J. Rubb. Res. Inst. Malaya, **21(2)**, 181–191 (1969)

Effect of Fertiliser Applications on Latex Properties

H. M. COLLIER and J. S. LOWE
Dunlop Research Centre, Batang Melaka, Negri Sembilan, Malaysia

Latex samples were taken for analysis at intervals from four long-term nitrogen × phosphate fertiliser experiments laid down at least eight years previously on rubber that had recently come into tapping. Additionally samples of concentrate were prepared from them.

Nitrogen fertilisation increased the nitrogen content of sheet and dried films made from the field latex. It reduced its total solids and dry rubber content and increased the concentration of titratable acids. Nitrogen fertilisation also increased the magnesium content of the latex.

In concentrate nitrogen fertilisation produced a significant reduction in mechanical stability which could not be fully accounted for by the increase in excess magnesium present. An increase in KOH No.—which is how the concentration of titratable acids is expressed in the concentrate—due to nitrogen fertilisation was clearly apparent in the samples tested, regardless of whether they were tested when twelve days or one month old.

Phosphate fertilisation increased the phosphate content of the field latex and as a result reduced the excess magnesium content, thus resulting in a general increase in stability of the latex concentrate. Where pre-war rubber had received limited phosphate fertilisation before coming into tapping phosphate also increased the titratable acids.

When the magnesium/phosphate balance in the field latex was adjusted prior to concentration by the addition of di-ammonium hydrogen phosphate, the depressive effect of nitrogen fertilisation on stability was again minimised. The addition of this phosphate however increases the level of KOH No.

The application of fertilisers to mature trees of *Hevea brasiliensis* has been common practice for many years because of the beneficial effect on yield, but there has been little investigation into the effect of a steady application of fertilisers over a period of years on the properties of the latex so produced. PHILPOTT AND WESTGARTH (1953) showed that a combination of potassium, phosphate, and nitrogen increased the stability of the concentrate from the latex of seedlings growing on a highly potassium deficient soil but the design of the experiment did not permit the effect of the different elements in the fertiliser application to be studied separately. Many workers have analysed field latex after fertiliser applications and BEAUFILS (1958 and 1959) has included such analyses in his system of 'Diagnostic Physiologique' for recommending fertiliser applications. None of these more recent studies have however been concerned primarily with the effect of fertiliser applications on latex properties. However during investigations into the factors affecting the properties of latex (LOWE, 1959, 1960, 1962), evidence began to accumulate indicating that certain fertilisers could have a marked effect, and several of the factoral field experiments carried out by Dunlop Estates Berhad were investigated further in order to examine this hypothesis.

Details of these N × P field experiments has been fully reported by MAINSTONE (1963) together with the effect on yield, leaf analysis and various aspects of growth. The design of each experiment was the same, namely six blocks each with six plots receiving nitrogen and phosphate fertiliser annually according to the following plan:

COMMUNICATION 461

Treatment	Ammonium sulphate	Christmas Island rock phosphate
Control (n_0p_0)	Nil	Nil
n_1p_0	$1\frac{1}{2}$ lb	Nil
n_2p_0	3 lb	Nil
n_0p_1	Nil	$1\frac{1}{2}$ lb
n_1p_1	$1\frac{1}{2}$ lb	$1\frac{1}{2}$ lb
n_2p_1	3 lb	$1\frac{1}{2}$ lb

Table 1 (see page 183) summarises the relevant agricultural information for the experiments.

METHODS

Latex was sampled from these experiments over the period 1963–1967 and either the field latex or the concentrated latex or both was analysed.

The latex from the thirty-six core trees of each plot of an experiment was bulked after normal collection. In the field latex studies the bulk was divided into two samples, one ammoniated to 0.5% NH_3 while the other was preserved with 0.4% formaldehyde/boric acid buffer. This latter sample was used for all analyses except the determination of titratable acids. A dried film of latex was prepared for the determination of nitrogen, acetone extract and potassium. B.S.I. methods of analysis were used for total solids, dry rubber content, nitrogen and acetone extract while potassium was determined with a flame photometer on an ashed sample of the dried film.

