Research Article

Clonal stability of latex yield in eleven clones of *Hevea brasiliensis* Muell. Arg.

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Abstract

Eleven *Hevea brasiliensis* clones were evaluated for clonal stability of latex yield. A randomized complete block design was used with four replicates, two locations, seven years and three periods per year. Stability analysis was based on clone x year and clone x year x location interactions. Five stability parameters viz environmental variance, shukla's stability variance, regression of clonal latex yield on environmental index, variance due to regression and variance due to deviation from regression were applied. There was significant clone x environment effect at the two levels of interaction. Among the eleven clones, C 162 was outstanding for clonal stability and it can serve as donor parent for stability alleles. Three clones (C 76, C 150 and C 154) were also stable. The four stable clones (C 76, C 150, C 154 and C 162) are suitable for broad-spectrum recommendation for latex yield. Five clones (C 83, C 143, C 163, C 202 and RRIM 600) will require environment-specific recommendation because of their unstable phenotype. The stability feature of two clones (C 145 and C 159) was not clear and this will be investigated in subsequent studies.

Key words: Hevea, clones, latex, stability.

Introduction

Genotype x environment interaction in *Hevea brasiliensis* has been reported for latex yield (Goncalves *et al.,* 1992) and several secondary characters (Jayasekera, 1983; Onokpise *et al.*, 1986). Despite the significant genotype x environment interaction, it is possible to have genotypes that maintain a relatively consistent performance across various environments. Such genotypes are referred to as stable genetic materials.

Several stability parameters have been proposed (Lin *et al.,* 1986) in two major groups. The first group includes environmental variance, which is clone-specific and hence, independent of the population of the test-clones. The second group measures genotypic stability relative to the population of the test-clones. This has two sub-groups, one of which measures linear and non-linear components of stability (Eberhart and Russell, 1966; Finlay and Wilkinson, 1963). The other sub-group includes parameters that measure bulk stability without reference to linear and non-linear components (Plaisted, 1960; Shukla, 1972).

Many high yielding *Hevea brasiliensis* clones have been developed worldwide (Alika, 1982; RRIM, 1977). In Nigeria, sixteen clones have been selected as commercial clones. The latex yield of the Nigerian clones is high at 2000-3500 kg/ha/yr compared to 900-1600 kg/ha/yr of exotic clones (Alika, 1982; Aliyu and Adedipe, 1997). Despite the relatively high latex yield of these clones, clonal stability is important. The yield figures of recommended clones, based on evaluation at the research centre, are often different from yields obtained in different locations. Also, among perennial crops, such as rubber, irregular annual yields make planning difficult. This is more pronounced in unstable clones and stable clones are therefore desired. Hence this study was carried out with the objective of evaluation of clonal stability of latex yield in eleven *H. brasiliensis* clones in Nigeria.

Materials and Methods

Eleven clones recommended for planting in Nigeria were evaluated at two experimental stations of the Rubber Research Institute of Nigeria (RRIN) over a period of seven years. The clones included ten developed in RRIN and one (RRIM 600) developed in Malaysia (Table 1). The eleven clones were planted in 1979 at each of the RRIN experimental stations. One of the stations was Akwete (5° N, 7° E) in Abia State (Nigeria) with relative humidity (r. h.) of 58.77% at 1500 Greenwich Mean Time (GMT). The second location was Etche (4.5° N, 6.5° E) in Rivers State, Nigeria with mean r. h. of 68.68% at 1500 GMT. In each

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Table 1 - Parentage of the experimental clones.

Clone	Parentage
C 76	RRIM 501 x HAR 1
C 83	RRIM 600 x PR 107
C 143	RRIM 501 x RRIM 628
C 145	ditto
C 150	ditto
C 154	ditto
C 159	ditto
C 162	ditto
C 163	ditto
C 202	RRIM 600 x PR 107
RRIM 600	TJIR 1 x PB 86

location, the experimental design was a randomized complete block design with four replicates and ten trees per clone per replicate. Plant spacing was 3.34 m x 6.7 m.

