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FACTOR ANALYSIS OF SOIL PROPERTIES IN *PARASERIANTHES FALCATARIA* (L.) NIELSON PLANTATIONS

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Abstract: Soil properties in different layers viz., 0-20 cm, 20- 40 cm, 40-60 cm and 0-60 cm in *Paraserianthesfalcataria* plantations in Kerala were subjected to factor analysis. Out of the eleven variables studied viz., gravel, sand, pH, organic carbon, exchange acidity, exchangeable bases, total N, P, K, Ca and Mg, factor analysis identified four factors which accounted for more than 72% of the variation in these variables in each layer. The four factors were textural component, organic matter component, acidic component and nutrient capital of the soil. Certain factors in 0-20 cm, 20-40 cm and 40-60 cm layers were common with those in the 0-60 cm layer. The study indicated that it is more advisable to interpret the different factors in the 0- 60 cm layer rather than those in individual layers.

Key words: Factor analysis, *Paraserianthesfalcataria*, soil properties.

INTRODUCTION

Paraserianthes falcataria (L.) Nielson, native to the eastern islands of the Indonesian archipelago (notably the Moluccas) and the New Guinea (particularly West Irian) is one of the fastest growing trees in the world. The growth of *Paraserianthes falcataria* is so rapid that the plant has been termed a miracle tree. It has been introduced to south east Asia and Philippines during 1870's (Anon, 1979). The wood is used for making match splints and boxes, packing cases, tea chests, fisherman's floats *(Katamarans)* and shelves. It is also a good source of pulpwood. It has been introduced in Trichur, Quilon and Trivandrum districts under afforestation programme during mid 1970 and so far about 1350ha of plantations have been raised by the Kerala Forest Department and Kerala Forest Development Corporadon. It grows well on sites with good soil and adequate rain fall. In Philippines and Taiwan, a few studies have been conducted on tree growth and soil properties (Dalmacio, 1987; Liu *et al.*, 1978). This investigation attempts to study the factor analysis of soil variables in *Paraserianthes* plantations.

MATERIALS AND METHODS

Two study areas were selected, one at Arippa and the other at Kollathirumed in Kerala, India . The plantation at Arippa is of Arippa subunit of the Kerala Forest Development Corporation while that at Kollathirumed belongs to Kollathirumed Range of Vazhachal Forest Division. Both the plantations were established in 1977. The terrain at Arippa is hilly while at Kollathirumed, it is gently rolling. The areas under plantations are 34 ha at Arippa and 25 ha at Kollathirumed. Leaving about 10 m on the periphery on all sides, 20 ha was demarcated in the two study areas. Plots of 10 m x 10 m were randomly laid out for every hectare in the two areas. From each plot, one soil pit was taken and samples from 0-20, 20-40 and 40-60 cm depths were collected. Soil samples were analysed for gravel, sand, silt, clay, organic carbon, pH, exchange acidity (EA), exchangeable bases (EB), total N, P, K, Ca and Mg as per standard procedures (Jackson, 1958; ASA, 1972). Mean values of soil properties in different layers at two locations are reported in Table 1 and 2. The soil properties with reference to 0-20 cm, 20-40 cm , 40-60 cm and

0- 60 cm layers of 40 pits, pooled over two locations, were subjected to factor analysis.

RESULTS AND DISCUSSION

The intercorrelation and the interdependence among variables in a multivariate data may be due to certain unobservable factors. Factor analysis reveals such underlined causative factors of multivariate data. Data on gravel content (G), sand content (S), organic carbon (OC), soil pH (pH), exchange acidity (EA), exchangeable bases (EB), total N, P, K, Ca and Mg obtained from individual layers of 40 pits, pooled over two locations Kollathirumed and Arippa were used for factor analysis.

Table 1. Mean values of soil properties in different layers at Arippa

Properties	Depth (cm)			
	0.20	20-40	40-60	0-60
Gravel (g kg^{-1})	237	322	377	312
Sand "	600	498	441	514
Sillt "	78	70	64	70
Clay "	85	110	118	104
Org. C "	17.58	10.25	6.51	11.45
Soil pH	5.5	5.3	5.2	5.3
Exch. acidity (me kg^{-1})	840	930	630	750
Exch. bases (me kg^{-1})	1180	880	430	830
Total N (g kg^{-1})	1.35	0.60	0.50	0.82
Total P "	0.49	0.52	0.23	0.41
Total K "	11.81	8.19	6.09	8.70
Total Ca "	2.99	2.20	1.52	2.23
Total Mg "	1.15	1.33	1.49	1.32

For factor analysis, principal component analysis method was used since it seems to be widely utilized (Harman, 1976). The factors were subjected to varimax rotation.

