

HUMIFIED PHENOL - RICH PLANT RESIDUES AND SOIL UREASE ACTIVITY †

K. Sivapalan, V. Fernando

(Tea Research Institute of Sri Lanka, Talawakele, Sri Lanka)

and

M. W. Thenabadu

(Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka)

A greenhouse experiment was conducted to examine the comparative effects of phenol-rich and phenol-poor plant residues after prolonged decomposition, on the urease activity of an acid soil. Addition of organic residues increased soil urease activity over that of control; but soils amended with phenol-rich residues had a urease activity which was about 50% lower than that of soils amended with phenol-poor residues. This reduction in soil urease activity was attributed to the higher content of soil polyphenols present in the soils amended with phenol-rich residues.

INTRODUCTION

In the tea fields of Sri Lanka, large amounts of polyphenol-rich tea residues are returned to the soil annually, as leaf-fall and as prunings. It has been shown recently that humification of polyphenol-rich tea residues leads to the formation of relatively large amounts of N-rich humic matter^{1,0}. It was of interest to examine further the effect of this humic material on the urease activity of the soil, especially because of conflicting reports regarding the effect of polyphenolic substances on soil urease activity^{1,6}. Bremner and Douglas¹ studied the effect of lignins, tannins and humic acids (polyphenolic substances) on soil urease activity and their results showed that none of the substances tested gave more than 4 per cent inhibition of soil urease activity under the conditions of their test. But Fernando and Roberts⁶ observed that aqueous extracts of polyphenol-rich residues when mixed intimately with urea were effective in depressing urea hydrolysis in soils; and also that polyphenol-rich solid tea waste in amounts exceeding 50 g kg⁻¹ soil added to the soil just prior to the urease assay, effected a substantial decrease in urease activity.

We report the effect of phenol-rich plant residues in comparison to other phenol-poor plant residues on soil urease activity after prolonged decomposition under greenhouse conditions.

MATERIALS AND METHODS

Experimental details of the plant residues, the greenhouse procedures and relevant analytical methods are described elsewhere¹⁰. Briefly soil (red yellow podzolic, clay loam, pH4.7, organic C = 2.8% N = 0.17%) was incubated with plant residues having varying phenolic contents. There were three replicates for each treatment, placed in randomized block design. The total plant material added in staggered applications of 5 g kg⁻¹ soil every four months was 15 g kg⁻¹ soil, and the total decomposition period was 12 months after which the soils were assayed for total N⁷, organic C¹³ and pH (1:1, soil-water). Humic matter was extracted⁹ and organic C in the extract determined by bichromate oxidation¹³.

† Reprinted from 'Plant and Soil' 70, 143-146 (1983) by courtesy of the Authors & the Editors.

Assay of soil urease activity

Soil urease activity was assayed by an earlier method⁶ with modifications as described below.

Ten g air-dried soil was placed in a 100 ml Erlenmeyer flask, 1.5 ml. toluene added, the contents well mixed and allowed to stand for 15 min. Then 10 ml 0.1 M McIlvaine's buffer (Citric acid-disodium hydrogen phosphate) pH 7.0, and 10 ml 1.5M urea solution were added, the contents mixed and incubated at 37°C for 5 h. Following this, 30 ml of the inhibitor KCl-HgCl₂ solution (100 ml 2 M KCl + 0.5 g HgCl₂) was added and shaken for 30 min and the contents filtered through Whatman No. 542 filter paper. For each soil sample a control was run in the same manner, but the addition of the inhibitor solution preceded the addition of the substrate.

The ammonium contents of the filtrates from the sample and the control were determined by the indophenol blue method³. The ammonium released by the hydrolysis of urea was obtained by subtracting the ammonium content of the control from that of the sample. The urease activity was expressed as $\mu\text{g NH}_4\text{-N}$ per g soil under the conditions of the incubation specified.

Assay of soil polyphenols

For the above analysis, 100 g soil samples were taken from each of the three replicates and mixed to make a composite sample for that treatment. The 'tannin-stripping, solvent'² was employed with modifications as described below.

Fifty g of the composite soil sample was stirred with ice-cold water and centrifuged. The supernatant carrying the floating debris was discarded. This operation was repeated once and the soil was then refluxed with 400 ml aqueous acetone (50%v/v) for 2 h, the filtered extract concentrated on a rotary evaporation at 40°C, and aliquots used for the determination of total phenols¹². The average value of duplicate determinations was reported.

Results and discussion

Phenol content of plant residues

It was shown previously¹⁰ that on the basis of their phenol content, the first four treatments (Table 1) namely Tea shoot tips, Mature tea leaf, Mixture, and Black tea, could be classified as phenol-rich treatments while the last four treatments namely Dadap, Mana, Guatemala and Tobacco could be referred to as phenol-poor treatments, and that 'spent tea-leaf' falls intermediate between these groups.

TABLE 1 — Some chemical characteristics of amended soils

Treatment	pH	Soil composition		
		Organic C (%)	Total N (%)	Humic matter (mg C g ⁻¹ soil)
Tea shoot tips	4.50	3.37	0.234	13.11
Mature tea leaf	4.75	3.37	0.217	12.74
*Mixture	4.60	3.23	0.220	13.04
Black tea	4.40	3.19	0.221	13.80
Spent tea leaf	4.85	3.15	0.236	12.68
Dadap leaf	4.30	3.10	0.206	11.85
Mana grass	5.05	3.23	0.183	11.85
Guatemala grass	5.00	3.15	0.182	11.56
Tobacco leaf	4.65	3.00	0.201	12.19
Control	4.70	2.79	0.167	11.23
LSD ($P=0.05$)	0.09	0.12	0.008	0.41

*Mixture - Mixture of treatments (1) and (2) in the ratio 1 : 1.