The plantation, in each location, was opened for tapping in 1991 and latex yield data were collected in three periods of the year for seven years (1991-1997). The periods were January to May, June to September and October to December. The tapping frequency was the half spiral, alternate daily frequency without stimulation (Opeke, 1987). Tapping was carried out at 6.00 to 9.00 h on each tapping day and data collection was twice a month. The latex from each day of data collection was allowed to undergo auto-coagulation in the latex cup to produce cup-lump. The cup-lumps in a replicate were air dried for twenty-one days and weighed on a ±0.01 g precision balance. A correction term of 0.53, as derived from the report of Aniamaka and Olapade (1990), was applied to obtain gram per tree per tapping (g/t/t). Latex yield data collection was throughout the year except for a one-month break in February each year. This is the period of severe defoliation of *Hevea* in Nigeria.

The analysis of variance (ANOVA) for the stability test was conducted as described by Singh and Chaudhaury (1977). In order to enhance the precision of factorial analysis (Omokhafe, 2000), the effect of the three tapping periods per year was a source of variation in ANOVA and it was a component of the average error in stability analysis. Clonal stability was evaluated on the bases of clone x year and clone x environment (year x location) interactions. The average error was calculated as recommended by Eberhart and Russell (1966). Five stability parameters viz environmental variance (S_i^2), Shukla's stability variance ($\hat{\sigma}_i^2$), regression of clonal latex yield on environmental index (b_i) and the Eberhart and Russell variance due to regression (S_{bi}^2) and deviation from regression (S_{di}^2) were applied. The formulae for these stability parameters were used as reported by Lin *et al.* (1986), Shukla (1972), Finlay and Wilkinson (1963) for S_i^2, $\hat{\sigma}_I^2$ and b_i respectively. Variance estimates of S_{bi}^2 and S_{di}^2 were calculated according to Eberhart and Russell (1966).

Results

There was no significant clone x year interaction at Akwete (Table 2). This was accompanied by insignificant non-linear component. However, the linear component of clone x year interaction was significant (Table 3). Despite the insignificant non-linear component, C 83 had significant contribution to the bulk deviation from linearity (Table 3). The unstable character of C 83 in Akwete was manifested as it was also detected as unstable by two stability parameters (Table 4).

At Etche, there was significant clone x year interaction with significant linear and non-linear components (Tables 2 and 3). Six clones (C 83, C 143, C 150, C 163, C 202 and RRIM 600) were rated as unstable by four stability parameters. On the other hand, C 154 was stable for four parameters (Tables 3 and 4).

In combined analysis, clone x environment interaction was significant (Tables 2 and 5). Both linear and

Table 2 - ANOVA for stability test of *Hevea* latex yield due to clone x year interaction in Akwete, Etche and combined data.

S.V.	df	Mean squares		
		Akwete	Etche	Combined data
Total	76	=	=	=
Year (Year)	6	=	6084.932	=
Clone (Cl)	10	1936.516**	555.565**	877.845**
Cl x Yr	60	35.960	75.028**	31.360**
Yr + (Cl x Yr)	66	=	=	=
Pooled deviation	55	28.994	51.254**	18.698**
Average error	210	24.952	21.599	10.933
Coefficient of variation		24.48%	34.20%	22.48%

**: Significant at p = 0.01 (F-test).

Table 3 - Mean squares of components of clone (Cl) x Year (Yr) interaction of *Hevea* latex yield in Akwete, Etche and combined data.

S.V.	df	Akwete		Etche		Combined data	
		SS	MS	SS	MS	SS	MS
Yr + (Cl x Yr)	66	8840.848	=	41011.288	=	18406.148	=
Yr (linear)	1	6683.229	=	36509.594	=	16524.531	=
Cl x Yr (linear)	10	562.951	56.295*	1682.711	168.271**	853.216	85.322**
Pooled deviation	55	1594.668	28.994	2818.983	51.254**	1028.401	18.698**
C 76	5	166.334	33.267	185.586	37.117	74.147	14.829
C 83	5	322.947	64.589*	515.981	103.196**	104.131	20.826
C 143	5	24.242	4.848	338.190	67.638**	115.458	23.092
C 145	5	73.799	14.760	205.638	41.128	62.854	12.571
C 150	5	52.884	10.577	329.326	65.865*	71.202	14.240
C 154	5	277.638	55.528	48.580	9.716	63.402	12.680
C 159	5	94.578	18.916	170.960	34.192	121.332	24.266
C 162	5	42.424	8.485	79.057	15.811	42.575	8.515
C 163	5	133.393	26.679	254.753	50.951*	13.206	2.641
C 202	5	212.395	42.479	271.921	54.384*	146.504	29.301
RRIM 600	5	194.034	38.807	418.991	83.798**	213.590	42.718**
Average error	210		24.952		21.599		10.933

