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Identification of Factors Influencing Microbial Population in Red and Black Soils by Path Analysis

K. K. MATHAN[1], P. P. RAMASWAMI[2], C. SUYAMBULINGAM[3] and W. JEBARANI[4]

Moisture, pH, depth and carbondioxide evolution were observed to be some of the major contributing factors influencing the microbial population in red and black soils. Path analysis revealed that the net contribution of pH and depth was negative and moisture and carbondioxide evolution positive. The effect of pH was mostly indirect via depth in black soil and direct in red soil. The contribution of moisture was direct in both the soils. The direct effect of CO_2 was low and negative in both soils. Depth had a direct negative influence on population in both soils.

Moisture, pH and depth funtions are considered to be some of the important factors that influence the microbial population in any soil. The evolution of carbon dioxide is a measure of the activity of the population which correlated well with the microbial population (Ramaswami and Raj, 1973). Soil microflora vary considerably both in quality and quantity depending upon the soil type and the physico-chemical properties of soil (Waksman, 1952). Subsequently variation in the microbial population in different soils was reported by Ramaswami (1966). Rangaswami and Venkatesan (1963) found the highest number of microbial population in the surface layers and a gradual decline in the deeper layers. They also observed seasonal variation in the population.

Several reports are available to show the influence of the various factors like moisture, pH, depth and CO_2 singly on the microbial population. In the field this does not happen. An interplay of the above mentioned factors occur. Repnevskaya (1967) reported that moisture was a limiting factor for the production of CO_2 during summer. Soil moisture was found to change the soil pH in calcareous soils (Huberty and Hass, 1940). Beyond 0.4 foot, a progressive increase in pH with depth was recorded even though the increase in depth was small (Kelley, 1923). To get a clear picture of the relative importance of direct and indirect influence of each of the component factors which infuences the microbial population, the path analysis advocated by Wright (1923) was employed in the present study.

METHODS AND MATERIALS

Red and black soil profiles were dug up to a depth of 180 cm. Soil

1-2 Dept. of Soil Science, 3-4 Dept. of Physical Science.
Tamil Nadu Agricultural University, Coimbatore-641 003.

samples were drawn from different layers of the profiles on the first of every month for a period of three months during December, January and February. Total bacterial population was estimated in the 1 : 10,000 dilution by the plate count method in Thornton's agar medium (Thornton, 1922). Actinomycetes were estimated in the 1 : 1000 dilution by the plate count method in asparagin glucose agar medium (Fred and Waksman, 1928). Fungi were estimated in the 1 : 1000 dilution by the plate count method in rose-bengal agar medium (Smith and Dawson, 1944). pH and moisture content of the soils were estimated by the standard methods. Carbon dioxide evolution of the soil was estimated by the method described by Chesters *et al.* (1957). Employing the path analysis a standardised partial regression equation was developed to partition the correlation co-efficients of the various factors.

RESULTS AND DISCUSSION

Correlations were worked out for all possible combinations of factors. Microbial population was considered as a resultant variable and others as casual variables. The zero order correlation matrix for the variables taken for the study is presented in table I for red soils. pH and depth were negatively correlated with the microbial population, the respective 'r' values being -0.6289** and -0.5965**. Moisture and CO_2 evolution correlated positively, of which CO_2 alone gave a significant correlation. A perusal of the table further revealed that there was a significant negative correlation (-0.8131**) between pH and CO_2 evolution and significant positive correlation between pH and depth (r= 0.7517**). There was also a significant negative correlation between CO_2 evolution and depth (r=-0.7436**).

Table II shows the zero order correlation matrix for the variables for for black soils. The table revealed that significant negative correlations existed between pH and microbial population (r= -0.4979*) and between pH and depth (-0.55**). Here again the correlation co-efficients for pH *vs* CO_2 evolution (e= -0.5734**);

TABLE-I. Coefficients of correlations between characters in Red Soil

Correlated characters		Moisture X_2	CO_2 evolution X_3	Depth X_4	Microbial population Y
pH	X_1	—0.0196	—0.8131**	0.7517**	—0.6289**
Moisture	X_2		—0.0166	0.0277	—0.1765
Co_2 evolution	X_3			—0.7436**	0.4822*
Depth	X_4				—0.5965**

TABLE II. Coefficients of correlations between characters in Black soil

Correlated characters		Moisture X_2	CO_2 evolution X_3	Depth X_4	Microbial population Y
pH	X_1	0.0024	—0.5734**	0.8936**	—0.4979*
Moisture	X_2		0.0370	—0.0315	—0.0523
CO_2 evolution	X_3			—0.7750**	0.3748
Depth	X_4				—0.55**

* Significant at 5% level
** Significant at 1% level

pH *vs* depth (r = -0.8936**); and CO_2 *vs* depth (r = -0.775**) were all significant.

