Journal of Applied Life Sciences International
10(3): 1-7, 2017; Article no.JALSI.31218
ISSN: 2394-1103

SCIENCEDOMAIN *international*
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Latex Yield of Para Rubber (*Hevea brasilliensis* Muell. Arg) as a Function of Clonal Variation and Age at Tapping in Three Locations in the Niger Delta Region of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author WBB designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MAI performed the statistical analysis. Author EEE performed the field work and author JDN managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2017/31218
Editor(s):
(1) Shahira M. Ezzat, Department of Pharmacognosy, Faculty of Pharmacy, Cairo University, Egypt.
(2) J. Rodolfo Rendón Villalobos, Department of Technological Development, National Polytechnic Institute, México.
Reviewers:
(1) Eric Soumahin, University Jean Lorougnon Guédé of Daloa, Côte d'Ivoire.
(2) Kenneth Omokhafe, Rubber Research Institute of Nigeria, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/17814

Short Research Article

Received 27th December 2016
Accepted 25th January 2017
Published 13th February 2017

ABSTRACT

The objective of this study was to assess the influence of clonal variability and tree-tapping age on latex yield in parts of the Niger Delta region of Nigeria. One exotic (GT 1) and three indigenous (NIG 800, NIG 803, NIG 805) clones of *Hevea brasilliensis* (Muell. Arg.), at three tree-tapping ages ('young', 'prime', 'old') were evaluated for latex yield in three estate plantations located in Calabar (latitude 4°58' N and 8°21' E), Nko (latitude 5°5' N; 8°11' E), and Uyo (latitude 5°01' N and 7°56' E). A split – split plot in which location of plantings, type of clone, and age at which trees were tapped comprised the main-, sub-, and sub-sub- plots respectively, was used for the experiment, and treatments arranged in randomized complete block design replicated three times. Data were generated on trunk girth, percentage tree dryness, and latex yield. Girth size increased with age of tree irrespective of clone type and location of plantings. The average girth of 'young' GT 1, NIG 800, NIG 803, and NIG 805 was 48.65, 49.07, 50.63, and 52.13 cm, respectively indicating that NIG

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805 and NIG 803 had a faster growth rate and attained the standard tappable girth of 50 cm earlier than NIG 803 and GT 1. Whilst 'young' NIG 805 and NIG 803 clones can be exploited, tapping NIG 800 and GT 1 clones at this stage of growth could have undesirable consequences on the tree's physiology, productivity and longevity. Panel dryness exceeded 20% in all clones, with the highest incidence in GT 1 at 25.03%. This might have contributed to the relatively low yield of 'old' trees, in comparison to the 'prime' ones. Significant genotype × location interaction was found for latex yield, indicating that clonal and ecological conditions of each location made significant contributions to latex yield. Differences in clonal latex yield are attributable to variations in girth, panel dryness and ecological conditions.

Keywords: Hevea brasilliensis; latex yield; clonal variability; tree-tapping age; tappable girth; tree dryness.

1. INTRODUCTION

The progressive decline in natural rubber production in Nigeria which began in the late 1960s has necessitated the introduction of a 'Presidential Initiative on Natural Rubber'; a policy framework that aims to increase rubber production through rehabilitation of old plantations, establishment of new ones, adoption of improved agronomic practices and tackling of technological and socio-economic factors militating against increased productivity [1,2]. Apart from the deciduous, rainforest regions that constitute its natural habitat [3], natural rubber cultivation in the country is being expanded to marginal, non – traditional rubber growing parts of central Nigeria including Southern Kaduna, Adamawa and Taraba states. Even in the Niger Delta Region where conditions for commercial natural rubber cultivation are adequate, estate plantations and small holder farmers that dominate the landscape [4] could attain higher yields by adopting improved and recommended agronomic practices. These include the use of improved clones planted as budded stumps [3,5], intercropping young plants with arable crops to reduce gestation period for early latex exploitation [6], maintenance of appropriate planting density necessary to provide resistance to wind damage [7], and reduce the severity of foliar and root diseases [8,9], as well as better soil management strategies [10]. At present, most farmers establish plantations with unselected planting materials (volunteer seedlings), instead of improved budded stumps, leading to low yields and such other undesirable secondary characteristics like poor bark regeneration and growth characteristics.