+: Based on Eberhart and Russell's model.
*, **: Significant at p = 0.05 and p = 0.01 respectively (F-test).
MS for each clone = S^2_{bi}.

non-linear components were significant in clone x year interaction (Table 3) while only the non-linear component was significant in clone x environment (year x location) interaction (Table 5). Clone C 162 was stable for four stability parameters in clone x year interaction and for all the five stability parameters in clone x environment (year x location) interaction (Tables 3, 4 and 5). Three clones (C 76, C 150 and C 154) were stable for four stability parameters in clone x year interaction (Tables 3 and 4).

In each location, clonal variation was significant with yield range of 16.67-33.63 g/t/t at Akwete and 19.38-29.64 g/t/t at Etche (Tables 2 and 4). Clonal variation was also significant in combined analysis with yield range of 20.18-31.30g/t/t/ (Tables 2 and 4).

Discussion

The application of five stability parameters derived from the different stability groups enhanced the inference drawn on clonal stability for latex yield in each of the test-clones. The controversy that often arises with different criteria at various times has been minimized in this study. Fears of bias of the individual parameters have been expressed (Lin *et al.,* 1986).

The significant linear and non-linear components of the clone x environment interaction were an indication of the importance of both predictable and unpredictable clonal response to the various environments. The unpredictable (non-linear) pooled deviation made the clonal contribution

to unpredictable components an imperative. This was such that C 162 was an outstanding clone for clonal stability. This was followed by C 154, C 76 and C 150 in descending order. According to Singh and Gupta (1988), clonal/variety stability has genetic control. The clone C 162, therefore, could be used as a parent-in-crosses to transfer genetic stability for latex yield to progenies. For commercial planting, C 162, C 154, C 76 and C 150 merit broad-spectrum recommendation because of their likelihood of relatively consistent latex yield across different environments. Conversely, C 83, C 143, C 163, C 202 and RRIM 600 will require environment-specific recommendation. This is more so as consistently high latex yield across various years and locations is desired by farmers. Clonal variation for latex yield suggests possible selection for latex yield among these clones.

The clone RRIM 600 was rated unstable in the present study by Goncalves *et al.* (1999). Meenattor *et al.* (1991) reported RRIM 600 stable for girth increment. These results suggest that clonal stability could vary depending on the character under consideration.

Despite the common parentage of C 143, C 145, C 150, C 154, C159, C162 and C 163, these clones exhibited different stability features. The entire range of clonal stability from highly stable clone (C 162) to intermediate (C 150 and C154) and unstable (C 143 and C 163) was manifested among the progenies of the same cross (RRIM 501 x RRIM 628). This suggests high heterogeneity in the parental clones, hence heterogenous progeny were produced. In addition, it supports the opinion of Omokhafe (1998) that

Table 4 - Mean clonal latex yield (g/t/t) and associated stability parameters (S_i, ..., S^2_{di}) of eleven Hevea clones in Akwete, Etche and combined data.

