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THE HERITABILITY OF RAW RUBBER PROPERTIES IN A *HEVEA* POPULATION

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ABSTRACT

The heritability of raw rubber properties in a *Hevea* population was studied and it was found to be low in the case of the population investigated. However some useful correlations between certain properties such as Wallace Plasticity, colour and Mooney viscosity were observed.

INTRODUCTION

The present technical specification system for natural rubber is primarily based on raw rubber properties, such as Nitrogen content, Dirt content, Volatile matter content, Plasticity Retention Index (PRI) and Mooney viscosity etc. In view of the increasing trend in consumer interest for rubbers with specific properties (eg. low protein content, constant viscosity), investigations on heritability of such important characters and possibilities of incorporating them into breeding programmes, are of obvious commercial importance. The present investigation was undertaken to see if these characters are heritable and if so, to see whether they can be incorporated to breeding programmes of *Hevea*.

An estimate of the possibility of improving a crop can be obtained by measuring the heritability of particular characters (Lush, 1937). This heritability can be measured in the 'narrow sense' through analysis of progeny from a diallel cross or in the 'broad sense' by analysis of progeny from a number of families (Hyun, 1970).

Experimental

The population: In-breeding success on controlled pollination was successful

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in only a few crosses which in turn yielded too few progeny to survive selection on early indices of yield and growth. Simmonds (1969) has mentioned that nearly all the characters that a plant breeder has to deal with are polygenic cannot be handled by Mandelian techniques but must be treated conceptually by biometrical genetical methods. The experimental field planted did not include parental trees as they had gone out of commercial planting.

The population studied consisted of (Table 1) progeny from 1957 to 1959 hand pollination programmes using material from the 'Wickham base' such as Mil 3/2, PB 86, Tjir 1 and the non Wickham introduction RRIC 52 originating from the Tjikadoe seed Garden of Indonesia in 1930. This population is representative of the crosses used currently in planting such as the RRIC 100 series.

The variables (properties)

The variables measured using standard methods for testing raw rubber were:

1. Plasticity (P)
2. Girth
3. Plasticity Retention Index (PRI)
4. Colour
5. Ash Content
6. Nitrogen content
7. Volatile matter content (VM)
8. Mooney viscosity (MV)

Heritability

Heritability of a trait is assessed as equal to the genotype variance divided by the phenotypic variance.
Notationally,

$$H = \frac{\sigma_g^2}{\sigma_g^2 + \sigma_e^2}$$

Where σ_g^2 is the genotypic variance of the trait and $\sigma_g^2 + \sigma_e^2$ is the phenotypic variance of the trait.

In practice, heritability (H) is estimated using experimental (sample) data using the formula

$$\hat{H} = \frac{\hat{\sigma}_g^2}{\hat{\sigma}_g^2 + \hat{\sigma}_e^2}$$

where $\hat{\sigma}_g^2$ is the estimated genotypic variance and $\hat{\sigma}_g^2 + \hat{\sigma}_e^2$ is the estimated phenotypic variance.

Table 1. *Parentage of progeny measured*

	Number of replications
1. Ch 26 x RRIC 52	11
2. Av 157 x RRIM 501	5
3. Av 163 x T 1968	12
4. Wg 6278 x T_j 1	3
5. T_j 1 x RRIC 50	16
6. RRIC 52 x PB 86	17
7. Av 163 x T 841	7
8. PB 86 x RRIC 52	6
9. PB 86 x RRIC 36	15
10. PB 5/139 x RRIC 52	10
11. PB 86 x T 306	13
12. T 713 x T_j 1	3
13. T 170 x T_j 1	6
14. LCB 1320 x RRIC 45	4
15. RRIC 45 x RRIC 13	4
16. RRIC 86 x RRIC 7	3
17. Ch 26 x RRIC 7	8
18. RRIC 86 x RRIC 52	4
19. PB 86 x RRIC 38	11
20. Mil 3/2 x T_j 1	3
21. RRIC 52 x T_j 1	6
22. PB 86 x T 243	4
Total(N) =	171

Table 2. *The general form of the analysis of variance (ANOVA). for a given trait*

Source of variation	Degrees of freedom	Mean square	Expected mean square
Clones	r-1	M1	$\sigma_e^2 + K\sigma_g^2$
Replications within clone (error)	N-r	M2	σ_e^2
Total	N-1		

where,

$$K = \frac{1}{r-1}\left(N - \frac{1}{N}\Sigma n_i^2\right)$$

r = Number of clones

N = Total number of observations (i.e. $N = \Sigma n_i$)

From the information in Table 2, we estimate σ_e^2 and σ_g^2 for this trait as follows:

$$\hat{\sigma}_e^2 = M_2 \; ; \; \hat{\sigma}_g^2 = (M_1 - M_2)/K$$

The following table (Table 3) summarizes results obtained from ANOVA done on the 8 variables studied.

