of agronomy]. Jakarta, ID: Gramedia.

Landon, J. R. (1991). *Booker tropical soil manual: A handbook for soil survey and agricultural land evaluation in the tropics and subtropics*. New York, USA: Routledge.

Njogu, R. N. E., Kariuki, D. K., Kamau, D. M., & Wachira, F. N. (2014). Effects of foliar fertilizer application on quality of tea (*Camellia sinensis*) grown in the Kenyan highlands. *American Journal of Plant Sciences, 5*, 2707-2715. http://doi.org/10. 4236/ajps.2014.518286

Ranjit, R., Dasog, G. S., & Patil, P. L. (2007). Effect of lime and phosphorus levels on nutrient uptake by groundnut genotypes in acid soils of coastal agro eco system of Karnataka. *Karnataka Journal of Agricultural Science, 20*(3), 631-633. Retrieved from http://14.139.155.167/test5/index.php/kjas/article/viewFile/944/937

Saha, P. K., Ishaque, M., Saleque, M. A., Miah, M. A. M., Panaullah, G. M., & Bhuiyan, N. I. (2007). Long-term integrated nutrient management for rice-based cropping pattern: Effect on growth, yield, nutrient uptake, nutrient balance sheet, and soil fertility. *Communications in Soil Science and Plant Analysis*, *38*(5–6), 579–610. http://doi.org/10.1080/00103620701215718

Setiawan, D. H., & Andoko, A. (2005). *Kiat mengatasi permasalahan praktis: Petunjuk lengkap budidaya karet* [Practical tips for overcoming problem: Complete instructions for rubber cultivation]. Jakarta, ID: Agromedia Pustaka.

Sholikah, M. H., Suyono, & Wikandari, P. R. (2013). Efektivitas kandungan unsur hara N pada pupuk kandang hasil fermentasi kotoran ayam terhadap pertumbuhan tanaman terung (*Solanum melongena* L.) [The effectiveness of nutrient rate N in dung fertilizer from fermented chicken manure on the growth of eggplant (*Solanum melongena* L.)]. *UNESA Journal of Chemistry, 2*(1), 131-136. Retrieved from ejournal.unesa.ac.id/article/2570/35/article.pdf

Suwandi. (2009). Menakar kebutuhan hara tanaman dalam pengembangan inovasi budidaya sayuran berkelanjutan [Plant nutrient requirements measuring innovation in the development of continuous vegetable cultivation]. *Pengembangan Inovasi Pertanian, 2*(2), 131-147. Retrieved from http://pustaka.litbang.pertanian.go.id/publikasi/ip022094.pdf

Wahyunto. (2015). Lahan gambut di Indonesia: Istilah, definisi klasifikasi, luasan, penyebaran, dan pemutakhiran data spatial lahan gambut [Peatlands in Indonesia: Terms, definitions classifications, area, deployment, and updating of spatial data of peat]. Retrieved from http://www.cifor.org/ipn-toolbox/wp-content/uploads/pdf/A1.pdf