Effect of Potting Mediums and Various Treatments on Growth Parameters of Young Budded Rubber in Iyanomo Southern Nigeria

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Abstract- ***Three planting mediums were used for this study; - one specialized (RT) and two improvised root trainers (PVC and WB) as well as integrated organic animal and plant wastes such as poultry manure, cow dung, coconut fiber, and oil palm fiber, incorporated into the soil to assess their impact on the growth of rubber plant in these planting mediums. The experiment, spanned two cropping seasons (2019/2020 and 2020/2021) were carried out in the screen house. A total of 108 planting mediums (RT, PVC and WB) were used, each filled with soil mixed with organic waste materials. The experimental design was a 3 x 12 factorial in a Completely Randomized Design (CRD), replicated three times. Growth parameters- plant height, girth, number of leaves, and leaf area index were measured respectively. The data were statistically analyzed using Tukey's Test at a 5% probability level. The research focused on the effects of the root trainers especially the improvised ones to replace the specialized one and the use of organic wastes of animal and plant and their combinations on the growth of the plant. RT ranged from 26.56a to 40.38a for plant height during 2019/2020 planting season and 26.28a to 38.91a during 2020/2021 planting season while PVC records the highest during 2020/2021 planting season with value 40.72a at the fourth month, followed by WB. The results showed that the three planting mediums were significantly different and the treatments had positive impact on the growth of rubber plant.***

Indexed Terms- ***Planting Mediums, Organic Wastes (Animal and Plant), Cropping Season, Rubber Plant, Growth Parameters***

I. INTRODUCTION

Rubber (*Hevea brasiliensis*) is an indigenous plant that originated from the humid tropics and has been traditionally planted here in Nigeria. It serves as a crucial raw material for various sectors like tire manufacturing industry, footwear, and other industrial products. Rubber (*Hevea brasiliensis*) is an economically valuable tree species grown in different types of plantations in more than 40 tropical countries throughout the world (Warren-Thomas *et al.,* 2015).

Planting materials of rubber are traditionally raised in polybags, and such plants, as soon as the roots reach the lower end of the polybag, strangling and distortion occur due to root coiling (Ginwal*et al.,* 2001; Soman and Saraswathy Amma, 1999). Traditional poly bags cause damage to plants due to poor drainage and suppresses plant root system causing die back of the plant (Beattie and White, 1993). In view of this challenge, the use of specialized and improvised root trainer is introduced in order to reduce to the least the incidence of die back of the plant especially in the nursery before transplanting to the field. Raising plants in root trainer containers is cost-effective, eco-friendly and saves labour as it is gaining popularity in many countries growing rubber including Nigeria. Root trainer grown plants constantly experience mild 'stress' due to the self-pruning of tap root, the tip of which is in contact with air and this leads to the

emergence of numerous lateral roots into the well-aerated potting medium. The hardened root trainer plant will have a root system consisting of a central tap root and well oriented lateral roots without any deformity (Mydin *et al.,* 2010). Plants raised in root trainers showed better sturdiness (height-diameter ratio) and uniform distribution of roots than polybag plants (Soman *et al.,* 2002). The lateral roots were also found to be significantly higher in root trainer plants than polybag plants (Soman and Saraswathy Amma, 2005).

Soils used for the growth of rubber are well drained and contains adequate supply of nutrients and so requires a lot of fertilizers (organic and inorganic) to support its growth (Shamshuddin and Fauziah, 2010). The selection of a potting medium is a factor influencing the growth of young rubber plants, directly impacting on the root development and nutrient availability. The incorporation of organic wastes onto the growth regimen has gained attention due to its potential in enhancing plant growth and soil fertility. This study, therefore, looked into the utilization of three root trainers via- one specialized (SRT) root trainer and two improvised (PVC and WB) root trainers and the use of organic wastes materials of plant and animals via coconut fiber, oil palm fiber, poultry manure and cow dung to facilitate the growth of rubber plant and to see which of these potting mediums and treatments application would be adopted by the local farmers for mass production of rubber plants.