The age at which a rubber field is opened for tapping depends on ecological conditions and clonal characteristics, and can vary from 6-9 years old, but clones that can be opened at 5 years in favorable conditions, and below 4.5 years in optimum conditions have been developed [11]. The criterion for opening a field is when the tree trunks attain a girth of about 50 cm at a height of 150 cm from the ground [9], but the age of the tree has also been used as basis for commencement of tapping [12]. It may however, be useful to combine the two criteria for determining the best time to commence taping operations.

In Nigeria, the improvement of genetic characteristics which started in the Rubber Research Institute of Nigeria (RRIN) in 1961 [13] has resulted in the development of several high yielding clones such as the NIG 800 and NIG 900 series, all of which are now in cultivation, along with such exotic clones as GT 1 and RRIM 600 [14,15]. Whereas the exotic clones yield between 900-1600 kg/ha/year under Nigerian conditions, the latex yield of NIG 800 series range from 2000-2600 kg/ha/year, while that of NIG 900 series is between 3000-3500 kg/ha/year [13], and it would be expected that new establishments adopt these clones.

The performance of a rubber clone varies with ecological conditions [16], and genotype × environment interactions are important in plant varietal evaluation because they reduce genotypic-stability values under diverse environments. The objective of this study was to investigate how location of plantings, type of clone planted, girth and age at which trees are tapped interact to influence latex yield of rubber in the Niger Delta region of Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

2.1.1 Geographical location and climate

Field studies were conducted over a two – year period (2012 and 2013) at PAMOL rubber estate

Akim Akim, Calabar, PAMOL rubber estate, Nko, Yakurr Local Government (both in Cross River State), and Akwa rubber estate Uyo, Akwa Ibom State. Under Kopens classification, Calabar (latitude 4°58'N and 8°21' E) features a tropical monsoon climate, with a rainy season spanning 10 months and a short dry season covering the remaining 2 months. The harmattan, which significantly influences weather in West Africa, is less pronounced in the area. The rainfall is bi-modal, averaging 3000 mm per annum and falls over a period of about 173 days annually. Temperatures are relatively constant throughout the year, with average high ranging from 25-28°C and low of 22.5°C. The average relative humidity of the area is 88%, while the mean monthly number of sunshine hours is 1405.7 [17].

Uyo is situated between latitude 5°01' North of the Equator and longitude 7°56' East of the Greenwich meridian [18]. The area has a mean annual rainfall of 2484 mm, spread over a period of 8-9 months starting from March to October, with a short dry season from November to February. It has a mean annual temperature of 27°C; cumulative monthly sunshine hours of 1450 and a relative humidity range of 70-80%.

Nko (latitude 5°5' N; 8°11' E), is about 120 km North West of Calabar, and is located within the equatorial forest region of the tropics characterized by a severe harmattan season. An annual mean rainfall of about 2300 mm spread over a period of about 135 days is received in the area, while the minimum and maximum ambient temperature is about 24.5°C and 31.0°C, respectively. The area enjoys abundant sunshine of over 2000 hours monthly and a relative humidity of 82%.

2.1.2 Soil properties

The soil at the Calabar and Uyo locations was sandy loam, while that at Nko was sandy clay loam. Soil pH across the plantations was acidic, but within the range recommended by [19], for rubber growing soils. These soils had low organic matter and total nitrogen percentage, and a high base saturation percentage.

