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A STUDY OF THE UREASE ACTIVITY IN THE RUBBER SOILS OF CEYLON

By

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SUMMARY

The urease activity of the rubber soils of Ceylon has been determined, along with the organic carbon, pH and soil moisture. The Matale and Parambe soil series, belonging to reddish brown lateritic great soil group have a significantly higher urease activity than the other soil series, belonging to the red-yellow podzolic great soil group. In all the six soil series pH shows a significant positive influence on urease activity. Organic carbon has a direct relationship to urease activity only in four soil series while in the other two soil series, organic carbon does not seem to have any influence.

It is suggested that urea can be used as the source of nitrogen under most situations in the rubber areas, except in the soils of the Matale series, where it could be used with caution for the present, until further studies are made on this subject.

INTRODUCTION

The use of urea as the main source of nitrogen, in the manuring of *Hevea brasiliensis* is becoming increasingly important. With its proposed manufacture in Ceylon, replacement of ammonium sulphate with urea is very likely ; hence it was considered useful to study the effectiveness of urea as a source of nitrogen.

It has been the opinion for a long time, that micro-organisms were solely responsible for the chemical transformation of organic substances in soils. But Conrad (1940 a, 1942) and Conrad & Adams (1940) have shown that it could be a process of enzymatic catalysis. Conrad (1940 b) has also shown that the enzyme urease was responsible for the hydrolysis of urea to ammonium carbonate, according to the following equation.

$$CO(NH_2)_2 + 2H_2O \longrightarrow (NH_4)_2 CO_3$$

The hydrolysis of urea to ammonia could be catalysed by active urease produced in soil micro-organisms, as well as by extra cellular urease found absorbed on the soil clay complex. Therefore the total urease activity in soils is a measure of both these forms of urease. In the present study however, only the extra cellular urease activity was measured.

The urease activity in the surface samples of six soil series identified by Silva (1969), in the rubber growing areas has been determined. Of these six soil series, the Matale and Parambe series belong to the reddish brown lateritic great soil group, while the other four soil series have been grouped as belonging to the red-yellow podzolic great soil group by Moorman & Panabokke (1961). The relationship of urease activity of the different soil series to soil reaction, organic carbon and soil moisture, has also been investigated.

The Parambe series soil derived from a biotite gneiss and the Matale series soil derived from crystaline limestone, both belong to the reddish brown lateritic great soil group while the Agalawatta series derived from a charnockite, the Ratnapura

series derived from a garnetiferous granulite, the Homagama series derived from a quartzite and the laterite dominant Boralu series, are all of the red-yellow podzolic great soil group. The rainfall in the area studied varies from 155 in. to 80 in. per annum. It is high in the Ratnapura series soil area and low in the Matale series soil area. The soil samples were removed from areas with a dense canopy. Therefore the ground was devoid of any living ground cover, except for the decomposing leaf litter.

MATERIALS AND METHODS

Soil samples were collected from the top 3 in. and sampling was done during the months, May to November, when the degree of decomposition of the leaf litter would have reached a similar stage. All soil samples were removed from existing rubber areas, in between four rubber trees, which were as far as possible of the same age and situated on comparable terrain. Three locations were selected in each soil series and at each location 12 sites were sampled. From each site two samples were removed, from the 0–3″ depth about two feet apart.

The sample was collected in a transparent polythene bag and transported to the laboratory, where it was mixed well, and passed through a 2 mm sieve, within 24 hr of collection. The fine earth fraction was used for these determinations.

The distribution of sites is shown in Fig. 1 and dates of sampling in Table 1.

TABLE 1

PLACES OF SOIL SAMPLING AND DATES OF SAMPLING

Soil series	Sampling site	Date of sampling
Agalawatta	Pahalahevessa	21st May 1969
		19th June 1969
	Yagirala	21st May 1969
		19th June 1969
	Hedigalla	5th June 1969
		3rd July 1969
Boralu	Tudugalla	5th June 1969
		24th June 1969
	Nelunuyana	11th June 1969
		24th June 1969
	Jawatta	11th June 1969
		3rd July 1969
Ratnapura	Mahapanwila	15th July 1969
	Hiniduma	24th July 1969
	Ratnapura	1st August 1969
Homagama	Opanayake	22nd August 1969
	Lathpandura	27th Sept. 1969
	Talgaswela	12th Oct. 1969
Matale	Wariyapola Group (Matale)*	29th August 1969
	Viharagama Group (Matale)*	7th Sept. 1969
	Tuttiripitiya (Matale)*	14th Sept. 1969
Parambe	Parambe Group	20th Oct. 1969
	Devalakande	28th Oct. 1969
	Pitiyakanda (Mawathagama)*	11th Nov. 1969

