SHOREA LEPROSULA AS AN INDICATOR SPECIES FOR SITE FERTILITY EVALUATION IN DIPTEROCARP FORESTS OF PENINSULAR MALAYSIA

Amir Husni Mohd. Shariff

Forest Research Institute Malaysia, Kepong, 52109 Kuala Lumpur, Malaysia

&

H.G. Miller

Department of Forestry, University of Aberdeen, AB9 2UD Aberdeen, Scotland, United Kingdom

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AMIR HUSNI MOHD. SHARIFF & MILLER, H.G. 1990. *Shorea leprosula* as an indicator species for site fertility evaluation in dipterocarp forests of Peninsular Malaysia. Soil chemical properties of Tekam and Pasoh forest reserves in Peninsular Malaysia were determined. In addition, foliar from four test species, namely *Shorea leprosula, Shorea parvifolia, Shorea ovalis* and *Koompassia malaccensis* were sampled and analysed. All trees of > 10 *cm* dbh were enumerated and their basal area calculated. Using Simple Regression analysis and Stepwise Regression analysis, the soil and foliar data were correlated against each other and against accumulated basal area. The results indicate that K is the primary limiting nutrient on both sites. The possibility of using the foliar of *Shorea leprosula* for fertility and growth evaluation under lowland rain forest is discussed.

Key words: Malaysia - dipterocarp forests - *Shorea leprosula* - indicator species - site fertility

Introduction

Indicator plants are widely used in site classification (Dorita 1976, Sadjak & Kotar 1985), as bioindicators (Yamada & Hattori 1979, Mikkonen & Huttunen 1981, Barklund & Rowe 1983) and as edaphic indicators (Chau & Lo 1980, Noraini 1981, Pregitzer & Barnes 1982, Minore *et al.* 1984).

The indigenous trees of Peninsular Malaysia are currently estimated to number 2650 species, distributed amongst 510 genera and 99 families (Ng 1988). Their distribution and association in tropical humid rain forest are imprecise. Therefore, the search for one or more species that can indicate site fertility is complex. The identification of such a species is beneficial to the ecologist and forest manager. A particular advantage would be in preliminary soil survey work and field evaluation where quick decisions are needed and money is at a premium.

The objective of this study is to explore the possibility of using *Shorea leprosula, Shorea ovalis, Shorea parvifolia* and *Koompassia malaccensis* as indicator species for site fertility evaluation, using soil and foliar analysis as the diagnostic tool.

Study site

The study was undertaken in two separate forest reserves in Peninsular Malaysia in order to encompass a varied range of soils and topography under very similar forest types. In this case, lowland diterocarp forest rich in *Shorea* and *Dipterocarpus* species were selected. The two sites are approximately 180 *km* apart, separated by a mountain range and highlands running parallel from north to the southern tip of the country.

Tekam Forest Reserve (TFR), encompassing 12400 *ha,* lies to the north of Jengka Triangle, Pahang (lat. 4°15' N; longtd. 102° 37' E). Mean annual precipitation ranges between 2765 to 2980 *mm* (Abdul Rahim 1983) whilst the air temperature ranges from 24 to 29°*C* (Dale 1963). The geology of this area is described to be of the upper Triassic and lower Cretaceous, belonging to Lanis conglomerate and Kerum formation, both of which are associated with volcanism (Khoo 1977).

Pasoh Forest Reserve (PFR), covering some 1360 *ha,* is located in the south-western part of Negeri Sembilan (lat. 58.4' N; longtd. 102°16.9' E). The climate of this area was described by Morgan (1971) as belonging to the west coast type (Lipis type). It has among the lowest average annual rain fall in Peninsular Malaysia, about 1800 mmy^1 (Dale 1959). The air temperature ranges between 24.5 and 27.2°*C* (Sani 1983). The geology of the region has been described by Khoo (1976) and Loganathan (1980). Pasoh Forest Reserve is underlain by sedimentary rocks in the east and igneous in the west. Alluvial deposits are also found in depression areas, resulting from weathered granite transported downslope.