The objectives of this study are as follows: (1) assess the effect of the planting mediums (improvised root trainer– PVC and WB and specialized root trainer-SRT) and the integrated organic wastes on plant growth parameters of young budded rubber (*Hevea brasiliensis*) and (2) ascertain which of the improvised planting mediums (PVC and WB) is capable of competing with the specialized planting medium (SRT), in order to encourage the local farmers to adopt its usage.

II. MATERIALS AND METHODS

This study was carried out in 2019/2020 and 2020/2021 cropping seasons at the Soil and Plant Nutrition Division screen house of Rubber Research Institute of Nigeria Iyanomo near Benin City Edo State. The study area lies between latitude 60001 and 70001 North and longitude 50001 and 60001 East of Equator within Ikpoba, Okha Local Government Area in Edo state as seen in the map below.

Fig.1 Map showing the location of the experimental site

III. SCREEN HOUSE EXPERIMENT (POT PREPARATION)

A total of 108 planting mediums (root trainers), with 36 for each planting medium (SRT, PVC and WB) and varying capacity for each of the root trainer, were filled with soil collected from the study area and mixed with animal and plant organic waste materials (Poultry manure, Cow dung, Coconut fiber and Oil palm fiber). Each container was filled with soil according to each container's capacity and 0.2 kg of the treatments and their combinations thereof (C, PM, CD, CF, OPF, PM + CD, PM + CF, PM + OPF, CD + CF, CD + OPF, CF + OPF, PM + CD + CF + OPF) were applied to the soil three (3) weeks before planting the rubber seedling, except for the control pot to enable the soil absorb the treatments. One seedling per container, was sown to assess the extent of the effect of the treatments (animal and plant organic waste) and the rate of growth in the planting mediums, specialized root trainer (SRT) and improvised root trainers (PVC and WB). Plant growth parameters were evaluated at the end of each month a 4-week interval respectively.

IV. EXPERIMENTAL DESIGN AND DATA ANALYSIS

The experimental design was a 3 x 12 factorial experiment laid out in a Completely Randomized Design (CRD), were planting mediums (SRT, PVC and WB) and treatments (PM, CD, CF, OPF, PM + CD, PM + CF, PM + OPF, CD + CF, CD + OPF, CF + OPF, PM + CD + CF + OPF) are factors replicated three times. Plant data were collected monthly during the planting season (2019/2020 and 2020/2021).

V. STATISTICAL ANALYSIS

The collected data were subjected to statistical analysis utilizing analysis of variance (ANOVA), with General Linear Model (GLM) data analysis employed to assess the impacts of treatments and the potting mediums on the growth of rubber plant. The means were separated using Tukey test. All statistical assessments were executed using Minitab Statistical Software Release 17.1, with significance levels reported at a 5% probability level.

VI. RESULTS

KEY:
SRT = Specialized Root Trainer (RT)
IRT = Improvised Root Trainer (PVC)
IRT = Improvised Root Trainer (WB – Water bottle)
C = Control (Bare Soil)
PM = Soil with Poultry Dropping Manure
CD = Soil with Cow Dung Manure
CF = Soil with Coconut Fiber
OF = Soil with Oil Palm Fiber
PM + CD = Soil with Poultry Dropping Manure + Cow Dung Manure
PM + CF = Soil with Poultry Dropping Manure + Coconut Fiber
PM + OF = Soil with Poultry Dropping Manure + Oil Palm Fiber
CD + CF = Soil with Cow Dung Manure + Coconut Fiber
CD + OF = Soil with Cow Dung Manure + Oil Palm Fiber
CF + OF = Soil with Coconut Fiber + Oil Palm Fiber
PD + CD+ CF + OF = Soil with Poultry Dropping Manure + Cow Dung Manure + Soil with Coconut Fiber + Oil Palm Fiber
PLANT PARAMETERS = Plant Height, Girth, No. of Leaves and Leaf Area.