Phosphate was determined directly on samples of the serum obtained by coagulating the latex with trichloracetic acid, filtering it, and passing it through a cationic exchange resin (Amberlite IR 112H) and then developing the molybdate blue complex. The phosphate figures quoted are therefore a measure of the ionic and not the total phosphate in the latex. However in field latex the quantity of bound phosphate is comparatively small, and in considering the stability of latex the ionic phosphate is of the greater relevance.

Magnesium in field latex samples was determined by direct titration of the latex, using essentially the method of RESING (1955) which involves diluting the latex one hundredfold, adjusting the pH to 10.5 with ammonia/ammonium chloride buffer and adding potassium cyanide before titrating with EDTA using Eriochrome Black as indicator. The titre gives a direct measure of total magnesium and calcium milli-equivalents in the latex. As the proportion of calcium is small its presence has been disregarded and magnesium regarded as the only divalent ion titrated. The results are expressed as a percentage rather than milli-equivalents because this is the more usual convention.

In latex concentrate the organic acids present are determined by direct titration of the latex with KOH and the results expressed as a KOH No. (g KOH/100 g solids). It is similarly possible to titrate ammonia preserved field latex with KOH, and assuming the organic acids are exclusively present in the serum phase, the titre and total solids of the latex will allow one to predict the KOH No. of the concentrate prepared from that latex. It has been shown by NANDY (1963), that the predicted KOH No. calculated from the field latex titre agrees very closely with that found by direct titration of the concentrate. (For eleven samples the predicted KOH No. averaged 97% of that found by direct titration of the concentrate). This indicates that the acids are present essentially in the serum, and may be determined by titration of the field latex.

The titratable acids in the field latex were always determined on the day of tapping, before there was any possibility of V.F.A. formation. The results were expressed as milli-equivalents/litre of serum.

In preparing the samples of concentrated latex, ammoniated samples of field latex from plots of similar treatment within the experiment were bulked before being passed through a de Laval LR 16 type centrifuge adjusted to produce a d.r.c. of 61%. The concentrate was quickly ammoniated to 0.7% NH_3 and divided

TABLE 1. AGRICULTURAL DETAILS OF THE EXPERIMENTS FROM WHICH LATEX SAMPLES WERE TAKEN

Experiment No.	1	2	4	5
Year of planting	1940/1	1940/1	1948	1948
Budded with clone	Tjir 1	Pil B 84	Tjir 1	PB 86
Fertiliser applications prior to commencement of tapping	Ammonium sulphate and Christmas Island rock phosphate applied during first year of growth and then not again until after the Japanese Occupation, *i.e.*, from 1947 to 1949		Ammonium sulphate and Christmas Island rock phosphate to rubber and rock phosphate to ground covers at equivalent rates of nitrogen and phosphate to those generally recommended for inland soils (RUBBER RESEARCH INSTITUTE OF MALAYA, 1953, 1954)	
Experimental treatments commenced	1950	1951	1956	1958
Tapping system at times of latex sampling	S/2.d/2	2 S/2.d/3	2 S/2.d/3	original
% Increases in yield over control due to application of ammonium sulphate at n_1 level	21	31	7	1
at n_2 level	31	38	21	2

Note: 1. The yield increases refer to the yield recording year 1965/6; no beneficial effect on yield as a result of phosphate fertilisation has been recorded in any of the experiments.
2. In studying field latex properties, three separate samplings were carried out in Experiment 1, referred to in the text as experimental samplings 1/1, 1/2 and 1/3.

into samples in full one litre containers which were then sealed and stored. % T.S., % d.r.c., volatile fatty acids (V.F.A.), KOH No. and mechanical stability (M.S.T.) were determined by normal B.S.I. procedures after twelve days and one month's storage.