Humic matter contents

Table 1 reveals that soils amended with phenol-rich residues have significantly higher contents of humic matter compared to control. The pH of the amended soils varied from 4.30–5.05 with an average value of 4.70.

Soil urease activity

It is evident from Table 2 that in all treatments, addition of plant residues has increased soil urease activity over that of control. This is in agreement with earlier observation¹¹. The major point of interest is that urease activity of soils treated with phenol-rich residues is much lower than that of soils treated with phenol-poor residues. The former averages to 44.7 while the latter averages to 97.2, indicating a 54% reduction compared to the former.

Dalal⁴ reported a high positive correlation between soil urease activity and soil organic C, while Zantua *et al.*¹⁴, showed that urease activity was correlated very highly significantly with organic C and total N of soil. But in the present study, soil urease activity was not correlated to either humic matter, organic C or total N (Table 3). In fact, although soils amended with phenol-rich residues had significantly higher values of soil humic matter, the urease activity of these soils was much lower than that amended with phenol-poor residues. This would therefore suggest the presence of some inhibitory factor which reduced soil urease activity in the soils amended with phenol-rich residues.

TABLE 2 — *Urease activity and soil polyphenol content of amended soils*

<i>Treatment</i>	<i>Urease activity</i> $\mu\text{g NH}_4\text{-Ng}^{-1}\text{ soil 5h}^{-1}$	<i>Soil polyphenols</i> $\mu\text{gg}^{-1}\text{ soil}$
Tea shoot tips	32.3	53.2
Mature tea leaf	51.0	26.6
Mixture	42.5	34.6
Black tea	44.1	69.2
Spent tea leaf	48.8	26.6
Dadap leaf	138.7	4.0
Mana grass	106.7	4.0
Guatemala grass	84.1	5.3
Tobacco leaf	60.6	6.0
Control	14.9	4.0
LSD ($P = 0.05$)	24.6	—

TABLE 3 — *Correlations between soil urease activity and other soil properties*

<i>Soil property</i>	<i>(r)</i>
Organic carbon	0.104
Total nitrogen	—0.196
Soil polyphenols	0.310
Humic matter	—0.356

Soil polyphenols

The content soil polyphenols in soils amended with phenol-rich residues is about five to ten-fold higher than that in soils amended with phenol-poor residues (Table 2). These data taken together strongly suggests, that the residual soil

polyphenols may be a factor responsible for the partial inhibition of soil urease activity in the above soils. However it is observed from Table 3 that a direct correlation between soil polyphenols and urease activity was absent. This is understandable because urease activity may be dependant on the interplay of more than one factor, acting may be in opposite directions; e.g. organic matter content may promote while soil polyphenol content may suppress urease activity. This is an important consideration which has to be borne in mind when attempting to correlate urease activity with soil properties; and it also lends support to an earlier observation⁸ that the urease activity of a soil is determined more by the nature of the vegetation than by the organic carbon content of the soil.

The practical implication of the results of this study is that tea soils humified with tea leaf litter would have a lowered urease activity; this is a desirable feature in terms of loss of ammonia in tea soils during urea fertilizer applications.

ACKNOWLEDGEMENTS

The authors are grateful to Dr G. R. Roberts and Dr S. Kulasegaram for helpful suggestions regarding the manuscript and to Mr C. V. R. D. Fonseka for preparation of typescript.

REFERENCES

- BREMNER J. M. and DOUGLAS, L. A. 1971 *Soil Biol. Biochem.* 3, 297-307.
COULSON, C. B. *et al.* 1960 *Soil Sci.* 11, 20-29.
CROWTHER, A. B. and LARGE, R. S. 1956 *Analyst.* 3, 297-307.
DALAL, R. C. 1975 *Soil Biol. Biochem.* 7, 5-8.
FERNANDO, V. and ROBERTS, G. R. 1976 *Plant and Soil* 44, 81-86.
HOFFMAN, E. 1963 *In Methods of Enzymatic Analysis.* Ed. H. U. Bergmeyer. Academic Press, New York pp 371-414.
JACKSON, M. L. 1958 *Soil Chemical Analysis*, Prentice Hall, Englewood Cliffs, New Jersey.
PANCHOLY, S. K. and RICE, E. L. 1973 *Soil Sci. Soc. Am. Proc.* 37, 47-50.
SEQUI, P. *et al.* 1975 *Can. J. Soil Sci.* 55, 439-445.
SIVAPALAN, K. 1982 *Soil Biol. Biochem.* 14, 309-310.
SKUJINS, J. J. 1967 *Soil Biochemistry.* Eds. A. D. McLaren and G. H. Peterson. Marcel Dekker, New York pp 371-414.
SWAIN, T. and HILLS, W. E. 1959 *J. Sci. Food Agric.* 10, 63-68.
TINSLEY, J. 1950 *Trans. 4th Int. Soc. Soil Sci.* 1, 161-164.
ZANTUA, M. *et al.* 1977 *Soil Sci. Soc. Am. J.* 41, 350-352.