International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 699-706 www.ijaem.net ISSN: 2395-5252

Impact of Potting Mediums and Treatments on the Growth and Survival Rate of Young Budded Rubber Plant in Iyanomo Southern Nigeria

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Date of Submission: 25-09-2024 Date of Acceptance: 05-09-2024

ABSTRACT
The research was conducted at the Soil and Plant Nutrition Division screen house of Rubber Research Institute of Nigeria. The study assessed the viability of improvised root trainers (PVC and WB) in comparison to specialized ones (SRT) for growing rubber plants,utilizing locally available and affordable organic wastesmaterials of animal and plant. The research, conducted over two cropping seasons (2019/2020 and 2020/2021) was carried out in thescreen house and later transplanted to the field. Growth parameters and rate of survival of rubber plantsacross the different root trainers and organic waste treatmentswere examined.A total of 108 planting mediums (RT, PVC and WB)were used, each filled with soil mixed with animal and plant organic waste materials.Experimental design was a 3 x 12 factorialin a Completely Randomized Design (CRD), replicated three times. Growth parameters(plant height, girth, number of leaves, and leaf area index) was measured respectively. The data were statistically analyzed using Tukey's Test at5% probability level. Results showed that improvised root trainers performed well compared to specialized one, with significant differences observed in the different growth parameters observed.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 during2020/2021 planting season with value 40.72a at the fourth month, followed by WB. The study highlights the potential of utilizing organic waste materials for plant growth and emphasizes the importance of promoting locally available resources in agricultural practices.

Key words: Planting Mediums, Organic Wastes (Animal and Plant), Cropping Season, Rubber Plant, Growth Parameters, Survival rate.

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).

Rubberplants are traditionally raised in polybags and as soon as the roots reach the lower end of the polybag, strangling and distortion occur due to

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 699-706 www.ijaem.net ISSN: 2395-5252

root coiling (Ginwalet al., 2001; Soman and SaraswathyAmma, 1999). Traditional polybags 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 seem to be cost-effective, eco-friendly and saves labour and 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.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 wastesonto 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 wastesmaterials 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: (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); (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 and (3) access the survival rate of the rubber (Hevea brasiliensis) plant transplanted in the field.

II. MATERIALS AND METHODS

The 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, OkhaLocal Government Area in Edo state as seen in the map below.

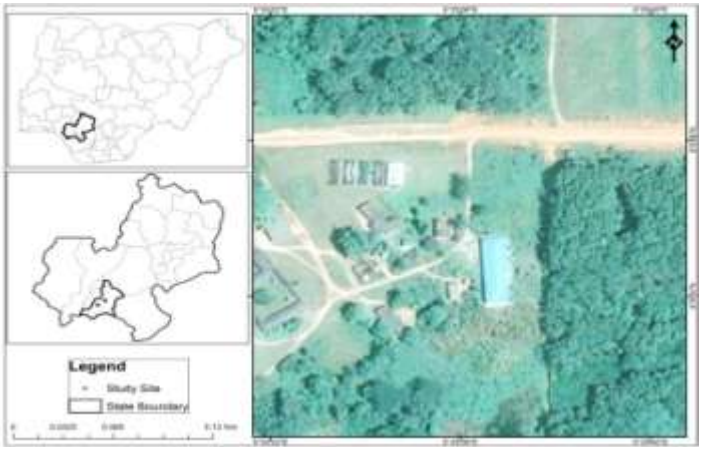

Fig.1 Map showing the location of the experimental site

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 699-706 www.ijaem.net ISSN: 2395-5252

SCREEN HOUSE EXPERIMENT (POT PREPARATION)

A total of 108 planting mediums (root trainers), 36 for each planting medium (SRT, PVC and WB) with varying capacity, 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 root trainerwas filled with soil according to each container's capacity and a fixed rate of0.2 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.

FIELD PREPARATION AND PLANTING

A plot size of 10.20m by 5.20m (53.04m^2), that is 0.0053ha was prepared and used for the field experiment with a planting distance of 1m by 1m apart.This was necessitated in order to ascertain the rate of survival of the rubber (Hevea brasiliensis) plant. The survival rate of the plant from each root trainer was thereafter calculated as follows;

$$\text{Survival rate} = \frac{\text{Number of plants in each root trainer that survived}}{\text{Number of plants originally planted in each root trainer}} \times 100$$

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 seasons (2019/2020 and 2020/2021).

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 and graphs plot on Excel 2016.

III. 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

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season (October to January – 2019/2021), while Table 2, relates the effectof the planting mediums and the treatments on the growth of the rubber (Hevea brasiliensis) plant. Significant differences ($p \leq 0.05$) among the planting mediums and the treatments wereobserved on 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

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

Effect of planting mediums and treatments on the survival rate of the young budded rubber in the field during the planting season of 2019/2020 and 2020/2021

The rate at which the rubber plant in each root trainer either specialized or improvised root trainer survived upon transplant onto the field are seen in figures 1 for 2019/2020 planting season and2 for 2020/2021 planting season. From the result, it is clearly seen that the treatment coconut fiber (CF) for all three planting mediums (RT, PVC and WB) did not grow in the field. Although, the result was below average, the treatments (PM + OPF and PM + CD + CF + OPF) showed that the improvised root trainer (PVC) is a very good march in competing with the specialized root trainer (RT) out there in the field for 2019/2020 planting season.