Methodology

Field procedures

The soils of TFR and PFR were described according to the field legend for soil surveyors in Malaysia (Paramananthan 1986), and identified at series level. The five dominant series in each forest reserve, chosen for this study are Tajau (TJU) (Typic Paleudult), Jempol (JPL) (Typic Paleudult), Bungor (BGR) (Typic Paleudult), Jengka (JKA) (Rhodic Paleudult) and Jeram (JRM) (Typic Paleudult) representing TFR. For PFR the five series are Padang Besar (PBR) (Orthoxic Tropudult), Bukit Tuku (BTU) (Aquic Paleudult), Ulu Dong (UDG) (Typic Paleudult), Awang (AWG) (Aquic Paleudult) and Chat series (Typic Paleudult).

A 2-*ha* plot (100 × 200 *m*) was laid out on each soil series, oriented in the north-south direction of both reserves. All trees of ≥ 10 *cm* dbh were enumerated and identified to species level. The species were grouped into preferred and acceptable timber species (see Wyatt-Smith 1952 p. 326 & 328), and the basal area of each group calculated. Each of the 2-*ha* plots were subdivided into 200 sub-plots, each 10 × 10 *m*. Ten of these sub-plots were selected in each 2-*ha* plot for soil sampling.

Bulk samples (taken from five sampling points) were collected from each sub-plot, to represent depths of 0 to 15 *cm* and 15 to 30 *cm*, using a screw auger. The samples of each sub-plot were thoroughly mixed to ensure uniformity and packed inside plastic bags for transportation to the laboratory for analyses. Thus, for every 2-*ha* plot a total of 20 samples were taken, ten from each chosen depth.

Fresh foliar samples were also collected from four test species in each of the 2-*ha* plots within a three week period. The species are *Shorea leprosula*, *Shorea parvifolia*, *Shorea ovalis* and *Koompassia malaccensis*; all of which belong to the evergreen type. All sampled trees were at least 30 *cm* dbh with crowns in the dominant layer. The choice of species was based on the fact that these species were found across the study areas and are easily identified. The foliage samples were collected from the upper one third of the canopy. Only mature leaves of the outer-whorl and 15 *cm* down the shoot were taken. All sampling was carried out in the morning and ceased during rainy spells. If rain occurs sampling commenced only after a lapse of 24 hours. The samples were packed into paper bags and taken to the laboratory for analysis.

Laboratory analyses

Soil

Soil samples were spread out on trays and dried in the oven for a period of 48 to 72 hours at 60°*C*. Samples were then rolled through the roller mill and passed through 2 *mm* sieve and collected for analysis. For the determination of Nitrogen (N), available and total Phosphorus (P), exchangeable Potassium (K), Calcium (Ca), Magnesium (Mg) and total K, Mg, Ca and micronutrients Copper (Cu) and Zinc (Zn), fine samples were used after sieving through a sieve of 60 mesh size.

Kjedahl digestion procedure was adopted for N (%) determination (USDA 1972). Available P was determined using Bray and Kurtz's Method No. 2 (1945), and measured colorimetrically in the presence of ammonium molybdate; with stannous chloride acting as reductant (Watanabe & Olsen, 1965). Leaching with 1 *N* ammonium acetate buffered at pH 7 was adopted for extraction of available cations. For total cations, total P, Cu and Zn, the perchloric sulphuric acid mixture ratio (1:1) digestion procedure was adopted (Lim 1975). Subsequent determination procedures were outlined by Jackson (1958). Exchangeable and total K were determined by flame photometer, and for Ca, Mg and Zn were determined by the atomic absorption spectrophotometer.

Foliar

The technique outlined by Yeoh (1975) regarding foliar preparation prior to analysis was strictly followed. The leaf petiole was removed and the samples dried in the oven for 24 to 72 *h* at 70°*C* until they turned brown and brittle. Samples were ground through a 1 *mm* sieve and thoroughly mixed before taking subsamples for analysis.