* Names in brackets refer to the location as given in Fig. 1

The method adopted was that described by Hoffmann & Teicher (1961) with certain modifications. Ten grammes of 2 mm fraction soil were placed in a 100 ml flask and 1 ml of toluene was added. After the contents were allowed to stand overnight, 10 ml of sodium citrate — citric acid buffer (pH 6·7) was added followed by 10 ml of 10% urea solution. The contents were well shaken and incubated for 6 hr at 37°C. A control was also run for each batch of samples, where 10 ml of distilled water were substituted for urea. The contents of each flask were then diluted to 100 ml with distilled water, shaken well, and filtered through Whatman filter paper No. 5. The indophenol blue technique was used to determine the amount of ammonia released, by the hydrolysis of the added urea and this was considered to be a measure of the urease activity of the soil sample. For this purpose 1 ml of the clear filtrate was taken and diluted with 4·5 ml of distilled water and 2 ml of freshly prepared sodium phenate. Next 1·5 ml of 0·9% bleaching powder were added and the colour developed was measured with a DU Beckmann spectrophotometer, using a wave length of 630 μ. The urease activity is recorded in mg ammonium nitrogen released per 100 g of oven-dry soil.

Soil moisture was determined by oven-drying 10 g of soil at 105°C for 24 hr. This determination was done on the same day the soils were removed from the field. Soil reaction was measured using a glass electrode Beckmann portable pH meter, with 25 ml of distilled water and 10 g of soil. Organic carbon was determined by the Walkely & Black (1934) method using 0·5 mm sieved soil.

RESULTS

Mean urease activity in the six soil series: Table 2 which gives the mean urease activity in each of the soil series, indicates that the Matale and Parambe series have significantly higher urease activity than all the other series.

TABLE 2

MEAN UREASE ACTIVITY IN THE DIFFERENT SOIL SERIES

Great soil group	Soil series	Mean urease activity	Range
Reddish brown lateritic	Matale	45·85	31·07 – 54·25
	Parambe	42·30	28·90 – 53·50
Red-yellow podzolic	Homagama	27·85	16·83 – 40·29
	Boralu	27·41	11·60 – 36·90
	Ratnapura	23·26	10·13 – 36·66
	Agalawatta	21·44	4·17 – 32·33

The sampling error of the above estimates of urease activity, determined from the variance components is $\pm$ 3·37.

Inter-relationship between urease activity and organic carbon, soil reaction and soil moisture: The mean values of the organic carbon contents and soil reaction are given in Table 3. The correlation coefficients are given in Table 4. Significant values are marked with an asterisk.

TABLE 3

MEAN VALUES OF UREASE ACTIVITY, ORGANIC CARBON, pH AND MOISTURE

Soil series	Mean U.A. mg NH_3/100g soil	Mean organic carbon %	Mean pH	Mean moisture %
Matale	45·85	1·53	5·87	16·53
Parambe	42·30	1·84	5·22	18·78
Homagama	27·85	1·76	4·88	18·32
Boralu	27·41	1·48	4·80	—
Ratnapura	23·26	1·80	5·08	20·54
Agalawatta	21·44	1·80	4·83	—

TABLE 4

CORRELATION COEFFICIENTS

	DF	Correlation (t)		
		pH and U.A.	Organic carbon and U.A.	pH and organic carbon
Between series	4	+ 0·8350*	− 0·2667	−0·2920
Between locations	16	+ 0·5127*	+ 0·0356	−0·3636
Between sites	214	+ 0·4005*	+ 0·1526*	−0·1940*

A positive correlation exists between soil reaction and urease activity within a certain pH range. This is true whether the consideration is between sites or between places or even between series.

A significant positive relationship between organic carbon and urease activity was also evident, when consideration was between sites within a series. Organic carbon and soil reaction were negatively related.

Multiple regression analysis has been carried out for each soil series separately, in order to understand more specifically the influence of pH and organic matter on urease activity. For the soil series where the moisture percentage also has been determined, this factor too is included in the analysis.