| | Akwete [Clone x (7) years] | | | | | Etche [Clone x (7) years] | | | | | Combined data | | | | | | | | | |
| | | | | | | | | | | | Clone x (7) years | | | | | Clone x (14) environments | | | |
Clone	g/t/t	S_i	$\hat{\sigma}_i^2$	b_i	S^2_{di}	g/t/t	S_i	$\hat{\sigma}_i^2$	b_i	S^2_{di}	g/t/t	S_i	$\hat{\sigma}_i^2$	b_i	S^2_{di}	S_i	$\hat{\sigma}_i^2$	b_i	S^2_{di}
C 76	30.11	15.06*	49.11	1.40	19.71**	23.52	21.93**	36.05	0.90	24.61**	26.81	17.42*	13.55	1.08	1.44	20.02*	196.351**	0.93	160.20**
C 83	23.28	10.87	67.29*	0.80	51.03**	25.05	21.28**	120.22**	0.81	90.68**	24.15	11.30	52.33**	0.66	7.44*	15.87	82.691**	0.82	50.16**
C 143	24.08	8.51	4.88	0.82	-8.71*	28.31	22.96**	64.68**	0.92	55.12**	26.20	14.86*	23.31	0.90	9.71**	17.24*	59.865**	0.93	39.21**
C 145	27.25	14.96*	35.70	1.45	1.20	24.93	25.85**	37.01	1.07	28.61**	26.09	19.79**	26.08*	1.23	-0.81	19.86*	56.600**	1.11	33.90**
C 150	21.02	9.62	7.80	0.91	-2.98	25.89	24.51**	58.90*	0.99	53.35**	23.45	15.97*	11.11	0.99	0.86	18.72*	72.716**	1.01	52.20**
C 154	16.67	10.17	60.28*	0.75	41.97**	25.73	23.04**	2.13	0.97	-2.80	21.20	14.22*	14.25	0.87	-0.71	21.37*	222.748**	0.99	185.15**
C 159	18.68	6.64	42.72	0.53	5.36	24.63	28.41**	50.04*	1.19	21.67**	21.66	16.08*	21.46	0.98	10.88**	21.08*	113.800**	1.12	83.99**
C 162	21.75	12.92	13.44	0.73	-5.07	22.57	16.77*	70.37**	0.70	3.30	22.16	11.25	34.52**	0.69	-4.87	12.18	32.315	0.70	-12.95
C 163	33.63	12.92	27.97	1.20	13.12**	28.97	28.46**	65.08*	1.18	38.43**	31.30	18.10*	5.23	1.14	-10.74**	21.62*	126.065**	1.14	92.82**
C 202	20.98	13.10	42.51	1.16	28.92**	19.38	19.41**	81.68**	0.77	41.87**	20.18	15.96*	26.71**	0.96	15.92**	15.52	68.450**	0.82	37.43**
RRIM 600	31.99	13.85*	43.69	1.26	25.25**	27.64	36.05**	240.49**	1.49	71.28**	30.82	24.49**	116.98**	1.50	29.33**	25.53**	154.686**	1.43	64.07**

*, ** : Significant at p = 0.05 and p = 0.01 respectively (t-test for S_i and S^2_{di}, F-test for $\hat{\sigma}_i^2$ and S^2_{bi}).
S_i: Environmental variance.
$\hat{\sigma}_i^2$: Shukla's stability variance.
b_i: Finlay and Wilkinson's regression index.
S^2_{di}: Deviation from regression.

Table 5 - Components of stability mean squares of latex yield of eleven *Hevea* clones (Cl.) in 14 environments (Env.)-seven years x two locations (Akwete and Etche)-Eberhart and Russell model.

S.V.	df	SS	MS
Total	153	75016.880	490.306
Env.	13	43436.763	3341.289
Clone (Cl.)	10	17557.539	1755.754**
Cl. x Env.	130	14022.578	107.866**
Env. + (Cl. x Env.)	143	57459.341	=
Env. (linear)	1	43436.763	=
Cl. x Env. (linear)	10	1516.285	151.629
Pooled deviation	132	12506.293	94.745**
C 76	12	2201.653	183.471**
C 83	12	881.210	73.434**
C 143	12	749.806	62.484**
C 145	12	686.049	57.171**
C 150	12	905.752	75.479**
C 154	12	2501.091	208.424**
C 159	12	1287.200	107.267**
C 162	12	123.882	10.324
C 163	12	1293.147	107.762**
C 202	12	728.410	60.701**
RRIM 600	12	1048.093	87.341**
Average error	420		23.275

**: Significant at p = 0.01 (F-test).
MS for each clone = S^2_{bi}.

evaluation and selection in *Hevea brasiliensis* should be based on individual selection rather than family selection.

Acknowledgment

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