For N determination, the classical Kjedahl method (Piper 1950) was adopted using sodium sulphate to promote oxidation of organic matter and selenium as catalyst. Dry ashing was used for P, K, Ca and Mg determination. For Cu and Zn, wet ashing was used. Phosphorus in the ash extract was determined colorimetrically by the formation of yellow vanado-molybdo-phosphate complex, measured using spectrophotometer. Potassium was determined by flame photometry. Calcium and Mg by atomic absorption spectrophotometer at wavelengths of 442.7 and 285.2μ, respectively. For Cu and Zn determinations, the wavelengths were set at 324.8 and 213.8μ, respectively.

Data analysis

Data for the two reserves were combined for scientific interpretation. The data from the two reserves can justifiably be analysed together as they both carry lowland dipterocarp forests of similar structure. The fact that the data on almost all parameters from the two reserves were found to be overlapping justified the lumping. For the foliage data, the number of samples used were 6, 7, 8 and 9 for *S. ovalis, S. leprosula, K. malaccensis* and *S. parvifolia,* respectively. The sample size is unequal due to the absence or virtual absence of these species from some of the sample plots.

The data was analysed by Simple Correlation and Stepwise Regression. The latter was adopted to eliminate any masking effect. Only N,P and K variables of the foliar nutrients were selected for the Stepwise Regression analysis. This choice was based on the results of Simple Correlation tests.

Using Structured Fortran 77 (Ellis 1980), a program was written to categorise out the raw vegetation data into species, family, frequency, basal area and girth classes distribution (at intervals of 30 *cm* gbh) and subsequently expressed as basal area of preferred, acceptable and all species. Simple Linear Correlation and Stepwise Regression analyses were carried out to establish the relationship between foliage nutrient levels of the test species with soil nutrients and accumulated basal area.

Results

The combined accumulated basal area of all species from both reserves, showed highly significant correlations (Table 1). Foliar K and Zn levels of *S. leprosula* having values of 0.83 and 0.90, respectively; whike K levels of *K.*

malaccensis being r = 0.89 (Table 1). There were no significant relationships in *S. ovalis* and *S. parvifolia.* With regards to the combined accumulated basal area of preferred and acceptable species, no significant correlations were observed with any of the foliar nutrient levels of the four test species.

Table 1. Correlation coefficients (rs) of accumulated basal area of Preferred, Acceptable and All species of PFR and TFR combined *versus* foliar nutrient levels of four selected species

Species	Preferred (PFR + TFR)	Acceptable (PFR + TFR)	All (PFR + TFR)
Shorea parvifolia:			
- N	-0.064	-0.284	0.590
- P	-0.130	0.134	0.153
- K	-0.058	0.158	0.226
- Ca	0.134	-0.107	-0.277
- Mg	-0.120	0.409	0.406
- Cu	-0.190	0.098	-0.340
- Zn	-0.036	-0.233	0.306
Shorea leprosula:			
- N	-0.187	-0.298	0.496
- P	0.012	-0.136	-0.120
- K	-0.193	0.326	0.828**
- Ca	-0.453	-0.379	0.162
- Mg	-0.350	0.085	0.155
- Cu	-0.621	0.058	-0.086
- Zn	0.264	0.030	0.899***
Koompassia malaccensis:			
- N	0.156	-0.466	0.073
- P	0.174	0.233	0.484
- K	-0.177	-0.128	0.894**
- Ca	0.570	-0.006	-0.368
- Mg	-0.111	0.371	-0.210
- Cu	-0.115	-0.117	-0.363
- Zn	0.034	-0.127	0.672
Shorea ovalis:			
- N	-0.030	0.181	0.360
- P	-0.508	0.684	0.483
- K	0.137	-0.299	-0.543
- Ca	0.396	-0.847	-0.802
- Mg	0.339	0.267	0.513
- Cu	-0.401	0.436	-0.090
- Zn	-0.056	0.056	-0.356

Note: Sample size used were as follows; *S. ovalis* (n = 6), *S. parvifolia* (n = 7), *K. malaccensis* (n = 8) and *S. leprosula* (n = 9). *, ** and *** significant at 5, 1 and 0.1%, respectively

In terms of soil-foliar relationship, the correlation between the four test species with total soil nutrients is illustrated in Tables 2 and 3. *S. leprosula,* in particular, showed a highly significant correlation between foliar K and soil total K in the topsoil (r = 0.90) and subsoil (r = 0.96). Correlations were found between foliar K and subsoil total K in *K. malaccensis* (r = 0.78). However, the relationship was weakly expressed when correlated with topsoil K.