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Volume 6, Issue 08 Aug. 2024, pp: 699-706 www.ijaem.net ISSN: 2395-5252

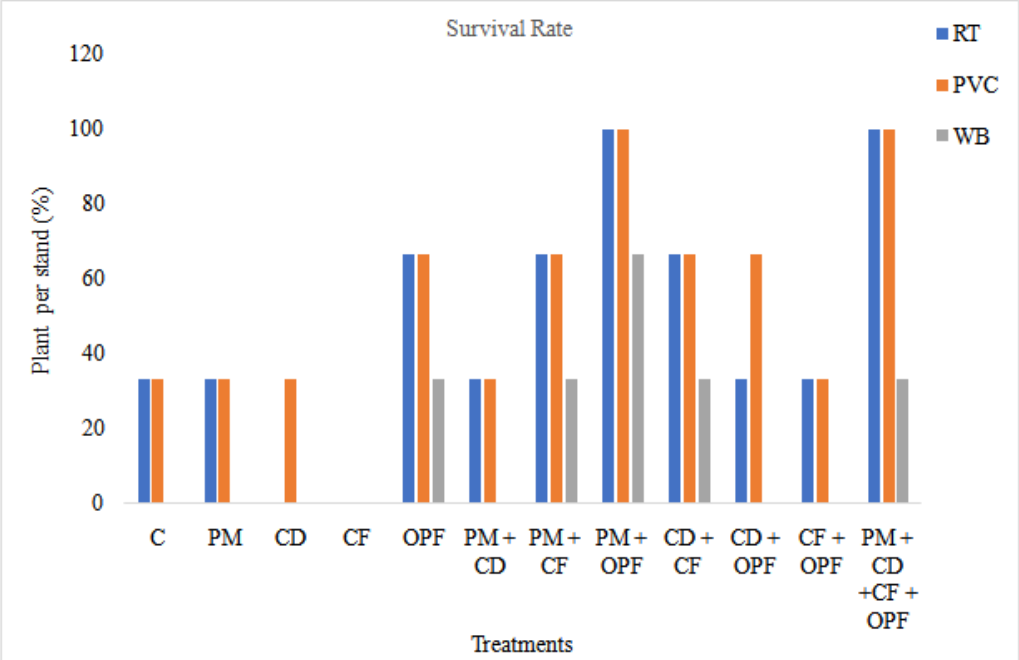

Fig.1 Survival rate of the rubber plant in the field for 2019/ 2020 planting season

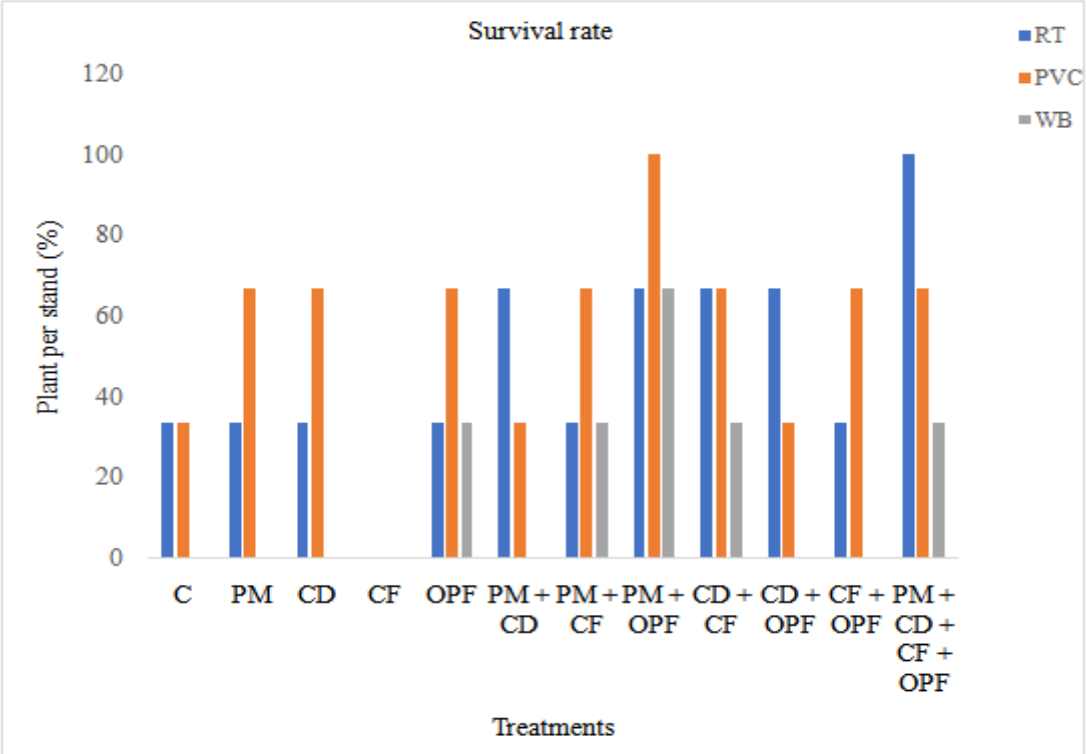

Fig.1 Survival rate of the rubber plant in the field for 2020 / 2021 planting season