RESULTS

Field Latex

When the experiments were started one half of the blocks in each experiment was tapped continuously (S/2.d/2,100%) while in the other half a periodic tapping system was used (S/2.d/2, 6m/9, 67%). Except for Experiment 5, however a common tapping system was in use by the time the experiments were sampled *(Table 1)*. These variations in tapping history will have meant some variation in the height of the tapping cut (or where the tapping system was 2S/2.d/3, 133 % in the height of the lower cut) but in the analysis of results, the tapping history was never found to affect the mineral analysis.

In those experiments tapped 2S/2.d/3, 133%, the latex from the upper and lower cuts was bulked at the time of sampling.

The effect of fertiliser treatment on % T.S. and % d.r.c. was similar and in *Table 2* only the % T.S. results are given in detail. Nitrogen fertilisation reduced % T.S. to a small extent, and the effect generally achieved a high level of significance. Phosphate fertilisation also tended to reduce % T.S. but only once was the effect significant.

Nitrogen fertilisation markedly increased the nitrogen content of the dried film *(Table 2)*; it also increased the nitrogen content of samples

TABLE 2. EFFECT OF NITROGEN FERTILISATION ON ANALYSIS OF FIELD LATEX

Experiment/Sampling No.	Treatment n_0	n_1	n_2	P value	S.E.
% Total solids					
1 (1)	37.4	36.8	36.2	N.S.	0.45
1 (2)	40.8	40.3	39.5	(<0.001)	*
1 (3)	39.0	37.5	36.9	<0.01	0.41
2	36.0	36.0	34.6	<0.01	0.34
4	40.0	38.6	37.5	<0.001	0.30
5	35.2	34.0	33.6	<0.001	0.22
Mean	38.1	37.2	36.4		
% Dry rubber content					
Mean	35.0	34.1	33.1	similar to those for total solids	
% Nitrogen on T.S.					
1 (1)	0.59	0.63	0.70	<0.001	0.015
1 (2)	0.61	0.64	0.69	<0.001	0.013
1 (3)	0.61	0.66	0.71	<0.001	0.019
2	0.63	0.66	0.72	<0.01	0.016
4	0.68	0.79	0.82	<0.001	0.014
5	0.69	0.78	0.81	<0.001	0.019
Mean	0.63	0.69	0.74		
% Magnesium on serum					
1 (1)	0.058	0.062	0.071	<0.01	0.0027
1 (2)	0.047	0.054	0.060	<0.05	0.0028
1 (3)	0.042	0.046	0.054	<0.05	0.0029
2	0.050	0.059	0.069	<0.001	0.0017
4	0.094	0.108	0.119	<0.01	0.0047
5	0.087	0.091	0.113	<0.001	0.0044
Mean	0.063	0.070	0.081		
% Potassium on serum					
Mean	0.34	0.35	0.35	P <0.05: in no sampling	
% Phosphate (PO_4) on serum					
Mean	0.250	0.233	0.227	P <0.05: in only one sampling†	

* Highly significant interactions between fertiliser treatments and the former tapping system prevented the calculation of a standard error.

† Experiment 5. $n_0 = 0.214$ $n_1 = 0.196$ $n_2 = 0.171$ P value <0.05 S.E. 0.0103

of rubber prepared by acid coagulation as the results in *Table 3* show. The acetone extract of these acid coagulated samples are also given in *Table 3*; no consistent trend is observed. The same was true in a few exploratory determinations on the acetone extract of dried films of field latex.

Nitrogen fertilisation consistently increased the magnesium content (expressed as a percentage on the serum) *(Table 2)* while phosphate fertilisation tended to reduce it to a small extent, though the effect was never significant.

Phosphate fertilisation increased the phosphate content of the serum on average by more than 60% *(Table 4)* and tended to reduce the magnesium content slightly though only once to a significant extent.