Table 3. *Estimates of genetic and environmental variance components and heritability for the raw rubber properties*

	Girth	VM	P_0	PRI	N	ASH	COLOR	MV
F value from ANOVA	3.15*	1.16	2.73	1.5	.51	.84	4.38*	3.5*
Estimated genetic variance $\hat{\sigma}_g^2$	29.6	0	18.2	7.1	0	0	1.8	29.9
Estimated environmental variance $\hat{\sigma}_e^2$	105.3	.01	80.4	112.8	.001	.001	3.96	92.2
Estimate of heritability	.22	0	.18	.06	0	0	.31	.24

where * denotes significant F-test at 5% level.

Since the correlations computed using "within clone" results do not say much about the genetical relationship among the characters, genetic correlations (and also phenotypic correlations) were computed.

Genetic correlation between two traits x and y, is estimated as follows:

$$\hat{r}_g = \frac{\hat{\sigma}_{g.x.y}}{\hat{\sigma}^2_{g.x.x} \quad \hat{\sigma}^2_{g.y.y}}$$

where $\hat{\sigma}_{g.x.y}$ = Estimate of genetic covariance between x and y

$\hat{\sigma}^2_{g.x.x}$ = Estimate of genetic variance of x

$\hat{\sigma}^2_{g.y.y}$ = Estimate of genetic variance of y

Phenotypic correlation between two traits x and y, is estimated as follows:

$$\hat{r}_p = \frac{\hat{\sigma}_{g.x.y} + \hat{\sigma}_{e.x.y}}{(\hat{\sigma}^2_{g.x.x} + \hat{\sigma}^2_{e.x.x})\ (\hat{\sigma}^2_{g.y.y} + \hat{\sigma}^2_{e.y.y})}$$

where $\hat{\sigma}_{e.x.y}$ = Estimate of environmental covariance between x and y

$\hat{\sigma}^2_{e.x.x}$ = Estimate of environmental variance of x (and similarly for y)

In addition to the ANOVA for x and y separately, the cross-product analysis (i.e. covariance) as given in Table 4, can be used to estimate the genetic and environmental covariance components.

Table 4. *General form of the cross-product analysis for two traits x and y*

Source of variation	Degrees of freedom	(xy)	Mean square
Clones	r-1	A1	M1
Replication within clone	N-r	A2	M2
Total	N-1		

Where (xy) denotes corrected sum of products of x and y.

$M_1 = A_1/r\text{-}1$; $M_2 = A_2/N\text{-}r$

and $\hat{\sigma}_{g.x.y} = \dfrac{M_1 - M_2}{K}$ where k is the same as before (Table 2).

It is important to note that one can not talk about genetic correlation between characters with very small genetic variance. Estimates of genetic correlations for those characters with not very small genetic variances are given in Table 5.

Table 5. *Estimates of genetic correlations*

	Girth	P_o	PRI	Colour	MV
Girth	1.00	-.52	.09	.29	-.44
P_o		1.00	-.73	-.42	1.00
PRI			1.00	.4	-.87
Colour				1.00	-.4

We note a value of 1.00 for the genetic correlation between P and MV in Table 5. This means P_0 is the same as MV in genetical sense. This is not very surprising as P_0 and MV refer basically to the same property, measured using different instruments.

Table 6. *Estimates of phenotypic correlations*

	GIRTH	VM	P_0	PRI	N	ASH	COLOUR	MV
Girth	1.00	-.11	-.09	.05	-.09	-.04	-.06	-.05
VM		1.00	-.06	.04	.04	.04	-.25	-.05
P_0			1.00	-.47	-.29	-.28	-.13	.91
PRI				1.00	.1	.11	.14	-.48
N					1.00	.16	-.02	-.25
ASH						1.00	.14	-.33
COLOUR							1.00	-.19

DISCUSSION

Improvement of the composition of latex and of the chemical and physical properties of the rubber obtained from it, is becoming increasingly important. It is therefore necessary to assess the genetic potential for such improvement in the crop. Earlier breeding programmes have concentrated on improvement of yield and growth. Heritability estimates permit us to establish how much of the observed variation is due to genetic causes, i.e. unaffected by the environment and how much is a direct result of the influence of the environment. However, it has to be remembered that this method is statistical rather than genetical and do not give exact genetical information the genetic basis of the different characters studied (Kempthrone, 1957). Heritability estimates also presuppose that the characters studied are conditioned by polymeric genes. The greater the heritability, the greater the average resemblance between the parents and the progeny. The greater the environmental component of the observed phenotypic variation, the lesser the correlation between parents and progeny.

The genetic variance of some characters (Table 3) is probably quite low as all our early rubber stemmed from few hundred seeds collected by Wickham from a single area in Brazil except for one clone RRIC 52 imported later from another area in Brazil and included in a seed garden. In view of the wide acceptance of Sri Lankan clones in other rubber growing countries these estimates would be of interest.

In the present investigation the estimates of heritability of various raw rubber properties as shown in Table 3 indicate that possibility of breeding towards a definitely improved raw rubber is rather remote in the context of the population under study. However, substantial correlation were shown between certain properties such as girth, plasticity, PRI, colour and Mooney viscosity (Table 5). Some of these correlations are quite unexpected and the present state of knowledge seems inadequate to explain them sufficiently. However, this information is of value in assessing the influence of one character on the other, particularly where the producer is solely interested in a single character (eg constant viscosity, low protein content) because of consumer preference for such characters.

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