Table 5 shows the regression equations. The values show what factors are significantly influencing urease activity, in each of the soil series. The significant values are marked with an asterisk.

TABLE 5

INFLUENCE OF pH, ORGANIC CARBON AND MOISTURE ON UREASE ACTIVITY

Soil series	Regression equation	R	t – values		
			pH	Org. C (C)	Moisture (M)
Boralu series	U.A. = −148·86 + 33·49 pH + 10·48C	0·75	4·83*	3·02*	—
Matale series	U.A. = 58·11 − 2·27 pH + 6·20C − 0·51 M	0·73	2·22*	4·17*	1·60
Parambe series	U.A. = −88·42 + 19·37 pH + 16·11C − 0·0005 M	0·69	3·10*	4·09*	1·00
Homagama series	U.A. = −19·39 + 5·68 pH + 7·08C + 0·39 M	0·49	1·35	1·96*	1·00
Agalawatta series	U.A. = −75·81 + 17·94 pH + 5·87C	0·42	2·26*	1·54	—
Ratnapura series	U.A. = 19·36 + 0·96 pH + 1·23C − 0·16 M	0·13	1·00	1·00	1·00
All soil series	U.A. = 28·31 + 9·45 pH + 6·67C	0·46	2·84*	1·52	—

When all series are considered, pH shows a significant influence on urease activity. This point was brought out when the correlations were discussed. In four out of the six soil series, organic carbon shows a positive influence on urease activity. Moisture content does not influence urease activity significantly.

DISCUSSION

The results show that each soil series has its characteristic level of urease activity. This also applies to each location and site within a series. The variation in urease activity between sites and locations within a single soil series seems to indicate that the criteria used in characterising soil series are not necessarily related to the factors that control urease activity.

It has been shown that soil properties which control soil biological activity influence the levels of urease activity. McGarity & Myers (1967) observed a very weak correlation between urease activity and soil reaction at the great soil group level. In this study except for the Matale series, the other series showed a significant positive influence of pH on urease activity *i.e.* a high pH tends to increase urease activity. But when soils in the higher pH range are considered (Matale series of pH 5·87), a high pH tends to lower the urease activity. This could possibly be explained by the fact that there is an optimum pH range for urease activity, which optimum is below 5·87 and a pH above this has a negative influence on urease activity. Apparently within this optimum pH range, the release and accumulation of urease from microbial sources are more efficient.

Organic carbon has a direct relationship to urease activity in the Matale, Parambe, Homagama and Boralu series. However, in the Ratnapura and Agalawatte series, organic carbon does not seem to have any influence on urease activity. It is not clearly understood why this should be so. But the fact that the Ratnapura and Agalawatte soil series have the lowest urease activity and also comparatively high organic carbon, it could possibly mean that at higher levels of organic carbon, there are other factors that control urease activity, so that organic carbon does not influence it.

The results indicate that the urease activity levels are high in the Matale and Parambe soil series and medium in the others, when compared to the values obtained by other workers working on different soils. This fact, as well as the observation that in a field experiment on the Agalawatte series soil, urea has been found to be an efficient source of nitrogen, indicates that under the conditions of the present study, urea could be used as the source of nitrogen. The soils of the Matale series because they are derived from dolomitic limestone, might tend to lose ammonia from the added urea, rather easily. The tendency of urea to increase initially the pH of the soil, would also suggest that in the Matale series soils, urea could be used with caution. Organic carbon having a favourable effect on urease activity, the presence of a decaying mulch at the time of urea application, would be favourable for the hydrolysis of urea in most soil series. Even though soil moisture does not apparently have a significant influence on urease activity, the hydrolysis of urea to ammonia being dependent on the presence of moisture, the availability of moisture for urea hydrolysis is important.

It appears that the levels of pH, organic carbon content, and moisture of the soils studied, are satisfactory for the use of urea as the source of nitrogen. But in the soils of the Matale series, this should be further studied in order to ascertain whether the fact that it is derived from a dolomitic limestone would hinder the use of urea, as a source of nitrogen, even though the urease activity of this soil series is high.