Factor analysis of soil properties in the 0-20 cm layer

Factor analysis identified four factors which accounted for 75% variation in the eleven variables. The proportion of variance explained by common factors is called the communality of the variables. The factor loadings and the communalities after iteration are given in Table 3. First factor was associated with G, *S* and pH. It was negatively correlated with G and positively correlated with *S* and pH. The second factor was associated with OC, EA, EB and N and showed positive correlation

Table 2. Mean values of soil properties in different layers at Kollathirumed

Properties	Layers (cm)			
	0.20	20-40	40-60	0-60
Gravel (g kg^{-1})	167	230	221	206
Sand "	601	537	540	560
Silt "	112	108	108	108
Clay "	120	125	131	126
Org. carbon "	7.14	12.02	10.48	13.21
Soil pH	5.2	5.3	5.2	5.2
Exch. acidity (me kg^{-1})	650	540	490	560
Exch. bases (me kg^{-1})	1080	740	560	800
Total N (g kg^{-1})	1.20	0.78	0.78	0.92
Total P "	0.62	0.53	0.54	0.56
Total K "	8.41	4.49	3.38	5.43
Total Ca "	3.62	2.51	2.41	2.68
Total Mg "	1.09	1.54	1.90	1.51

Table 3. Factor loadings and communalitics of soil variables in the 0-20 cm layer

Variables	Communality	Factor loadings			
		F1	F2	F3	F4
G	0.9360	-0.9464	-0.1134	-0.1352	0.0959
S	0.8736	0.8793	0.2994	0.0817	-0.0649
OC	0.7628	0.1833	0.8355	0.1586	-0.0774
pH	0.5842	-0.4785	0.3519	-0.0998	-0.4706
EA	0.5852	0.1165	0.5726	0.2378	0.4327
EB	0.6296	-0.0906	0.7770	0.0088	-0.1328
N	0.7245	0.3817	0.7211	0.0951	0.2231
P	0.7847	-0.2004	0.0576	-0.1421	0.8491
K	0.4993	0.2314	0.2461	0.5716	-0.2420
Ca	0.9520	0.6628	0.0065	-0.7097	-0.0943
Mg	0.8818	0.1004	0.0841	0.9290	0.0410

G = Gravel; S = Sand; OC = Organic carbon; pH = Soil pH; EA = Exchange acidity; EB = Exchangeable bases; N = Total N; P = Total P; K = Total K; Ca = Total Ca; Mg = Total Mg.

Table 4. Factor loadings and communalities of soil variables in the 20-40 cm layer

Variables	Communality	Factor loadings			
		F1	F2	F3	F4
G	0.9388	-0.4125	-0.8512	0.1489	0.1480
S	0.9085	0.3835	0.8641	-0.0330	-0.1169
OC	0.7054	0.6809	0.3740	-0.2855	0.1429
pH	0.7796	0.0951	-0.0279	0.0456	0.8762
EA	0.4569	0.6511	0.1158	0.1279	-0.0570
EB	0.6872	0.7898	0.0949	-0.0593	0.2256
N	0.3864	0.3250	0.2093	-0.4867	-0.0060
P	0.5436	-0.0059	-0.3037	0.6565	-0.1426
K	0.7546	0.1550	0.1512	0.8203	0.1865
Ca	0.9157	-0.2956	0.8397	-0.1678	0.3084
Mg	0.7921	0.7213	-0.0866	0.0065	-0.5141

G = Gravel; S = Sand; OC = Organic carbon; pH = Soil pH; EA = Exchange acidity; EB = Exchangeable bases; N = Total N; P= Total P; K = Total K; Ca = Total Ca; Mg = Total Mg.

Table 5. Factor loadings and communalities of soil variables in the 40-60 cm layer

Variables	Communality	Factor loadings			
		Fl	F2	F3	F4
G	0.9456	-0.8843	-0.0253	0.2210	-0.3379
S	0.9390	0.8667	-0.0017	-0.2652	0.3427
OC	0.7060	0.6701	0.3244	0.3178	0.2253
PH	0.6759	0.1670	-0.7607	-0.2433	0.1006
EA	0.7979	0.3564	0.7840	-0.2211	0.0850
EB	0.4784	0.5592	0.2295	0.2926	-0.1656
N	0.7487	0.7253	-0.2939	0.1933	0.3144
P	0.5204	-0.0365	0.2186	0.6778	0.1086
K	0.7754	0.0286	0.4465	-0.7319	0.1988
Ca	0.9273	0.1656	-0.0006	-0.0015	0.9486
Mg	0.9234	0.8786	, 0.0306	-0.2183	-0.3208

G = Gravel; S = Sand; OC = Organic carbon; pH = Soil pH; EA = Exchange acidity; EB = Exchangeable bases; N = Total N; P = Total P; K = Total K; Ca = Total Ca; Mg = Total Mg