2.2 Methodology

In each plantation, there were GT 1 Java (exotic), NIG 800, NIG 803, and NIG 805 (indigenous) clones in blocks, out of which four hundred (400) trees per clone were demarcated into blocks of 'Young' (7 to 11 years- old), 'Prime' (12 to 24 years- old), and 'Old' (above 25 years - old) trees. Of these, fifty (50) trees were randomly selected, marked and evaluated for girth, tree dryness and latex yield. The tapping panel was opened at 1.2 m from the ground level for all trees, and tapping followed the downward half- spiral method (S/2). Trees were tapped every three (3) days in a six (6) day- week (d3 6d/7) as described by [9].

2.3 Data Collection

Coagulum from all tapped trees was collected and weighed with a digital weighing scale, and the dry rubber content (DRC) determined using a Metrolac (latex meter), following standard procedure [20]. Stem girth at a height of 150 cm was measured with vernier caliper, while evaluation for tree dryness was by scoring (dry: if dryness was observed; normal: if there was no dry portion), and expressed in percentage.

2.4 Experimental Design and Data Analysis

The experimental design was a split – split plot whereby location, clone type, and age at tapping comprised the main-, sub-, and sub-sub- plots, respectively, and treatments laid out in randomized complete block design replicated three times. The statistical analyses were carried out with SAS software version 8 [21].

3. RESULTS AND DISCUSSION

Girth size increased with age of tree irrespective of clone type and location of plantings. At 'opening' of the field, the average tree girth of 48.65 and 49.07 cm for GT 1 and NIG 800 respectively, was less than the recommended standard of 50 cm [9,6], while that of NIG 803 and NIG 805 were higher at 50.63 and 52.13 cm, respectively. The girth size of NIG 805 was consistently larger than that of other clones across the various age levels evaluated (Table 1). This implies that the initial growth rate of GT 1 and NIG 800 clones was not rapid enough and tapping them at the 'young' stage could have had adverse consequences on the tree's physiology, productivity and longevity. The panel dryness (i.e. cessation of latex flow from the cut) which was observed mainly on 'old' trees, exceeded 20% in all clones, the highest being GT 1 with 25.03% (Table 1). This syndrome arises from a number of dysfunctional factors in the plant [22], and significant clonal variation exists for tree dryness [23], while significant genotype × environment interaction

has also been reported for it [24,25]. Inter-clonal variation which obscures clonal character is also a common feature in the incidence of tree dryness in rubber [26].

Significant genotype × environment interaction was found with latex yield (Table 2), which indicates that the ecological conditions of each location made significant contributions to yield as reported by [24,25,27].

In the three locations assessed, the three Nigerian clones (NIG 800, NIG 803, NIG 805) out- yielded the exotic GT 1 clone, and amongst the indigenous clones, the yield of NIG 805 was highest, though not significantly different from that of NIG 803, while NIG 800 consistently gave the lowest yield (Table 2). On the contrary, latex yield was not significantly influenced by the interaction of location × age of tree at tapping since trees that were tapped at their 'prime' consistently out-yielded the 'old' ones as well as those that have just transited the 'immature' stage (Table 3).

The effect of genotype on latex yield also varied with the age at which trees were tapped as shown in the significant interaction between clone type and tapping age (Table 4). Irrespective of clone, more latex was obtained by tapping trees at their 'prime', followed by the 'old' and 'young' ones. However, the yield difference between the 'prime' and 'old' NIG 805 clones was not significant, indicating that this clone could give consistent high yields up to 'old' age.

Fungal diseases which are prevalent in high rainfall areas become very severe when the rainy season is prolonged with inadequate sunshine. It was visually observed that the incidence of mistletoe, an air-borne parasitic plant which lives off the sap of the host, was high in all the plantations, and might have contributed to the low latex yields obtained as was previously reported by [28], especially with NIG 800 which is highly susceptible to this parasite, and GT I and NIG 803 which have moderate and high tolerance to the parasite, respectively [29].