Main and Interaction impacts of planting mediums and treatments on the growth parameters of young budded rubber plant during the planting season for the years 2019/2020 and 2020/2021

Table 1, shows the interaction effects of the planting mediums and the treatments on the young budded rubber plant. Except for the number of leaves not being significantly different ($p \leq 0.05$), for October, both the planting mediums and the treatments showed remarkable significant difference in all the growth parameters during the planting season (October to January – 2019/2021). Table 2, relates the interaction between the planting mediums and the treatments. There were significant differences ($p \leq 0.05$) among the planting mediums and the treatments in the growth parameters considered throughout the planting season (October to January – 2020/2021) with the exception of the number of leaves (October to December) and the leaf area for the month of January with no significant difference ($p \leq 0.05$) at all.

Table 1. Main and Interaction effect of the planting mediums and treatments for growth parameters of Rubber during the period

Factor	Planting season for 2019 – 2020															
	October				November				December				January			
Planting Medium	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)
PVC	25.07ab	2.68b	2.72b	10.66a	27.30b	2.84c	4.03a	11.27b	28.81b	3.21b	5.06b	9.84b	30.23b	3.93b	4.83b	10.92b
WB	23.82b	2.81b	2.81ab	11.40a	30.76a	3.51b	3.27b	21.07a	32.56b	3.58b	3.22c	12.03a	37.32a	4.02b	4.69b	14.12a
RT	26.56a	3.53a	3.28a	10.16a	31.86a	4.05a	4.08a	9.64b	37.22a	10.90a	5.83a	4.95c	40.38a	11.07a	6.39a	5.12c
Treatment																
CONTROL	22.66cd	2.68de	2.56a	8.42bc	21.00de	2.83d	3.89abc	13.40cd	26.29c	3.33cd	4.00cd	9.10bc	25.22e	3.33cd	4.56cd	8.08bcd
PM	22.84cd	2.75de	2.78a	11.93ab	26.78cd	3.30cd	3.33bc	9.33de	28.56bc	5.24bc	3.67de	9.73abc	26.89e	5.60bc	4.22cde	6.99cd
CD	20.31d	2.53e	3.00a	8.07cd	22.22d	2.65d	2.89cd	8.11de	25.63c	5.99abc	4.22bc	6.24cd	24.22e	6.98abc	4.78bcd	6.66cd
CF	13.91e	1.35f	2.56a	6.01e	13.74e	1.38e	2.78de	6.02e	13.82d	1.36d	2.78ef	4.48de	12.22f	1.37d	2.56e	4.41de
OF	14.65e	1.66f	2.89a	6.91de	13.22e	1.56e	2.22e	5.83e	13.65d	1.46d	2.33f	4.05e	12.11f	1.46d	2.78de	3.82e
PM + CD	31.52ab	4.19a	2.67a	11.09ab	35.70ab	4.32ab	3.22bc	13.95cd	42.44a	8.68ab	5.00abc	7.14cd	41.52cd	8.68ab	5.89bc	10.77bc
PM + CF	30.50ab	3.92ab	3.56a	11.87ab	39.79ab	4.36ab	3.89abc	20.79ab	40.34a	9.17a	5.56ab	11.00ab	48.98ab	9.17a	6.22abc	14.15ab
PM + OF	35.26a	3.77ab	3.67a	12.66ab	41.42a	4.72a	4.33ab	12.90cd	39.17ab	7.97ab	5.89ab	10.87ab	43.73bc	7.97ab	7.33a	13.88ab