TABLE 3. AIR DRIED SHEET PREPARED ON FIVE SEPARATE OCCASIONS FROM LATEX FROM EXPERIMENT 4

Fertiliser treatment					
n_0		n_1		n_2	
% Nitrogen	% Acetone extract	% Nitrogen	% Acetone extract	% Nitrogen	% Acetone extract
0.32	3.15	0.42	2.66	0.48	2.40
0.32	3.09	0.43	2.65	0.46	3.70
0.33	4.39	0.42	3.69	0.47	3.63
0.33	4.41	0.42	3.68	0.53	2.57
0.40	3.47	0.48	2.81	0.53	2.36

The combined effect of nitrogen and phosphate fertilisation on the residual magnesium and phosphate remaining after ammoniation and removal of sludge will be very marked. The two way table *(Table 5)* has been calculated by way of example from the results in *Tables 2* and *4* for experimental sampling 1(1) on the assumption that on ammoniation the magnesium and phosphate will be precipitated stoichiometrically in the proportion 1:1, a proportion that is close to that found in practice.

TABLE 4. EFFECT OF PHOSPHATE FERTILISATION ON ANALYSIS OF FIELD LATEX

Experiment/Sampling No.	Treatment p_0	Treatment p_1	P value	S.E.
% Phosphate (PO_4) on serum				
1 (1)	0.169	0.308	<0.001	0.0078
1 (2)	0.137	0.285	<0.001	0.0076
1 (3)	0.169	0.301	<0.001	0.0113
2	0.208	0.330	<0.001	0.0105
4	0.227	0.319	<0.001	0.0076
5	0.163	0.221	<0.001	0.0084
Mean	0.179	0.294		
% Total solids				
Mean	37.5	36.9	$P<0.05$: in only one sampling*	
% Dry rubber content				
Mean	34.4	33.7	$P<0.05$: in only two samplings	
% Nitrogen on T.S.				
Mean	0.69	0.69	$P<0.05$: in no sampling	
% Magnesium on serum				
Mean	0.074	0.069	$P<0.05$: in no sampling	
% Potassium on serum				
Mean	0.35	0.35	$P<0.05$: in no sampling	

*Sampling 1(1) $p_0 = 37.8$ $p_1 = 36.0$ P value < 0.01 S.E. 0.37

TABLE 5. EXCESS MAGNESIUM OR PHOSPHATE REMAINING IN SAMPLES FROM EXPERIMENTAL SAMPLING 1 (1) AFTER AMMONIATION EXPRESSED AS % Mg OR % PO_4 ON SERUM

	Treatment		
	n_0	n_1	n_2
p_0	0.012% Mg	0.018% Mg	0.033% Mg
p_1	0.071% PO_4	0.067% PO_4	0.031% PO_4

Neither nitrogen nor phosphate fertilisation affected the concentration of potassium. The average figure in only one sampling was outside the range 0.33 to 0.38%.

Nitrogen fertilisation on all occasions increased the titratable acids *(Table 6)* whereas phosphate fertilisation increased them only in the two experiments, which were planted prewar, and which by present day standards received during immaturity an inadequate level of phosphate fertilisation. The increase in titratable acids due to nitrogen fertilisation is modest, the high levels of significance obtained nonetheless being a reflection of the fact that each figure in *Table 6* is the mean of determinations on separate samples from each of the six plots. As an ammoniated latex ages, however, the KOH No. even in the absence of V.F.A. formation increases considerably and quite possibly the percentage differences in KOH No. will be maintained, widening the actual differences. This point has not been investigated on the field latex samples, but is considered in the next section.

Concentrate Latex

The production of concentrate from field latex by centrifugation can introduce certain variables into an investigation such as this. The properties of concentrated latex must be assessed when the latex has matured to give a full development of the mechanical stability (M.S.T.) and volatile fatty acid (V.F.A.) and this introduces the factor of preservation standards. Using gaseous ammonia it is difficult to ammoniate small volumes of concentrate to a given level, while a solution of ammonia causes a decrease in % d.r.c. However for latex which is stored in full sealed containers immediately after processing, the ammonia level (as long as it is above 0.60% NH_3) does not seem in any way important. The prompt centrifugation of the field latex also eliminated much of the variation in its standard of preservation and V.F.A. formation in sealed containers is negligible. By eliminating V.F.A. as a variable in the properties of concentrated latex it was possible to relate variations in KOH No. and M.S.T. to the fertiliser treatments.