Table 1. Average tree girth and panel dryness percentage of different clones across the three study locations

Clone type	Girth of tree (cm)			Panel dryness (%)
	Young	Prime	Old	
NIG 800	49.07	65.77	120.52	21.69
NIG 803	50.63	69.19	122.07	20.01
NIG 805	52.13	73.01	126.68	22.46
GT 1	48.65	59.44	120.45	25.03
Mean	50.12	66.85	122.43	22.30
SD	±0.11	±0.03	±0.09	±1.04
CV (%)	11.28	16.41	13.59	5.07

Table 2. Effect of location of plantings and clone type on rubber latex yield (kg/ha/yr)

Treatment	Year		Mean
	2012	2013	
Calabar × NIG 800	1405.9^{bc}	1423.6^{d}	1414.8
Calabar × NIG 803	1961.3^{ab}	2211.8^{ab}	2086.6
Calabar × NIG 805	2329.6^{a}	2500.0^{a}	2414.8
Calabar × GT 1	731.9^{d}	737.5^{e}	734.7
Uyo × NIG 800	1247.0^{c}	1302.8^{d}	1274.9
Uyo × NIG 803	1652.6^{b}	1989.0^{b}	1820.8
Uyo × NIG 805	2001.8^{ab}	2215.4^{ab}	2108.6
Uyo × GT 1	541.5^{d}	566.3^{f}	553.9
Nko × NIG 800	1200.9^{c}	1227.0^{de}	1214.0
Nko × NIG 803	1612.2^{b}	1600.8^{c}	1606.5
Nko × NIG 805	1898.7^{b}	2006.1^{b}	1952.4
Nko × GT 1	544.8^{d}	560.2^{f}	552.5

In a column, means followed by the same letter are not significantly different at 5% probability by Duncan's Multiple Range Test (DMRT)

Table 3. Effect of clone type and tapping age on rubber latex yield (kg/ha/yr)

Clone type	Tapping age			Mean
	Young	Prime	Old	
NIG 800	497.9	2126.5	1322.8	1315.7
NIG 803	746.6	2594.7	1916.1	1752.5
NIG 805	889.6	3033.9	2148.0	2023.8
GT 1	369.2	847.5	631.7	616.1
LSD ($_{0.05}$)	33.5	105.3	27.8	

Table 4. Effect of location of clone and tree tapping age on rubber latex yield (kg/ha/yr)

Treatment	Year		Mean
	2012	2013	
NIG 800 × Young	497.9^{e}	506.3^{f}	502.1
NIG 800 × Prime	2126.5^{bc}	2243.5^{bc}	2185.0
NIG 800 × Old	1322.8^{c}	1367.8^{d}	1345.3
NIG 803 × Young	746.6^{d}	767.3^{ef}	757.0
NIG 803 × Prime	2594.7^{b}	2616.4^{b}	2605.6
NIG 803 × Old	1916.1^{bc}	2001.9^{c}	1959.0
NIG 805 × Young	889.6^{d}	1010.6^{de}	950.1
NIG 805 × Prime	3033.9^{a}	3094.1^{a}	3064.0
NIG 805 × Old	2948.0^{a}	3018.7^{a}	2983.4
GT 1 × Young	369.2^{e}	431.4^{fg}	400.3
GT 1 × Prime	847.5^{d}	909.7^{e}	878.6
GT 1 × Old	631.7^{de}	687.6^{f}	659.7

In a column, means followed by the same letter are not significantly different at 5 % probability by Duncan's Multiple Range Test (DMRT)

4. CONCLUSION

Inter-clonal differences exist in the genus *Hevea* with respect to tree panel dryness, girth and latex yield. There was significant Location × Clone and Clone × Tree age interactions, and this may lead to location-specific recommendation. Young NIG 803 and 805 clones attained the recommended tappable girth of 50 cm at a height of 1.25 m above the ground, and thus, could be commercially exploited.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/17814