A soil-foliar Mg correlation was also found for Mg in *S. parvifolia* and *S. leprosula* for both soil horizon. The correlation was more significant in the subsoil for both reserves. In the case of micronutrients, a weak correlation was established between the foliar and subsoil Zn level in *S. ovalis* (Table 2).

Table 2. Correlation coefficients (rs) of foliar nutrient levels of four selected test species *versus* total soil nutrient levels of PFR and TFR combined

Species		*S.parvifolia*	*S.leprosula*	*K.malaccensis*	*S.ovalis*
Soil nutrients:					
N	- topsoil	0.016	-0.368	-0.714	-0.739
	- subsoil	0.234	-0.355	-0.684	-0.674
P	- topsoil	0.162	0.088	0.140	0.656
	- subsoil	0.120	0.139	-0.048	0.589
K	- topsoil	0.075	0.904***	0.671+	-0.446
	- subsoil	0.175	0.957***	0.778*	-0.501
Ca	- topsoil	-0.564	0.297	0.214	-0.265
	- subsoil	-0.477	0.339	0.347	0.021
Mg	- topsoil	0.701+	0.639+	-0.079	0.358
	- subsoil	0.747+	0.743*	-0.127	0.193
Cu	- topsoil	-0.073	0.397	-0.097	0.136
	- subsoil	-0.353	0.018	-0.140	0.492
Zn	- topsoil	0.432	0.059	0.149	0.436
	- subsoil	0.224	-0.053	0.136	0.735+

Note: +, *, ** and *** are significant at 10, 5, 1 and 0.1%, respectively (Notations follow for Table 3)

Table 3. Correlation coefficients (rs) of foliar nutrient levels of four selected species *versus* soil exchangeable and available nutrient levels of PFR and TFR combined

Species		*S.parvifolia*	*S.leprosula*	*K.malaccensis*	*S.ovalis*
Soil nutrients:					
Av.P	- topsoil	-0.130	0.483	-0.659	0.129
	- subsoil	-0.185	0.160	-0.439	0.813*
Ex.K	- topsoil	0.606	0.290	0.543	-0.320
	- subsoil	0.530	0.389	0.639+	-0.397
Ex.Ca	- topsoil	-0.329	0.057	-0.140	0.810+
	- subsoil	-0.277	0.277	0.543	0.855*
Ex.Mg	- topsoil	0.750+	0.815**	-0.468	0.083
	- subsoil	0.670+	0.810**	-0.308	-0.152

In terms of exchangeable and available soil nutrients (Table 3), subsoil exchangeable K was weakly correlated with foliar K for *K. malaccensis* (r = 639, $P < 0.10$) (Table 3). Exchangeable Ca in the subsoil was positively correlated to *S. ovalis* foliar Ca levels, while the relationship was weak for topsoil (Table 3). The correlation was strong between foliar Mg of *S. leprosula* and exchangeable Mg in both soil horizons (Table 3). Similarly was observed for *S. parvifolia* but weakly expressed. Interestingly, soil available P showed fairly high correlations with foliar P, in *S. ovalis* in the subsoil (Table 3).

Using Stepwise Regression analysis, the foliar data from each of these test species, taken individually, were tested for their ability to predict the accumulated basal area. Total accumulated basal area of all species (Table 4) was significantly correlated to the levels of foliar K using the data of *S. leprosula* (t = 3.90, $P<0.01$) and *K. malaccensis* (t = 6.61, $P<0.001$); although for the latter species, there was also a weak negative relationship with foliar N levels.

However, the total basal area was not related to the foliar nutrient concentrations in either *S. ovalis* or *S. parvifolia* (Table 4).

