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FOLIAR ANALYSIS IN EUCALYPTUS TERETICORNIS AND E.GRANDIS TO ASSESS SOIL TEST MATHODS FOR NITROGEN, PHOSPHORUS AND POTASSIUM

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Abstract

While plantations of cucalypts, occupy over 35,000 ha in Kerala, no studics have been conducted far to explore the possibilities of nutrient management for increasing productivity. The present work aims at assessing the foliar nutrient levels of E. tereticornis and E. grandis especially the concentration of nitrogen, phosphorus and potassium in relation to the content of these elements in the soil.

Field work was carried out in Kondazhi (1977, E. tereticornis plantation, Trichur Forest Division) and Muthanga (1980, E. grandis plantation, Kozhikcde Forest Division). Soils were collected from pits (0 – 20, 20-40 and 40 – 60 cm layers) and the foliar material was sampled thrice, (April 1983, September 1983 and March 1984). Analysis of N.P and K in soil and plant were carried out following standard procedures.

Soils in both E. tereticornis and E. grandis plantation:; contained low levels of NO_3-N and extractable P while the content of K was modarately high. The same trend was observed in foliar concentrations of these elements. Sampling season did not have an impact on foliar levels of N, P and K and fully expanded leaves were found to be reliable material for foliar analysis. Thc markedly low concentrations of N and P in the soil as well as plant material suggest that productivity can be improved by soil nutrient management. '

Introduction

Judicious management of tree nutrition is an important tool not only to ensure increased tree productivity but also to sustain productivity of forest plantations over a long-term period. It is therefore nacessary to identify the characteristics of the nutrient reserve in the soil and assess the same in relation to the supply of essential elements to the trees. Foliar analysis is a well established and sensitive method used to assist diagnosis of mineral requiriements in agriculture and horticulture (Driessche, 1974) although its application in forestry has commenced recently (Bowen and Nambiar, 1984; Schonau, 1984). Application of foliar analysis to a tree species for the purpose of diagnosing nutrient requirements is based on the premise that a general relationship exists between foliar nutrient concentration and growth or yield parameters with in the species.

Exhaustive investigations have been carried out on the mineral nutrient diagnosis of forest tree species in the temperate zone; western hemlock (Radwan and De Bell, 1980), pine (Bevege and Richards, 1972) and Tilia (Insley et al., 1981). Use of leaf nutrient levels has been scarce in relation to management of plantations in the tropics and only explorative investigations have been reported (Nanda, 1963; Seth and Bhatnagar, 1962; Haaq, 1983; Sharma, 1983).

With the introduction of a range of eucalypt species all over the world, especially in the tropics, as a major component in the plantation forostry programme, of' late, much attention has been drawn to the nutritional problcmn related with them (Lamb, 1976; Lamb, 197'7;

Schonnu, 1981; Cromer and Williams, 1982; Bel1 and Ward 1984; Haridasan, 1985). Although eucalypts play a dominant role in Indian forestry, comprehensive investigations are lacking only isolated attempts on the nutrient relations of eucalypt seedlings have been made (Hussain and Theagarajan, 1966; Kaul et. al, 1968; Chauhan, 1977). As trees have three distinct nutritional stages with advancing age (Miller et al., 1981) studieson young seedlings may provide little information for the nutritional management of older stands. With reference to Kerala, where plantations of' two species of eucalypts E.tereticornis and E. grandis occupy over 35,000 ha no studies have been conducted so far to explore the possibilities of nutrient management in increasing productivity. This project aims at, assessing the foliar nutrient; levels of E. tereticornis and E. grandis plantations, especially the concentration of nitrogen, phosphorus and potassium in relation to the content of the same in soil.

Materials and Methods

The study sites were Kondazhi (10o42'N 76o24'E) for E. <u>tereticornis</u> and Muthanga (11^{o}40'N, 76^{o}22'E) for E. <u>grandis</u> in Trichur and Kozhikode Forest Divisions respectively. Details on the plantations are given in Table 1.

Four plots 10 x10 m in E. tereticornis plantations and 12.5 x 12.5 m in E.. grandis plantation were demarcated to have 20 trees in each. The plots were on an average 500 m from each other.

Current year twigs were sampled from top one third of the crown in April 1983, September, 1983 and March 1984. Tho leave.; from one plot were pooled after stratifying them into different classes viz. ncwly expanding, class I expanded and class II expanded depending on their position and size from top to bottom. The samples were oven dried at $60^{o}C$, ground and prepared for analysis. Leaf nitrogen (N) was estimated using modified Convey's microdiffusion tcchniquc after wet digestion (Walsh and beaton, 1973). Phosphorun (P) and potassium (K) were assessed after dry ashing the samples by colorimetry (Walsh and Beaton, 1973).

Soil samples were collected from three soil pits dug in each plot from 0–20, 70–40 and 40–60 cm depths. They were air dried and passed through a 2 mm sieve. NO_3-N was estimated using $CaSO_4$ as extractant, P using Bray-2 method and K with sodium acetate cxtractant (ASA, 1965).