Table 7 gives the properties of latex concentrate prepared on four separate occasions from three different experiments. The samples were tested twelve days and one month after processing.

Nitrogen fertiliser alone had a marked depressive effect on the stability of the latex and caused an increase in the excess magnesium but the extent of this decreased stability was greater than could be accounted for wholly by magnesium because when the excess magnesium levels were corrected by the addition of di-ammonium hydrogen phosphate (DAHP) to the field latex a somewhat lower stability was still associated with nitrogen fertilisation *(Table 8)*.

Phosphate fertiliser when applied alone had very little effect; when used in conjunction with nitrogen fertiliser, however it improved the mechanical stability, eliminating in large part the destabilising effect of the nitrogen fertiliser, wherever it brought the concentration of magnesium and phosphate roughly into balance.

Generally speaking nitrogen fertiliser applications caused an increase in KOH No. whereas phosphate fertilisers had no effect. In individual experiments the results are not always clear-cut. In *Table 9*, therefore, the average KOH No. by treatments for all month-old samples from *Table 7* have been calculated. The results are in qualitative agreement with the effect of fertiliser treatment on the concentration of titratable acids, obtained by direct titration of the field latex and discussed in the previous section. Quantitatively, the effect of nitrogen fertilisation is if anything more marked.

TABLE 6. TITRATABLE ACIDS IN FIELD LATEX IN MILLI-EQUIVALENTS/LITRE OF SERUM

Experiment/Sampling No.		Treatments			Phosphate means	Effect of treatments	
		n_0	n_1	n_2		Nitrogen	Phosphate
1/1	p_0	89	94	102	95	P < 0.001	P < 0.001
	p_1	96	101	106	101	S.E. 1.3	S.E. 1.1
Nitrogen means		92	97	104			
1/2	p_0	109	118	131	119	P < 0.001	P < 0.001
	p_1	123	137	134	131	S.E. 2.3	S.E. 1.8
Nitrogen means		116	128	132			
1/3	p_0	108	106	122	112	P < 0.01	P < 0.01
	p_1	120	119	123	121	S.E. 2.1	S.E. 1.6
Nitrogen means		114	112	123			
2	p_0	105	113	119	112	P ca 0.05	P < 0.001
	p_1	121	124	125	123	S.E. 2.2	S.E. 1.8
Nitrogen means		113	119	122			
4	p_0	145	155	156	152	P < 0.01	P < 0.20
	p_1	138	150	154	147	S.E. 2.7	S.E. 2.2
Nitrogen means		141	153	155			
5	p_0	119	138	139	132	P < 0.001	N.S.
	p_1	123	130	137	130	S.E. 2.9	S.E. 2.3
Nitrogen means		121	134	138			
Overall nitrogen means		116	124	129			
Overall nitrogen means as KOH No.*		0.39	0.42	0.44			

*The KOH No. is calculated from the preceding data for a putative concentrate of 61.8% T.S. on the assumption that all the titratable acids are in the serum. The units are g KOH/100 g solids.