Table 6. Factor loadings and communalities of soil variables in the 0-60 cm layer

Variables	Communality	Factor loadings			
		F1	F2	F3	F4
G	0.9468	-0.8951	-0.2111	-0.2504	0.1956
S	0.9110	0.8862	0.1878	0.2789	-0.1122
OC	0.7655	0.2361	0.8358	0.0846	-0.0637
pH	0.8485	-0.0071	0.0906	0.0188	0.9164
EA	0.5598	-0.0791	0.4036	0.6249	-0.0160
EB	0.7957	-0.0630	0.8652	0.1656	0.1254
N	0.7034	0.5904	0.5738	-0.1596	-0.0058
P	0.4870	-0.4463	0.0670	-0.4299	-0.3138
K	0.7334	0.0623	-0.0482	0.8520	0.0343
Ca	0.8248	0.8541	-0.0859	-0.2394	0.1747
Mg	0.7521	0.3099	0.3941	0.5712	-0.4177

G = Gravel; S = Sand; OC = Organic carbon; pH = Soil pl I; EA = Exchange acidity; EI3 = Exchangeable bases; N = Total N; P = Total P; K = Total K; Ca = Total Ca; Mg = Total Mg

with all the four properties. The third factor was associated with K, Ca and Mg, and showed negative correlation with Ca while there was positive correlation with the rest.The fourth factor was associated with P and it was positively correlated. It is found that the eleven soil variables measure only three components of the system. The components are the textural component (factor 1), organic matter component (factor 2) and nutrient capital of the soil (factor 3 and factor 4).

Factor analysis of the soil properties in 20-40 cm layer

Factor analysis identified four factors which accounted for 72% variation in the eleven variables. First factor was associated with OC, EA, EB and Mg and showed positive correlation with all the four properties. The second factor was associated with G,S and Ca. It showed negative correlation with G and positive correlation with the rest. The third factor was associated with N, P and K and showed negative correlation with N. The fourth factor was associated with pH and it was positively correlated. The factor loading and communalities after iteration are reported in Table 4. The result reveals that the eleven soil variables could measure only four components of the system viz., organic matter component (factor 1), textural component (factor 2), nutrient capital (factor 3) and acidic component (factor 4) of the soil.

Factor analysis of the soil properties in 40-60 cm layer

Factor analysis identified four factors which accounted for 77% of the variation among eleven variables. The first factor was associated with G, S, OC, EB, N and Mg and showed negative correlation with G and positive correlation with the remaining properties The second factor was associated with pH and EA and had negative correlation with pH. The third factor was associated with P and K and it was positively correlated with P

and negatively with K. The fourth factor was associated with Ca and it was positively correlated. The factor loadings and communalities after iteration are given in Table 5. These four factors were found to measure the three components of the systems. The components are textural and organic matter components (factor 1), acidic component (factor 2) and nutrient capital (factor 3 and factor 4) of the soil.

Factor analysis of the soil properties in 0-60 cm layer

Factor analysis identified four factors which accounted for 76% of the variation among eleven variables. The first factor was associated with G, *S*, *N*, P and Ca. It was negatively correlated with G and P. The second factor was associated with OC and EB and showed positive correlation with both properties. The third factor was associated with EA, K and Mg and showed positive correlation with all the three properties. The fourth factor was associated with pH and showed high positive correlation. The factor loadings and communalities arc reported in Table 6. It was observed that the eleven variables could measure only four components of the system viz., textural component (factor 1), organic matter component (factor 2), nutrient capital (factor 3) and acidic component (factor 4) of the soil. It has also been found that the factors were poorly correlated in each layer. Factor analysis of the soil properties in each layer resulted in four factors which occurred in different order in different layers. The four factors accounted, on an average, for 75% of variation in 0-20, 20-40 and 40-60 cm layers.

The impact of plantation activities will be mostly on the surface layer i.e., 0-20 cm. The effect in the sub-surface (20-40 cm) and deeper layer (40-60 cm) will be less when compared with the surface layer. Hence the observed variations in factor analysis could be ascribed to the plantation activities. It has been observed that certain factors in 0-20 cm, 20-40 cm and 40-60 cm layers are common with those in the 0-60 cm layer. As such, for generalization purposes, instead of interpreting the different factors in each layer, it is more advisable to go for the soil pit i.e., 0-60 cm layer. The observation on the percentage of variation accounted for eleven variables by their mean values for the three layers and that of 0-60 cm layers lend credence to the above findings. In other words, the study suggests that whatever may be the effect of individual layers on different factors, their overall effect can be obtained from the soil pit taken as a whole. The factors identified will be of use in rating the soil in plantation management programme.

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