Table 1 Characteristics of study sites and plantations

Species and Year of planting	Location	Elevation m asl	Rainfall mm	Mean height* (m)	Mean gbh* (cm)
Euca lypt.us *tereticornis* 1977	Kondazhi (Trichur Forest Division)	100	3000	9.0	27.3
Eucalyptus grandis 1980)	Muthanga (Kozhikode Forest Division)	800	1700	12.0	30.4

* as of April 1984 for E *tereticornis* and April 1983 for E.*grandis*

n= 5–7

Results and Discussion

Soil analyses

The results of soil analyses of NO_3-N, P and K are presented in Tables 2 and 3 for Kondazhi and Muthanga sites respectively. The values have been adjusted for the gravel content, in the soil as reported earlier (Alexander and Thomas, 1985). These authors have found that where gravel is a major component in soils such adjustments help to arrive at. more meaningfuI interpretations.

NO_3-N. Ths levels of N03-N in soils from both plantations are low, while the soil at Muthanga site contains more nitrogen. NO_3-N being labile, it is more or less evenly distributed in the surface and sub-surface layers.

P-The extractable P content of both soils is extremely low which *is* typical of tropical ,soils with high levels of iron and aluminium in the system. There is a reduction of P content with depth. In thc case of P too, the Muthanga soil is slightly richer.

K-Soils from both plantations have fairly rich amount of K. The Muthanga site has two-fold concsntration of soil K when compared to Kondazhi.

Foliar analyses

The rationale behind foliar analysis is that the concentration or content of nutrients reflects thc nutritional status of the plant, and thus its growth potential (Mead, 1984). The results of foliar analytical investigations conducted in E. tereticornis and E. grandis

Table 2 Distribution of NO_3-N, P and K in soil in Kondazhi*

Plot	Depth (cm)	N	P	K
		(..........mg kg^{-1}.......)		
1	00-20**	3.5	1.5	43
	20-40	3.5	0.8	23
	40-60	3.7	0.5	25
2	00-20	1.3	1.4	50
	20-40	0.9	0.7	31
	40-60	1.0	0.3	27
3	00-20	0.8	1.5	38
	20-40	0.6	5.0	17
	40-60	0.5	0.8	7
4	00-20	1.4	2.0	112
	20-40	1.6	1.3	72
	40-60	1.3	1.2	56
Mean**	00-20	1.7	1.6	61
	20-40	1.4	2.0	37
	40-60	1.4	0.7	29
CV	00-20	73	17	57
	20-40	60	102	65
	40-60	67	56	70

* NPK values are adjusted for the gravel content in the soil

** Average of three soil pits- in each plot

*** Mean and CV based on twelve soil pits

Table 3. Distribution of NO_3-N, P and K in soil in Muthanga*

Plot	Depth (cm)	N	P	K
		(.........mg Kg^{-1}	....	.........)
1	00-20**	1.5	1.3	117
	20-40	1.6	0.6	115
	40-60	1.0	0.1	68
2	00-20	2.0	1.5	
	20-40	2.0	0.5	54
	40-60	3.0	0.2	38
3	00-20	3.1	5.8	178
	20-40	2.0	0.8	165
	40-60	3.5	0.5	130
4	00-20	2.3	1.2	114
	20-40	2.3	0.2	49
	40-60	1.6	tr	38
Mean***	00-20	2.2	2.4	129
	20-40	2.0	0.5	96
	40-60	2.0	0.2	68
CV	00-20	32	93	25
	20-40	12	50	57
	40-60	45	110	64

* NPK values are adjusted for the gravel content in the soil

** Average of three soil pits in each plot

*** Mean and CV based on twelve soil pits are given in Tables 4 and 5. As many factors influence the levels of elements in the leaf, the results are presented and discussed under the following subheadings:

Foliage age and nutrient levels

Leaves from current year twigs were sampled and segregated into 3 types: newly expanding, class I expanded and class IT expanded leaves for analysis N. In E. grandis foliage only the first two types could be identified. Newly expanding leaves have slightly higher levels of' NP and K than mature ones (tables.4 and 5). The only exception to this is with N content, in E. tereticornis foliage (Table 4). Class II expanded leaves being older than the other two show lowest concentrations of nutrient elements. Similar results have been obtained elsewhere (Bell and Ward, 1984). The N, P and K concentrations in young leaves show high variability among plots (cv = *25-60%)* while in expanded leaven the variability is less (cv =5-20%). The concentration of elements being more stable in class I and class II expanded leaves than newly expanding *ones,* sampling may be restricted to them in foliar diagnosis activities.