CD + CF	27.66bc	3.24cd	2.89a	13.36a	40.69a	4.14ab	4.44ab	26.13a	42.70a	6.12abc	4.67abc	9.37bc	53.83a	6.12abc	6.00abc	17.41a
CD + OF	26.16bc	3.16cd	2.78a	11.77ab	35.29ab	4.13ab	4.33ab	23.79ab	42.78a	6.87abc	6.22a	8.30bc	49.84ab	6.87abc	6.78ab	12.73ab
CF + OF	29.11b	3.33bc	3.11a	12.21ab	32.28bc	4.26ab	5.11a	11.71de	36.09ab	6.53abc	6.44a	12.37ab	40.72d	6.53abc	6.89ab	10.32bc
PM + CD + CF + OF	27.21bc	3.47bc	2.78a	14.59a	37.54ab	3.89bc	5.11a	15.98bc	45.31a	7.98ab	5.67ab	14.63a	52.42a	7.98ab	5.67bc	11.62abc
P value																
Planting Medium	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Treatments	*	*	NS	*	*	*	*	*	*	*	*	*	*	*	*	*
Planting Medium * Treatments	*	*	NS	*	*	*	*	*	*	*	*	*	*	*	*	*
CV (%)	31.43	33.25	78.71	61.56	32.09	35.1	51.67	74.92	43.45	51.67	63.68	62.32	33.19	44.34	63.94	65.85
R^2 (%)	89.20	91.36	41.46	69.50	87.96	9.69	73.74	84.69	84.40	85.22	82.85	80.69	92.57	84.86	77.61	80.90

The means with same letters in the columns separated using Tukey's Test are not significantly different at $p \leq 0.05$ level test. Same letters, NS = Not Significantly different and different letters, * = Significantly different.

Table 2. Main and Interaction effect of the planting mediums and treatments for growth parameters of Rubber for the period

Factors	Planting season for 2020 – 2021															
	October				November				December				January			
Planting Mediums	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)	Plant Height (cm)	Girth (cm)	NO. of Leaves	Leaf Area (cm^2)
PVC	24.46a	3.19b	2.81a	12.05a	35.38a	4.33a	3.86a	16.49b	34.53a	4.29b	3.25a	12.32b	40.72a	4.84a	4.64b	43.49a
WB	24.26a	3.30ab	2.92a	11.80a	32.30b	3.89b	3.39b	20.83a	32.81a	4.59a	3.62a	12.65b	39.63a	4.30b	4.89ab	14.20a
RT	26.28a	3.49a	3.19a	10.80a	34.86ab	4.20a	3.92a	16.49b	32.83a	4.24b	3.64a	15.60a	38.91a	4.41b	5.47a	14.18a
Treatments																
CONTROL	23.82cd	3.24ab	3.11a	10.59ab	30.06bc	3.90bc	2.56e	12.70b	25.50cd	3.75cd	3.11bc	10.44b	25.22e	3.87d	4.44c	8.53a
PM	22.84cd	3.09ab	2.78a	11.39ab	26.87c	3.88bc	3.44bcd	14.24b	30.16bc	3.72cd	3.22bc	13.07abc	27.21c	4.34cd	4.89bc	7.25a
CD	20.30d	3.60a	3.56a	10.89ab	26.50c	4.13ab	3.56abc	10.67b	26.94cd	4.12bc	3.11bc	12.66abc	31.10bc	4.35cd	5.00bc	9.42a
CF	19.05ef	2.95ab	3.00a	10.29ab	26.00c	3.14d	3.00cde	10.04b	22.11de	3.74cd	2.00c	6.77c	22.44c	2.11e	2.00d	6.33a
OF	17.00f	2.56ab	2.67a	8.55b	22.89c	3.28cd	2.78de	8.83b	21.89e	3.52d	2.00c	7.05c	23.00c	2.80e	2.00d	8.33a
PM + CD	31.52ab	3.45a	2.78a	14.87b	39.88a	4.59ab	3.56abc	14.87b	34.24ab	5.19a	3.33abc	17.40a	50.64ab	5.17ab	5.89ab	17.85a
PM + CF	25.67bc	3.01ab	3.33a	30.06a	39.43a	4.51ab	4.11abc	30.06a	40.04ab	4.47ab	4.11ab	11.78abc	47.32ab	5.22ab	5.11ab	19.43a
PM + OF	33.63a	3.72a	2.69a	12.79b	40.01a	4.84a	4.56ab	12.79b	36.66ab	4.65ab	4.33ab	14.36ab	45.98b	5.10ab	5.78ab	19.06a
CD + CF	28.16abc	3.57a	2.89a	34.90a	42.78a	4.41ab	4.78a	34.90a	42.70a	4.79ab	4.22ab	18.06a	52.83ab	5.31ab	6.78ab	15.48a
CD + OF	23.56de	3.45a	3.56a	35.16a	38.30a	4.50ab	4.22abc	35.16a	34.94ab	4.73ab	4.22ab	17.67a	50.64ab	5.57ab	7.11a	15.93a
CF + OF	31.50ab	3.69a	2.67a	14.16b	37.58ab	4.53ab	4.00abc	14.16b	41.77ab	4.62ab	3.67ab	16.65ab	43.03b	4.62bc	4.67bc	15.66a
PM + CD + CF + OF	23.92cd	3.61a	2.82a	17.36b	39.43a	3.97bc	4.11abc	17.36b	45.33a	5.14a	4.78a	16.34ab	57.47a	5.72a	6.35ab	19.23a