Table 4. Stepwise regression analysis of foliar nutrients of four selected test species *versus* all species basal area and dipterocarp basal area of combined forest reserves

a.	All species basal area = 10.13 + 26.5 *Shorea leprosula* foliar K t-ratio for *Shorea parvifolia* foliar K is 3.90**.
b.	All species basal area = 26.95 + 11.6 foliage K. *Koompassia malaccensis* K - 3.8 foliage *Koompassia malaccensis* N t-ratio for *Koompassia malaccensis* foliar K is 6.61*** t-ratio for *Koompassia malaccensis* foliar N is - 2.23+
c.	All species basal area has no response to either the variable of the species *Shorea parvifolia* and *Shorea ovalis*
d.	Basal area of dipterocarps has no response to the variables of the four test species

(Note: +, *, ** and *** are significant at 10, 5, 1 and 0.1% respectively)

Discussion

From the correlation analysis, it is striking to note the extent to which foliar levels of K in *S. leprosula* and *K. malaccensis* predict growth, at least as expressed by accumulated basal area. The relationship is further supported by the Stepwise Regression analysis. The role of K as the limiting nutrient in the growth of tropical rain forest species has been noted (Amir Husni & H.G. Miller unpublished).

The results of this study indicate *S. leprosula* to be a suitable indicator species for fertility evaluation in the two reserves. It suggests that the growth of forest species studied are perhaps limited by soil K supplies. The advantage of foliar analysis in indicating nutrient status of forest species has been discussed by Miller (1984) and Amir (1989). The fact that K is the growth limiting nutrient is further supported by work on *Hevea brasiliensis* where soil K correlated positively to foliar K (Lau *et al.* 1973) and total K was found to be the main limiting nutrient for its growth and yield (Pushparajah 1969).

Relationships were established between growth and soil Mg, but no correlation was established with basal area and foliar Mg. Perhaps, this may suggest that soil Mg in particular, is covarying with soil K. The problem of soil Mg covarying with soil K, and thereby, confounds the interpretation of soil analysis. This accords with the observation by O'Carroll (1966), who concluded that foliar analysis is required to identify growth limiting nutrients.

Some exchangeable soil nutrients exhibited a significant relationship with foliar nutrient levels in *S. leprosula* and *S. ovalis* but no correlation with growth basal area, an indication of excess uptake (Table 1). According to Austin *et al.* (1972) the prediction of tree growth using available and exchangeable nutrients is confounded by the extraction method used. The variable chemical extractants used may not reflect the true availability of a particular nutrient for uptake by tree roots.

There has never been any reported micronutrient deficiencies in natural forest ecosystems. This is probably due to the fact that they are required in small amounts for normal growth (Leaf 1968). Moreover, under undisturbed environments, where nutrient cycling is efficiently taking place, the loss is kept to a minimum. The retranslocation of nutrients from leaf into the tree prior to abscission is continually taking place (Qureshi & Srivastava 1966, Van den Driessche 1974, 1984, Miller 1984, Lim & Cousens 1986, Amir *et al.* 1989). By contrast, under plantation conditions, micronutrient deficiencies have been recorded, for example in rubber (Zin 1979) and oil palm (Singh 1983). The deficiencies are often established on rather degraded soils, resulting from agriculture or exploitative logging.

The fact that the accumulated basal area of preferred and acceptable species show no correlation with nutrient levels in soil and foliar is not surprising. It is because the species composition of each guild has no rationale in terms of physiological, morphological or biological features. Indeed, many characteristics vary drastically within themselves, since some species are shade tolerant while others are light demanders, and some tend to have both characteristics (Wyatt-Smith 1952). Even the dipterocarp species are known to vary amongst themselves (Wyatt-Smith 1954,1966, Ashton 1976, Whitmore 1984).

Conclusion

Of the four selected test species, *S. leprosula, S. parvifolia, S. ovalis* and *K. malaccensis*, only *S. leprosula* has promise as indicator species for fertility evaluation. This is based on the significant relationship established between accumulated basal area and foliar K for this species. *S. leprosula* is easily identified in Malaysian dipterocarp forests. Furthermore, this particular species enjoys a wide range of ecological distribution in the lowland rain forest.

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