Season of sampling

Foliar level of essential elemenets can vary during the year. The concentration of N P and K in the foliage of E. tereticornis and E, grandis sampled in March 1953, September 1983 and April 1984 arc given in Table s 4 and 5. The data indicate that sampling time does not play a crucial role in humid tropical areas in comparison with temperate areas, where there is a marked physiologically inactive period during winter (Leaf, 1973; Driessche, 1974) although wet and dry seasons can

Table 4 NPK levels in E *tereticornis* foliage %

		N	P	K
Newly expanding leaves	April	0.94	0.05	0.69
	Septmber	0.92	0.11	0.82
	March	9.72	0.07	0.82
	Average**	0.86	0.08	0.73
Class I expanded leaves	April	0.88	0.06	0.76
	September	0.94	0.08	0.68
	March	1.18	0.06	0.88
	Average	1.00	0.06	0.77
Class II expanded leaves	April	0.74	0.05	0.74
	September	0.90	0.06	0.56
	March	-	-	-
	Average	0.77	0.06	0.65

* n = 4 (plots) **n = 3 (seasons)

Table 5. NPK levels in E *grandis* foliage %*

		N	P	K
Newly expanding leaves	April	1.36	0.10	0.88
	September	1.40	0.18	0.70
	March	0.48	0.15	0.82
	Average*	1.08	0.14	0.80
Class I expanded leaves	April	1.10	0.08	0.76
	September	0.72	0.08	0.50
	March	0.73	0.13	0.72
	Average	0.85	0.10	0.66

n=4 (plots) n=3 (seasons)

Table 6 **Diagnostic criteria** for NPK **in _E. grandis_ foliage (Schonau, 1984).**

Element	Concentration %		
	Optimum	Minimum	Maximum
N	2	0.85	3.12
P	0.16-0.15	0.11	0.35
K	0.70	0.36	1.02
N/P	13.00	3.29	26.00
N/K	3.00	0.99	4.62
P/K	0.23	0.11	0.47

Table 7. Nutrient **ratios in eucalypt foliage in study sites***

Nutrient/Species	_E. tereticornis_	_E. grandis_
N/P	16.57	8.50
N/K	1.30	1.23
P/K	0.08	0.15

*based on average values of class I expanded Leaves.

impart difrerences in nutrient concentrations in the tropic:: (Lamb, 1976).

Yutrient levels and diagnostic criteria

Foliar analysis has the prime objective of' contributing information on the nutrient. element limitationn. Optimum lcvcls of' nutrient levels have not been reported for E. tereticornis and E. grandis for local conditions meanwhile a general guidance is available from the work of Shonau (1984) (Table 6). Data given in tables 4 and 5 clearly indicate that the 1evels of N and P in both the species are below optimum with moderately optimal potassium levels. It may be stressed here that the levels of N and P are below even the minimum range prescribed by Schonau (1984) while that of K need not pose a problem given current growth rate:: are maintained. Nutrient ratios (Table 7) can also aid in interpretation of foliar analytical data. Even the ratios arrived at f'or both the species reveal imbalances in N and P supply to the plants.

Relationship between foliar and soil levels of NPK and eucalypt growth

Coefflcients of correlation (tables 8 and 9) show that in certain cases high values of exist for eg. between soil K and foliar K in Kondazhi (r = 0.98). Otherwise foliar concentration shows no direct relationships with soil levels . At the same time low levels of N (NO_3-N) and extractable P in the soils of both plantation:; are reflected in the below minimum concentrations of N and P in the leaves

Table 8. Correlation coefficients between soil and foliage level of NPK and tree growth in E. tereticornis

Variable**	SP	SK	FN	FP	FK	h	d^2h
SN	-0.06	-.14	.33	.98	-.18	.68	.94
SP		.95	.80	-.24	.98	.68	.22
SK			.86	-.34	.98	.60	.08
FN				.12	-81	.84	.46
FP					-.38	.52	.88
FK						.58	,06
h							.a4

* data for April 1984. * -values for 2df = .95 and .39 at 95% and 99% levels

** SN = Soil Nitrogen, FN = Foliar Nitrogen, SP = Soil Phosphorus, FP = Foliar Phosphorus, d = diameter, SK = Soil Potassium, FK = Foliar Potassium.h = height,

Table 9. Correlation coefficients between soil and foliage levels of NPK and tree growth in E. Grandis

Variable*	SP	SK	FN	FP	FK	h	d^2h
SN	.86	.84	0.006	-.45	-.62	.49	.35
SP		.99	-.46	-.83	-,92	.01	-.12
SK			-.42	-.84	-.94	.02	-.07
FN				.79	.67	.86	.94
FP					77	.50	.56
FK						.	.34
h							.98

* data for April 1983, r - values for 2df = .95 and .99 at 95 and 99° levels.

** as in table 8.

of E. tereticornis and E. grandis. While moderately high levels of soil K have provided for optimum range of foliar K in both species.

High values of r exist between soil N and folinr P and tree growth In E. tereticornis (Soil N: d_2h = 0.94; Soil P: d_2h = 0,88). In E. grandis the correlation between foliar Nitrogen and growth is high (Foliar N: d_2h = 0.94). This suggests that certain linkages are present and high positive correlations between growth and nutrient levels are associated with deficiencies.

Conclusion

Less variability in elemental. concentrations in fully expanded leaves render them more reliable material for foliar analysis. Comparison between the foliar and soil levels of N, P and K suggests that both soil and plant test data supplement and complement one another. The present levels of foliar N and P are below optimum while that of K is within the range prescribed. The same is due to low content of N and P in the soi1 with moderately high Levels of K. The markedly low concentrations of N and P in both soil and plant material suggest that growth can be increased by soil nutrient management.

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