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Preliminary Investigation into Tree Dryness in *Hevea brasiliensis* (Wild. Ex Adr. De Juss) Muell. Arg. by Path Analysis of Tree Dryness and Latex Parameters.

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Summary

The correlative path analysis between tree dryness and four latex parameters was studied in eleven clones of Hevea brasiliensis. *The latex parameters used for evaluation were initial volume, initial flow rate, final volume and plugging index with tree dryness as the dependent factor. Estimates of direct and indirect effects of each of the latex parameters on tree dryness were calculated through linear correlation and path analysis.*

The correlation coefficient between initial volume and initial flow rate was 1.00 and both characters had the same correlation coefficients with other latex parameters and tree dryness. This implies that initial volume and initial flow rate are alternatives for evaluation of correlation between latex parameters and tree dryness.

There was significant correlation between initial volume, initial flow rate and tree dryness at √= -0.52 and high indirect effect of initial volume and initial flow rate through final volume. In addition, despite the low correlation coefficient of √= -0.20 between final volume and tree dryness, the direct effect of final volume on tree dryness was high at 0.812. Final volume is therefore an important factor in the incidence of tree dryness.

Résumé

Etude préliminaire du tarissement de l'encoche de saignée chez *Hevea brasiliensis* (Wild. Ex Adr. De Juss) Muell. Arg. par établissement de régressions linéaires entre les paramètres du tarissement des arbres et de la production de latex

Cette étude évalue les corrélations, établies par régression linéaire entre le tarissement des arbres (facteur dépendant) et quatre composantes du rendement en latex (volume initial, taux de saignée initial, volume final et l'index d'obturation de l'encoche) chez onze clones d'Hevea brasiliensis. *Les résultats obtenus montrent que le coefficient de corrélation entre le volume initial et le taux de saignée initial s'élevait à 1. Ces deux paramètres ont donné les mêmes coefficients de corrélation avec les autres paramètres relatifs à la production du latex et au tarissement de l'encoche de saignée. Le volume initial et le taux de saignée initial constituent donc des alternatives pour l'évaluation de corrélations entre les composantes du rendement en latex et le tarissement de l'encoche de saignée. Une corrélation négative (r = -0,52) a été observée entre, d'une part, le volume initial, le taux de saignée initial, le dessèchement de l'encoche de saignée, et d'autre part, le volume initial, le taux de saignée initial et le volume final. Bien que le coefficient de corrélation entre le volume final et le tarissement de l'encoche de saignée ne soit pas élevé (r= -0,20), un effet direct a été observé entre le volume final et le tarissement de l'arbre avec un coefficient de corrélation de 0,812. Le volume final constitue donc un facteur important pour l'évaluation du tarissement de l'encoche de saignée.*

Introduction

Hevea brasiliensis (Wild. Ex Adr. De Juss) Muell. Arg. is valued mainly for natural rubber which is obtained by wounding the bark of the tree in a process called tapping. Natural rubber is valued for the production of heat resistant plastic products such as tyre, tube and bearings. It is possible to obtain natural rubber also called latex, from the tree in a period of thirty years through conventional tapping system of alternate daily, half spiral tapping frequency ($\frac{1}{2}$S, d/2). However, it is often observed that the rubber tree could become dry such that latex will not be produced even with several tapping cuts (4). This situation is referred to as tree dryness.

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The onset of tree dryness is marked by dry portions of the tapping cut which eventually spread through the entire tapping cut.

Tree dryness in *Hevea brasiliensis* has been attributed to over-exploitation and influence of genetic factors. Over-exploitation is either in the form of high frequency of tapping or the use of stimulants (9, 10). In the case of genetic factors, there is clonal variation in incidence of tree dryness (2, 4).

Despite clonal variation among cultivated clones of *H. brasiliensis*, no single clone has been found to have genetic resistance to tree dryness; rather intra-clonal variation is a common occurence in many field trials (5). Further studies on the influence of genetic factors revealed low heretability of tree dryness (6). With low heritability of tree dryness, improvement in genetic tolerance can be aided by combined breeding and selection for other characters that are closely associated with tree dryness. A number of characters has been proposed for studies in association with tree dryness (5). Among such characters are latex parameters, leaf and soil nutrient status and enzyme activity with latex parameters as primary indicators. This study was therefore conducted to determine the direct and indirect effects of latex parameters that are closely associated with tree dryness.

Material and methods

Survey of tree dryness was carried out in Rubber Research Institute of Nigeria (RRIN) experimental station at Etche, Rivers State, Nigeria. The plantation was established in 1979 with ten Nigerian clones (RRIN C-clones) and a Malaysian clone (RRIM 600). The ten RRIN C-clones were coded as follows: C76, C83, C143, C145, C150, C154, C159, C162, C163, C202. The plantation was opened for tapping in 1989 at $\frac{1}{2}$S, d/2 tapping frequency without stimulation. Tapping was carried out with the conventional tapping knife between 6.00 hours and 8.00 hours of each tapping day. Evaluation for tree dryness and latex parameters was carried out in 1994 on tree basis as prescribed in the procedure for studies on tree dryness (3). During data collection, the condition of each tree was recorded as the tapping cut was opened on each tapping day. Incidence of tree dryness was scored as M1 with dryness on 20% of the cut, M2 with dryness on 20-80% of the cut and M3 with dryness on >80% of the cut. Trees without dryness were scored as normal trees (N). The incidence of tree dryness was converted to percentage and transformed using arcsine transformation to conform with the rules of analysis of variance (1).