P value																
Planting Mediums	NS	*	NS	NS	*	*	*	*	NS	*	NS	*	*	*	*	NS
Treatments	*	*	NS	*	*	*	*	*	*	*	*	*	*	*	*	NS
Planting Medium * Treatments	*	*	NS	*	*	*	*	*	*	*	*	*	*	*	*	NS
CV (%)	44.22	34.32	68.58	84.5	31.74	31.51	54.34	61.58	60.47	34.19	28.44	61.58	43.67	34.19	46.50	92.00
R^2 (%)	72.47	56.35	41.06	57.80	77.59	75.76	40.72	82.58	64.23	76.14	61.22	68.16	83.80	85.47	73.75	32.75

The means with same letters in the columns separated using Tukey's Test are not significantly different at $p \leq 0.05$ level test. Same letters, NS = Not Significantly different and different letters, * = Significantly different.

VII. DISCUSSION

The relationship existing between seedlings growth and containers or planting potting mediums has been generally established (Dominguez-Lerena, *et al.*, 2006). But there are limited studies on the effects of containers or planting potting mediums and treatments on nursery trees like rubber (*Hevea brasiliensis*). Root trainers are specially designed plastic containers that have vertical ridges inside to promote fast and healthy growth of roots. Rubber seedlings grown in root trainer containers has shown to develop 300% more lateral roots as compared with rubber seedlings grown in conventional polybags. The result is faster growth and development of quality rubber planting materials. From the results above, the use of different treatments (plant and animal waste materials) and their combinations showed promising prospect in the development of more young rubber stumps for establishing rubber plantations by our local farmers as it reduced the rate of die back of the plants.

During the 2019/2020 and 2020/2021 planting season, that spans from October to January, the three (3) planting potting mediums or containers had effects on the growth of the plants. The three planting potting mediums or containers (RT, PVC and WB) are significantly different ($p \leq 0.05$) from each other with RT possessing the highest value for plant height, followed by PVC and then WB throughout the planting season (October to January) for 2019/2020 planting season, while 2020/2021 planting season it was observed that the plant height was not significantly different ($p \leq 0.05$) in the first, third and fourth month (October, December and January) except for the second month (November) that it was significantly different ($p \leq 0.05$) and from the second month (November to January), plant height recorded highest in PVC than in WB and RT, indicating how successful the use of the improvised root trainer (PVC) is in comparison to the specialized root trainer (RT).The girth, number of leaves and leaf area shows significant difference ($p \leq 0.05$)throughout the planting season (October to January) for the planting potting mediums (RT, PVC and WB) except for the very first month (October) for the leaf area for the planting potting mediums (RT, PVC and WB) for 2019/2020 planting season. For 2020/2021 planting season, the girth was significantly different ($p \leq 0.05$) all through the planting season. The number of leaves saw significant differences ($p \leq 0.05$) in the first month (October) and third month (December) but no significant difference ($p \leq 0.05$) in the second (November) and fourth month (January), with PVC recording the highest value. Leaf area shows very index for PVC over WB and RT mediums with significant difference ($p \leq 0.05$) seen in the first month and the fourth month while, no significant difference ($p \leq 0.05$) was seen in the second (November) and third month (December). This shows, that these planting mediums used had impact on the rubber seedling growth.