TABLE 7. TEST FIGURES ON CONCENTRATE SAMPLES

Experiment	NH_3 (% on latex)	Mg (% on film)	12 Days V.F.A.	12 Days KOH No.	12 Days M.S.T. (sec)	1 Month V.F.A.	1 Month KOH No.	1 Month M.S.T. (sec)
No. 1								
Control n_0p_0	0.64	0.007	0.016	0.43	680	0.016	0.50	820
n_1p_0	0.61	0.013	0.021	0.59	540	0.021	0.59	825
n_2p_0	0.62	0.022	0.025	0.70	300	0.025	0.71	265
n_0p_1	0.65	0.004	0.016	0.53	735	0.016	0.53	760
n_1p_1	0.61	Nil	0.018	0.67	545	0.018	0.62	640
n_2p_1	0.64	Nil	0.020	0.61	530	0.018	0.61	625
No. 1								
Control n_0p_0	0.67	0.003	0.017	0.47	700	0.014	0.48	1045
n_1p_0	0.69	0.006	0.015	0.50	580	0.014	0.54	820
n_2p_0	0.73	0.017	0.016	0.62	330	0.016	0.73	460
n_0p_1	0.73	Nil	0.017	0.48	725	0.025	0.55	940
n_1p_1	0.69	Nil	0.018	0.52	540	0.023	0.52	875
n_2p_1	0.73	0.003	0.015	0.53	590	0.014	0.61	1000
No. 2								
Control n_0p_0	0.50	0.002	0.019	0.49	525	0.019	0.59	950
n_1p_0	0.47	0.006	0.027	0.54	430	0.027	0.59	885
n_2p_0	0.50	0.017	0.043	0.70	300	0.043	0.85	525
n_0p_1	0.62	Nil	0.016	0.54	815	0.017	0.59	1085
n_1p_1	0.63	Nil	0.020	0.60	720	0.017	0.60	1165
n_2p_1	0.62	Nil	0.024	0.61	510	0.024	0.67	1095
No. 4								
Control n_0p_0	0.84	0.018	0.016	0.56	240	0.014	0.53	425
n_1p_0	0.81	0.033	0.021	0.66	120	0.021	0.58	230
n_2p_0	0.77	0.050	0.019	0.60	165	0.016	0.55	195
n_0p_1	0.81	0.014	0.021	0.54	225	0.016	0.54	520
n_1p_1	0.72	0.020	0.015	0.60	165	0.016	0.60	400
n_2p_1	0.73	0.036	0.020	0.58	130	0.019	0.60	220

TABLE 8. EFFECT OF DAHP ADDITION ON THE M.S.T. AND MAGNESIUM CONTENT OF CONCENTRATE SAMPLES* FROM EXPERIMENT NO. 4

	M.S.T. (sec) Treatment n_0	n_1	n_2		% Magnesium on serum Treatment n_0	n_1	n_2
Original				Original			
p_0	425	230	195	p_0	0.018	0.033	0.050
p_1	520	400	220	p_1	0.014	0.020	0.036
With DAPH†				With DAHP†			
p_0	640	490	400	p_0	0.006	0.009	0.008
p_1	740	700	570	p_1	0.004	0.003	0.007

*Tested when 1-month-old
†The quantity of DAHP added was calculated to remove all the excess magnesium.

The results quoted in *Table 7* are for concentrate that has been prepared from field latex without any adjustment to properties, and it will be noted that even in some of the phosphate fertiliser treatments the level of magnesium in the concentrate is too high for the latex to be fully acceptable to the consumer. For commercial production of concentrate from such latex DAHP would have to be added before centrifugation, and as will be seen, this in itself raises the level of KOH No. in all treatments, due presumably to the release of KOH titratable acids (HX) according to the equation:

$$MgX_2 + (NH_4)_2\,HPO_4 \longrightarrow Mg\,NH_4\,PO_4 \downarrow + NH_4X + HX$$

TABLE 9. OVERALL EFFECT OF FERTILISER APPLICATIONS ON KOH No.

Nitrogen fertilisers		Phosphate fertilisers	
Treatment	KOH No.	Treatment	KOH No.
n_0	0.54	p_0	0.60
n_1	0.58	p_1	0.59
n_2	0.67		

When the same amount of DAHP was added to half the field latex from each treatment in Experiment No. 5, and subsequently the KOH Nos. of the resulting concentrates compared the results were:

Treatment of latex	Fertiliser treatment					
	n_0p_0	n_1p_0	n_2p_0	n_0p_1	n_1p_1	n_2p_1
Untreated	0.53	0.58	0.60	0.54	0.60	0.60
Treated with DAHP	0.65	0.71	0.71	0.60	0.65	0.71

but the final magnesium levels were variable since the latex from the n_2 treatments would have required far more DAHP than the control or n_0 treatment latex if the same magnesium level was to be arrived at. To demonstrate the effect of DAHP independent of any fertiliser applications two high magnesium latex clones: Gl 1 and PB 86 were sampled and DAHP added to half of each of the latices so that after concentration the level of magnesium had been reduced from the range 0.04%–0.06% to 0.005% on the concentrate solids. The concentrate was stored for one month and tested for KOH No. With each clone the whole experiment was repeated to ensure that the results were not fortuitous:

	KOH No.			
	Gl 1		PB 86	
	Expt. A	Expt. B	Expt. C	Expt. D
Control	0.46	0.54	0.51	0.54
DAHP added	0.55	0.69	0.64	0.70

DISCUSSION

The use of fertilisers such as ammonium sulphate and Christmas Island rock phosphate on mature *Hevea* has been prompted by the desire to improve the yield and condition (girthing and canopy) of the trees, on the assumption that the final product of the plantation—sheet or latex concentrate—would not be affected in properties.

The experiments described above show that fertilisers can have a marked effect on properties. Nitrogen fertiliser applications increase the non-rubbers in ADS which in turn must affect the properties of the rubber and both nitrogen and phosphate fertilisers markedly affect the properties of latex concentrate.

The use of ammonium sulphate fertiliser not only markedly lowers the mechanical stability of the latex, in part by causing an increase in the excess magnesium content, but it also raises the level of KOH No; and since the higher level of excess magnesium would need to be reduced in commercial practice, nitrogen fertiliser applications require the addition of extra di-ammonium hydrogen phosphate which itself causes further increases in the level of KOH No.

Rock phosphate fertiliser raises the stability fo the concentrate by reducing the excess magnesium and eliminating the destabilisation effect due to nitrogen fertiliser applications.

These results go a long way towards explaining the embarrassing fact that smallholder latex from areas which are known to receive no manurial attention, if adequately preserved often gives a much less variable latex concentrate than that from a more progressive estate that uses fertilisers regularly under good supervision.

The influence of di-ammonium hydrogen phosphate on the KOH No. is very pertinent because recently there has been an attempt to set the I.S.O. standards for the KOH No. in latex concentrate at a maximum of 0.80.

Over the decade 1957 to 1967, the average KOH No. recorded each year by Dunlop Estates Berhad for their C.60 shipments has risen steadily from 0.64 to 0.78, while the V.F.A. has remained constant throughout at 0.11 ± 0.01. The determinations were carried out one month after shipment when the latex was fully matured and each year's result is the average for roughly 9 000 000 gallons of concentrate *(Table 10)*.

TABLE 10. AVERAGE TEST FIGURES OF DUNLOP COMMERCIAL SHIPMENTS ON A YEAR-BY-YEAR BASIS

Year	KOH No.	V.F.A.
1957	0.64	0.117
1958	0.65	0.116
1959	0.64	0.117
1960	0.66	0.090
1961	0.69	0.091
1962	0.72	0.092
1963	0.77	0.113
1964	0.75	0.108
1965	0.76	0.117
1966	0.76	0.110
1967	0.78	0.118

During this period the application of ammonium sulphate fertiliser—but not rock phosphate—to mature trees on the Dunlop estates has been standard practice. The quantity of DAHP that has had to be added to the latex to counteract an increased magnesium level has risen over the same period from 0.034% to 0.144% DAHP expressed on the field latex d.r.c., corresponding to an increase in KOH No. in the concentrate of roughly 0.03. The remaining increase in KOH No., it is suggested, can be accounted for strictly in terms of changes in agricultural practice. Two factors that may well have had a bearing are alterations in the clonal make-up of the rubber being tapped, and a tendency to tap an increasing proportion of the older rubber on a high cut. It is clear however from the results given in this paper that an important and quite possibly the most important cause has been the fertiliser policy practised on the company's estates.

To set a maximum KOH No. of 0.80 on latex concentrate when figures of this order are achieved as a result of the introduction of up-to-date agricultural policies would penalise the plantation industry in its attempts to reduce production costs and keep its products competitive in present day markets. This limitation seems particularly illogical in that little, if any, experimental work has been carried out on the effect the acids titrated as KOH No. (other than the V.F.A. portion) have on the processing properties of the latex.

ACKNOWLEDGEMENT

The authors would like to thank Dunlop Estates Berhad for permission to present this paper and their colleagues for assistance in obtaining the data included in it.