Four latex parameters viz initial volume of latex five minutes after opening the cut (V1), volume of latex at cessation of flow of latex (V2), initial flow rate (IFR) and

Table 1
Analysis of variance of incidence of tree dryness (M1, M2, and M3) in RRIN C – clones and RRIM 600

Source of variation	df	ss	ms
Clone	10	163.25	16.33*
Dryness	2	107.66	58.83**
Error	20	135.77	6.79

*, **: Significant at p = 0.05 and p = 0.001 respectively (F-test).

Table 2
Analysis of variance of tree dryness (M1 and M2) in RRIN C- clones and RRIM 600

Source of variation	df	ss	ms
Clone	10	200.86	20.09*
Dryness	1	57.45	57.45*
Error	10	65.95	6.60

*, **: Significant at p = 0.05 (F-test).

Table 3
Mean percent incidence of tree dryness

Clone	Partial dryness M1	M2	(M1 + M2)*	Total dryness (M1 + M2 + M3)*
C 83	26.09	13.04	39.13 a	43.98 a
C 162	18.52	7.41	25.93 ab	25.93 ab
C 143	12.50	6.25	18.75 bc	24.76 ab
C 76	12.50	0.00	12.50 bc	12.50 bc
C 159	8.11	3.70	11.81 bc	11.81 bc
C 154	9.10	0.00	9.10 bc	13.62 bc
C 163	4.55	4.55	9.10 bc	9.10 bc
C 202	8.33	0.00	8.33 bc	16.45 bc
RRIM 600	0.00	7.69	7.69 bc	7.69 bc
C 150	4.55	0.00	4.55 c	4.55 bc
C 145	0.00	0.00	0.00 c	0.00 c
$\bar{X}$	9.48	3.88	13.35	15.49
Lsd	-	-	19.83	23.04

*: Means followed by different letters in each column are significantly different at p = 0.05 (lsd).

Table 4
Analysis of variance of latex parameters in RRIN C – clones and RRIM 600 with M1 and M2 levels of dryness

Source of variation	df	Mean squares V1	IFR	V2	PI
Clone	10	35.84	1.43	645.65	19.10
Dryness	1	209.32	8.37	330.42	103.12*
Error	10	59.52	2.37	936.54	14.63

*: Significant at p = 0.05 (F-test)

Table 5
Analysis of variance of latex parameters in RRIN C – clones with M1 and M2 levels of dryness

Source of variation	df	Mean squares V1	IFR	V2	PI
Clone	9	39.79	1.59	620.17	17.98
Dryness	1	343.29*	13.73*	1571.06	129.49*
Error	9	38.35	1.53	632.53	12.73

*: Significant at p = 0.05 (F-test)

Table 6
Analysis of variance of latex parameters in RRIN C – clones with N, M1 and M2 levels of dryness

Source of variation	df	Mean squares V1	IFR	V2	PI
Clone	9	40.79	1.63	596.77	12.15
Dryness	2	402.39**	16.10**	2035.80*	91.17**
Error	18	31.05	1.24	476.53	10.78

*, **: Significant at p = 0.05 and p = 0.001 respectively (F-test)

Table 7
Mean values of latex parameters of dry trees in (M1 and M2) and (N, M1 and M2) for RRIN C-clones

	(M1 and M2)*				(N, M1 and M2)*			
Dryness	V1 (ml)	IFR (ml/min)	V2 (ml)	PI	V1 (ml)	IFR (ml/min)	V2 (ml)	PI
N	-	-	-	-	16.18 a	3.24 a	43.43 a	8.45 a
M1	12.00 a	2.40 a	32.93	8.19 a	12.00 a	2.40 a	32.93 ab	8.18 a
M2	3.72 b	0.74 b	24.40	3.09 b	3.09 b	0.74 b	15.20 b	3.09 b
lsd	6.17	1.23	-	3.56	5.64	1.13	26.84	3.32

**: Means followed by different letters in each column are significantly different at p = 0.05 (lsd).*

Table 8
Correlation coefficients of latex parameters and tree dryness (TD)

	V1	V2	IFR	PI
TD	-0.52*	-0.20	-0.52*	-0.26
V1		0.80**	1.00**	-0.01
V2			0.80**	-0.52*
IFR				-0.01

**, **: Significant at p = 0.05 and p = 0.001 respectively (t-test)*

Table 9
Modified table of correlation coefficients of latex parameters and tree dryness

	V1, IFR	V2	PI
TD	-0.52*	-0.20	-0.26
VI, IFR		0.80**	-0.01
V2			-0.52*

**, **: Significant at p = 0.05 and p = 0.001 respectively (t-test)*

Table 10
Direct (diagonal) and indirect (off diagonal) effects of latex parameters on tree dryness.