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IV. DICUSSION

Studies shows, there is relationship between seedling growth and container or planting potting mediums has been generally established (Dominguez-Lerena, et al., 2006). But there are limited studies on the effects of container or planting potting mediums and treatments on nursery trees like rubber (Hevea brasiliensis).

Rubber seedlings grown in root trainer containers develop 300% more lateral roots as compared with rubber seedlings grown in conventional polybags. The result is faster growth and development of rubber quality planting materials. The root trainer technology enhances the development of straight tap root and many root hairs allowing the rubber plant to withstand environmental stress after planting, resulting in high survival rate and uniformity in growth. In this study, three (3) different containers or planting potting mediums (SRT, PVC and WB) of varying sizes were employed and they showed significant effects on the growth of rubber budded stumps.

The resultsas expressed in Tables 1 and 2, showed that the three (3) planting potting mediums namely: specialized root trainer (RT) and the improvised root trainer (PVC and WB) were successful in the raising of the rubber plantsduring the planting season of the two (2) years trial. The use of the different treatments (plant and animal waste materials) and their combinations also 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.

The results 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 is unique as it affects the plant as seen from the results.It enhances plant growth due to better pore distribution (Rodriguez et al., 2006). In order to achieve better root growth, the right treatments must be used alone as substrate or mixed well with other processed or organic materials (Noto 1993). This reduces some of the problems like pests and diseases associated with the growth of rubber plant.

The results as presented in figures1 and 2 clearly shows the impact of the planting mediums and the treatments on the survival rate of the rubber plants in the field during the two (2) years planting seasons (2019/2020 and 2020/2021). The rubber plants from the three (3) different planting mediums grew in accord with the different treatments applied. The best treatments encouraged to be used in the field are PM + OPF and PM CD + CF + OPF as observed from the result above and the best competing improvised root trainer to the specialized root trainer is the PVC type.

V. CONCLUSION

The findings from this study have demonstrated the effectiveness 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 (OF)] 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). From the results, it could be said that the root trainers were very effective in the raising of rubber plants in the nursery for transplant to the field for the establishment of rubber plantation especially in our country Nigeria.

Therefore, the results shows that the improvised root trainers competed well enough to replace the specialized root trainer in the raising of rubber plants in the nursery before transplanting onto the field as seen from the survival rate result chart.

The study also demonstrated the effective use of our natural resources sourced locally such as the poultry manure, cow dung, coconut fiber and oil palm fiber used as treatments in the cultivating and establishment of rubber plantation.

Finaly, the data generated from this study could be used for further research in proposing standard application rates of these integrated organic waste products (animal and plant) for successful raising of rubber plants in the nursery and transplanting onto the field, providing valuable insights on the integration of animal and plant organic wastesmaterials in the propagation of rubber plantation in Nigerian fieldsdue to scarcity of literature presently.

VI. RECOMMENDATIONS

The findings from this study offers advantages on the use of root trainers especially the improvised ones since they competed well with the specialized root trainer which are expensive and rare, while the improvised root trainer seems to be less expensive and affordable. The use of animal and

plant organic wastes as treatments in the propagation of rubber plants are also encouraged due to their accessibility, cost-effectiveness, and environmentally friendly nature.

Hence, the following recommendations are made:

(i) Local farmers are encouraged to key in the use of indigenous and locally sourced animal and plant organic wastes and integrate them together especially poultry and oil palm fiber and the use of PVC for raising rubber seedlings in the nursery before transplant to the field.

(ii) The Nigerian government should acknowledge the effectiveness of the use of the improvised root trainers (PVC and WB) and the safety of the integrated system of the use of animal and plant organic waste materials and encourage its use through the relevant ministries of Agriculture and Environment.

(iii) Regular trainings should be organized in communities for local farmers and stakeholders, where rubber plantations are established by educating them about the utilization of this improvised root trainers and the eco-friendly materials (animal and plants organic wastes) as soil treatments, which are readily available locally and at a minimal cost, among others and to encourage our local famers to key in the use of improvised root trainers in raising rubber plants for the establishment of rubber plantations.

(iv) NGOs should be encouraged to participate in initiatives promoting the adoption of the use of root trainers (improvised) over the use of poly bags due to its advantages to enhance good and quality rubber plant.

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