REFERENCES

BEAUFILS, E.R. (1958) Le diagnostic physiologique II—Conception des recherches et méthodologie; établissement de la méthode dans les plantations. *Revue gén. Caoutch.*, **35**(7), 922.

BEAUFILS, E.R. (1959) Le diagnostic physiologique III—Mécanisme de l'interprétation. *Revue gén. Caoutch.*, **36**(2), 225.

LOWE, J.S. (1959) Formation of volatile fatty acids in ammonia-preserved natural latex concentrate. *Trans. Instn Rubb. Ind.*, **35**(1), 10.

LOWE, J.S. (1960) Substrate for VFA formation in natural rubber latex. *Trans. Instn Rubb. Ind.*, **36(4)**, 202.

LOWE, J.S. (1962) Effect of magnesium on latex quality. *Trans. Instn Rubb. Ind.*, **38(5)**, 208.

MAINSTONE, B.J. (1963) The effects of nitrogen and phosphorus fertilisers on *Hevea brasiliensis* when applied after commencement of tapping. *Emp. J. exp. Agric.*, **31(123)**, 226.

NANDY, A.R. (1963) Private communication. Dunlop Research Centre.

PHILPOTT, M.W. AND WESTGARTH, D.R. (1953) Stability and mineral composition of *Hevea* latex. *J. Rubb. Res. Inst. Malaya*, **14**, 133.

RESING, W.L. (1955) Magnesium and phosphate distribution in latex. *Archs Rubb. Cult.*, **32(1)**, 169.

RUBBER RESEARCH INSTITUTE OF MALAYA (1953) Fertiliser treatment and maintenance for young replantings. *Plrs' Bull. Rubb. Res. Inst. Malaya No. 9*, 120.

RUBBER RESEARCH INSTITUTE OF MALAYA (1954) Establishing a legume cover. *Plrs' Bull. Rubb. Res. Inst. Malaya No. 14*, 93.

DISCUSSION

Chairman: Prof. D.S. MacLusky

Mr. E. Pushparajah noted that the rise in KOH number was observed from the late 1950's when magnesium fertilisers were first widely used without a concomitant increase in applications of potassium; the latter were now recommended and better balanced K/Mg fertilisers might reduce the KOH number by increasing the content of phosphorus in latex and depressing the amount of magnesium. Mr. Collier replied that magnesium fertilisers were not applied in the mature areas concerned, where the potassium content of the soils was relatively high as compared to average Malaysian conditions; therefore, this did not seem a likely explanation, although admittedly the effect of potassium amendments alone had not been investigated.

Mr. Pushparajah added that earlier work had shown that increases in KOH number and V.F.A. value and decreased mechanical stability were in response to nitrogen applications, but these trends were reversed by applications of PK or NPK. Mr. S.M. Warriar added that the dry rubber content of the field latex was always depressed by application of nitrogen, even when the yield was not affected. He had observed similar effects when the tapping intensity was increased. Mr. Collier agreed that nitrogen invariably depressed d.r.c., and suggested that the other interactions must be investigated in suitable factorial experiments. Mr. P. Zeid asked if the increasing KOH numbers observed in newly opened areas might not be due to residual effects of the large amounts of nitrogen returned to the soil by leguminous cover plants. Mr. Collier said that leguminous covers had been established in the areas concerned, but had disappeared long before the trees came into tapping; he thought that residual effects of such long duration were unlikely.

Mr. I.H. Duckworth stated that the rise in KOH numbers had been observed elsewhere and were originally thought to be due to the clonal composition of the plantings. They were now shown to be an effect of application of fertilisers. Many consumers, especially in the U.S.A., would not accept latex with a high KOH number, despite several independent investigations showing that it was not harmful. Mr. A.D.T. Gorton asked what the effect of laurate was and queried the value of the KOH test; he thought that the 0.80 limit was unrealistic. Mr. Collier agreed that it had little significance; Dunlops experienced no difficulty in processing concentrate with the higher KOH numbers, formic acid preserve being an example. The effect of laurate had not been studied.