	V1, IFR	V2	PI	√TD
V1, IFR	-1.168	0.650	-0.002	-0.52
V2	-0.934	0.812	0.078	-0.20
PI	0.012	-0.422	0.150	-0.26
Residual factors	-	-	-	0.77

plugging index (PI) were recorded for each tree in all the clones. IFR and PI were calculated as follows (3):

$$IFR = \frac{V1}{5} \text{ (ml/min)}$$

$$PI = \frac{IFR}{V2} \times 100$$

The clones were evaluated for incidence of tree dryness and latex parameters using analysis of variance, correlation and path analysis. For the purpose of correlation analysis, tree dryness was scored as N = 0, M1 = 1 and M2 = 2.

Results

There was significant variation in incidence of tree dryness ranging from zero incidence in C145 to 43. 98% in C83 and population mean incidence of 15.49% (Tables 1, 2 and 3). At the M3 level of tree dryness, the latex produced coagulated on the tapping cut such that it was difficult to obtain latex through dripping.
Tree dryness in RRIM 600 was observed at M2 with zero incidence at M1 (Table 3). This made it difficult to obtain a trend of latex parameters from M1 to M2 (Table 4). Following analysis of variance of experimental clones developed in RRIN, there was significant variation in latex parameters of N, M1 and M2 levels of dryness (Tables 5 and 6) with significant reduction in latex parameters from N to M2 (Table 7).

The correlation between V1 and IFR was 1.00 with uniform correlation with other latex parameters (Table 8). The correlation table was therefore modified with significant correlation coefficient of –0.52 between V1, IFR and tree dryness. The correlation coefficients of 0.80 between V1, IFR and V2 and –0.52 between V2 and PI were also significant (Table 9).

The path analysis of correlation between latex parameters and tree dryness revealed appreciable effect of V2 with positive direct effect of 0.812 on tree dryness. Also, the indirect effect of V1 and IFR on tree dryness via V2 was relatively high at 0.650. The highest effect of PI on tree dryness was through V2 at –0.422 to mask the direct positive effect of PI on tree dryness (Table 10). The direct effect of V1 and IFR on tree dryness which was negative and higher than unity was reduced considerably by the positive indirect effect on tree dryness via V2. The effect of residual factors was relatively high at 0.77 (Table 10).

Discussion

Clonal variation in incidence of tree dryness, as in previous reports (2, 4) was obtained in this study. The population mean incidence of tree dryness of 15.49% falls within the range of tree dryness in high yielding clones (8). The RRIN C-clones are among the high yielding clones developed in Nigeria (7). This level of incidence of tree dryness in less than ten years of tapping will lead to loss of revenue.
At the level of M3 tree dryness, it was difficult to collect latex for determination of volume related latex parameters. Hence, the evaluation of latex parameters only at the level of M1 and M2 tree dryness. Other latex parameters that are not based on volume of latex will be considered in subsequent studies to determine the relationship between such latex parameters and tree dryness at M1, M2 and M3 levels of tree dryness.
The reduction in latex production due to the incidence of tree dryness is evident with significant reduction in bulk

volume of latex from 43.43 ml in normal trees to 15.20 ml in M2 dry trees. This accounts for the immense loss of revenue as a result of tree dryness (8).
The significant negative correlation between initial volume, initial flow rate and tree dryness is consistent with results obtained in previous evaluation (6). However, path analysis revealed that the significant correlation between initial volume, initial flow rate and tree dryness is influenced by variation in final volume of latex. This was such that the positive indirect effect of initial volume and initial flow rate on tree dryness via final volume had a significant impact on the negative direct effect of initial volume and initial flow rate of tree dryness. This means that in order to harness the significant correlation between initial volume, initial flow rate and tree dryness for the purpose of improvement, final volume should be considered relevant. In addition, the direct effect of final volume on tree dryness was positive and very high in comparison with the direct effects of other latex parameters on tree dryness. These results show the importance of the effect of final volume on tree dryness.
The high effect of residual factors on tree dryness suggests an increase in the number of potential causal factors that will be investigated in subsequent studies. Some of such potential factors are dry rubber content, total sugars, inorganic phosphorus, leaf nutrient analysis and several other factors (3).
Initial flow rate is directly proportional to initial volume (3). Thus, for data analysis based on variance, initial volume and initial flow rate will produce identical results. Hence, initial volume and initial flow rate have same correlation coefficients with other characters. For variance based analysis, therefore, one of them can be used instead of using the two at the same time.
In conclusion, initial volume and initial flow rate can be considered as alternative characters for evaluation of correlation between latex parameters and tree dryness. Despite the low correlation between final volume and tree dryness, final volume is relevant to the occurence of tree dryness. This is due to the high direct effect of final volume on tree dryness and the high indirect effect of initial volume and initial flow rate on tree dryness through final volume.

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