The results also showed that with the passage of time, the integration of the treatments (animal and plant organic wastes - cow dung, poultry dropping, coconut fiber and oil palm fiber) had significant impact on the growth of the rubber plants. Each treatment was unique as it affects the plant as seen from the results. During the 2019/2020 planting period (October to January), the treatments showed significant differences ($p \leq 0.05$) as compared to the control. All the treatments are significantly different ($p \leq 0.05$) on the plant except for the number of leaves in the first month (October) which was not significantly different ($p \leq 0.05$). There are significant differences ($p \leq 0.05$) in plant height throughout the planting season with the integration of poultry manure and oil palm (PM + OF) giving the highest value of 32.26a, followed by poultry manure and cow dung (PM + CD) with 31.52ab, for the first month (October), while for the last month (January), the integration of cow dung and coconut fiber (CD + CF) showed high value of 53.83a followed by the combination of all the treatments (PM + CD + CF + OF) with 52.42a and this shows how effective the use of these treatments are in the planting of rubber plants. The use of these treatments enhanced plant growth due to better pore distribution (Rodriguez *et al.*, 2006) as the penetrate into the soil. In order to achieve better root growth, the right treatments must be used as substrate or mixed well with other organic materials (Noto 1993). This reduces problems like pests and diseases associated with the growth of rubber plant. The 2020/2021 planting season, the treatments showed significant difference ($p \leq 0.05$) on all growth parameters of the rubber plant with the exception of the number of leaves in the first month (October) with CD and CD + OF recording the highest

and the leaf area in the fourth month (January) with PM + CF and PM + CD + CF + OF recording high, showing that the treatments were effective in the growth of the rubber plant.

CONCLUSION

The findings from this study have demonstrated the effective use of three (3) planting mediums (SRT, PVC and WB) as well as the animal and plant waste products [poultry droppings manure (PM), cow dung (CD), coconut fiber (CF), oil palm fiber (OPF)] and their combined use (integrated), in providing essential nutrients for the growth of rubber plants during the two years planting trial period (2019/2020 and 2020/2021) for the establishments of rubber plantations in our country Nigeria. From the findings obtained, it could be said that the root trainers were very effective in the raising of rubber plants in the nursery for transplant onto the field for the establishment of rubber plantation. The results also showed that the plants grown in the specialized root trainer (SRT) recorded higher leaf area index (LAI) in 2019/2020 planting season but the improvised root trainer (PVC) did more in 2020/2021 followed by the water bottle (WB).

In conclusion, plants raised in root trainers showed better sturdiness in terms of height-diameter ratio and uniform distribution of roots than polybag plants (Soman *et al.*, 2002). The lateral roots were higher in root trainer plants than in polybag plants (Soman and Saraswathyamma, 2005). Another advantage is that it is easy to handle and bulk materials can be transported at a time without causing any damage to the plants. Root trainer plants will be the preferred planting material in the future owing to its several advantages in the nursery stage.

Therefore, this study has also demonstrated the effective use of our natural resources that can be sourced locally such as the poultry manure, cow dung, coconut fiber and oil palm fiber.

Finaly, the data generated from this study could be used for further research in proposing standard application rates of these animal and plant organic waste products in the successful raising of rubber plants in the nursery, providing valuable insights on the integration of animal and plant organic wastes materials in the propagation of rubber plantation in Nigerian fields due to the scarcity of literature presently.

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