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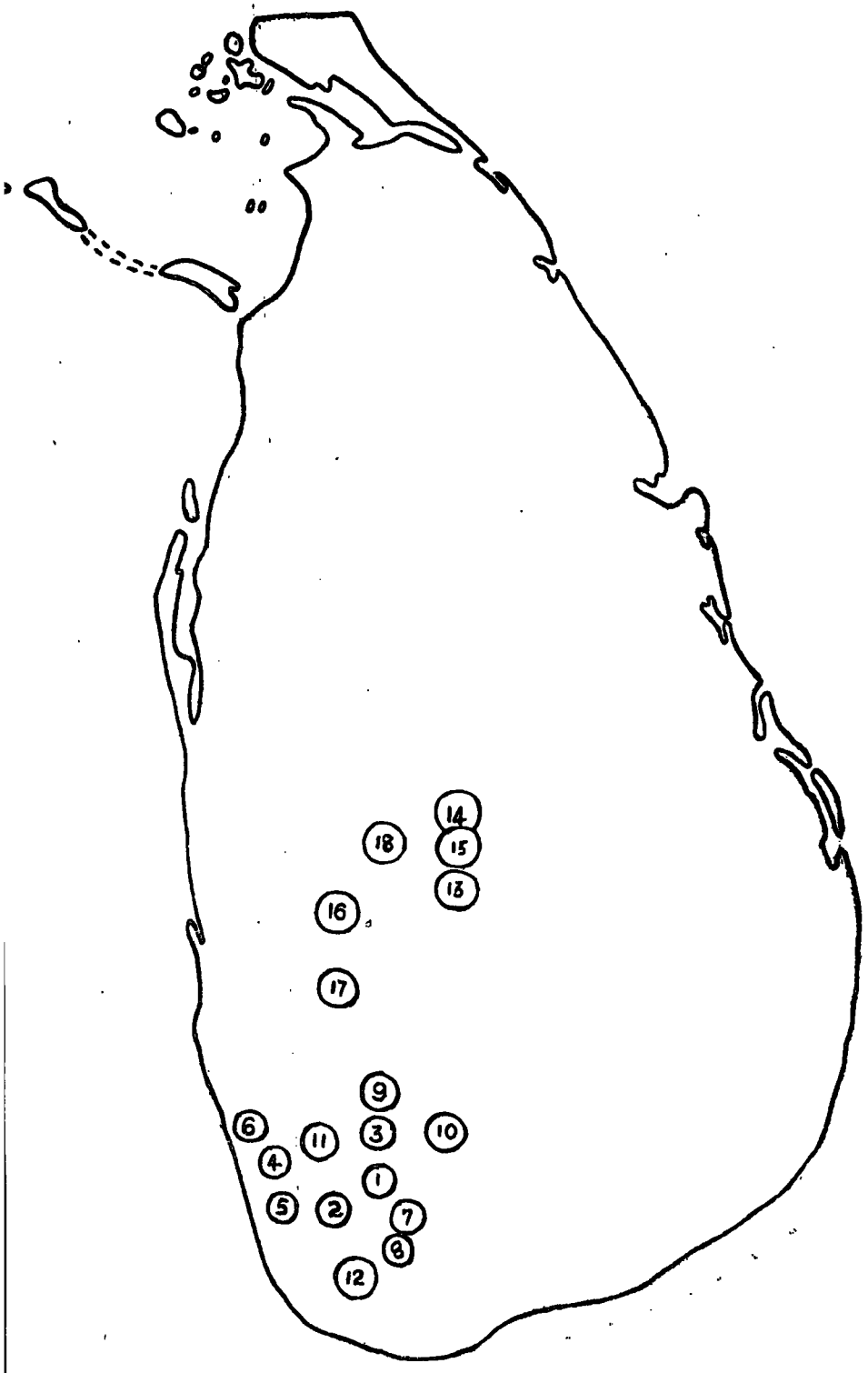

1. PAHALAHEWESSA
2. YAGIRALA
3. HEDIGALLA
4. TUDUGALLA
5. NELUNUYANA
6. JAWATTA
7. MAHAPANWILA
8. HINIDUMA
9. RATNAPURA
10. OPANAIKE
11. LATHPANDURA
12. TALGASWELA
13. WARIYAPOLA GROUP
14. VIHARAGAMA GROUP
15. TUTTIRIPITIYA
16. PARAMBE GROUP
17. DEVALAKANDE
18. PITIYAKANDE

Fig. 1. Sites sampled for urease activity survey.