The foregoing observations revealed the influence of the variables pH, moisture, CO_2 and depth on the resultant variable, microbial population and at the same time the inter-dependent of the casual variables themselves. Using the above tables, therefore, the following equations, in the matrix form for the path analysis were constructed.

Inverting the square matrix on the left hand side and premultiplying with the column vector on the right hand side in the case of red soils P_1Y = -0.52313, P_2Y = +0.17286, P_3Y = -0.21247 and P_4Y = -0.36607, P_1Y = 0.064449, P_2Y = 0.13746, P_3Y = -0.144376 and P_4Y = -0.696131 in the case of black soils. The data showed that in the case of red and black soils, moisture content promoted the microbial population. The pH did not influence the microbial population in black soil whereas it had an adverse effect in red soils.

Microbial population was observed to decrease with depth. Further in both the soils, the zero order correlation coefficient values were positive for pH and depth and negative for CO_2

RED SOIL

$$\begin{Bmatrix} +1.0000 & -0.0196 & -0.8131 & +0.7517 \\ -0.0196 & +1.0000 & -0.0166 & +0.0277 \\ -0.8131 & -0.0166 & +1.0000 & -0.7436 \\ +0.7517 & +0.0277 & -0.7436 & +1.0000 \end{Bmatrix} \begin{Bmatrix} P_1Y \\ P_2Y \\ P_3Y \\ P_4Y \end{Bmatrix} = \begin{Bmatrix} -0.6289 \\ +0.1765 \\ +0.4822 \\ -0.5965 \end{Bmatrix}$$

BLACK SOILS

$$\begin{Bmatrix} +1.0000 & +0.0024 & -0.5734 & +0.8936 \\ +0.0024 & +1.0000 & +0.0370 & -0.0315 \\ -0.5734 & +0.0370 & +1.0000 & -0.7750 \\ +0.8936 & -0.0315 & -0.7750 & +1.0000 \end{Bmatrix} \begin{Bmatrix} P_1Y \\ P_2Y \\ P_3Y \\ P_4Y \end{Bmatrix} = \begin{Bmatrix} -0.4979 \\ -0.0523 \\ +0.3748 \\ -0.5500 \end{Bmatrix}$$

TABLE III. Path coefficient analysis of correlation of factors with microbial population-red soil

Correlated characters	Direct and indirect effects pH	Moisture	CO_2	Via Depth	Correlation with population
pH	<u>−0.5231</u>	−0.0034	+0.1728	−0.2752	−0.6289
Moisture	+0.0103	<u>+0.1729</u>	−0.0166	+0.0101	+0.1765
CO_2	+0.4253	−0.0029	<u>−0.2125</u>	+0.2722	0.4822
Depth	−0.3932	+0.0048	+0.1580	<u>−0.3661</u>	−0.5965

(Figures underlined denote the direct effects)

TABLE IV. Path coefficient analysis of correlation of factors with microbial population - Black soil

Correlated characters	Direct and indirect effects pH	Moisture	CO_2	Via Depth	Correlation with population
pH	<u>+0.0645</u>	+0.0003	+0.0828	−0.6220	−0.4979
Moisture	+0.0002	<u>+0.1375</u>	−0.0053	+0.0219	+0.1543
CO_2	−0.0370	+0.0051	<u>−0.1444</u>	+0.5395	+0.3748
Depth	+0.0576	−0.0043	+0.1119	<u>−0.6961</u>	−0.5500

(Figures underlined denote the direct effects)

evolution and depth. Similar observations were reported by Rangaswami and Venkatesan (1963).

Results of direct and indirect effect path co-efficients are presented in Table III for red soils and in Table IV for black soils. The conjoint effect of all the characters studied is seen from the tables.

Population and pH: The net effect of pH on microbial population is negative in red and black soils. The direct effect of pH on population was high in red soil (-0.5231) and very low in blak soil (0.06445). In both the soils the indirect effect of pH via depth was the major contributing factor, followed by carbon dioxide and moisture.

Population and moisture: The contribution of moisture towards population was mostly direct and positive. The indirect influence through other factors was very low. The trend was similar in both the soil types.

Population and CO_2 evolution: The population and CO_2 evolution were positively related in both the soils. The direct influence was low and negative.

The indirect effect was higher and positive via pH followed by depth in red soil, but in black soil the indirect effect was higher through depth.

Population and depth: In both the soils the population and depth were negatively correlated, and the effect was direct. It was pronounced more negatively in black soil (-0.6961) and less in red soil (-0. 3661). In red soil pH and CO_2 evolution were equally important negatively correlated indirect factors, while in black soil indirect effect through CO_2 evolution was fairly low and positive.

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