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INCREASING GROWTH OF ESTABLISHED TEAK

By

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Summary

Teak plantations, 3 to 16 years old, were thinned and fertilized in an effort to increase productivity. The best single method for increasing rate of tree increment was removal of competitors. Larger trees had a faster basal area increment but slower height growth than smaller trees on the same site conditions. Height growth was greater in the areas with higher rainfall, but basal area increment was not. Both height and basal area growth were greater on the andesite-derived alluvial sites than on the residual soils over limestone. Basal area increment was correlated with addition of phosphorus; total height growth was correlated with added potassium. The effect was quite minor in both cases, and neither height nor basal area was significantly influenced by added nitrogen, calcium, nor magnesium.

Resumen

Plantaciones de teca de 3 a 16 años de edad fueron entresacadas y se les aplicó abono químico en un esfuerzo para aumentar su crecimiento. El método que resultó mejor para aumentar su crecimiento proporcional fue el de remover los árboles competidores.

Los árboles de más edad tuvieron un aumento mayor de área basimétrica, pero crecieron menos en altura total que árboles más jóvenes sembrados en sitios con las mismas condiciones. El crecimiento de altura fue mayor en areas de mayor cantidad de lluvia, pero no

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así el crecimiento de area basimétrica. El crecimiento de altura y area basimétrica fue mayor en sitios aluviales derivados de andesita que en sitios residuales sobre piedra caliza.

El aumento en area basimétrica tuvo relación con la aplicación de fósforo y el crecimiento de altura total tuvo relación con la aplicación de potasio. El efecto fue secundario en ambos casos y ni la altura total o el area basimétrica fue significativamente influenciada al añadirle nitrógeno, calcio, o magnesio.

Introduction

Nowhere in the Western Hemisphere is competition for available land more intense than in Puerto Rico, with less than two-fifths of an acre of arable land per person. Thus, it is economically imperative that lands managed for forestry produce as high a yield per acre as possible. This objective may be obtained by (1) introduction and development of high yielding species or strains of trees; (2) manipulation of phytogenic competition; and (3) increasing site productivity.

These three basic techniques are mutually complementary, and all three were incorporated in the study reported here. On a volumetric basis, teak (Tectona grandis L.) may be considered moderate to fast-growing; when the quality of the wood is included, however, value growth of teak must be classified as fast to outstanding. Eighteen different fertilization treatments were tested for improving site productivity, including zero fertilization. All trees included for fertilizing were released to prevent intense competition from obscuring the fertilization effects.

Methods

In the absence of specific information on either requirements or optimums for teak, a wide variety of fertilizer levels was included (Table 1). Application was for five consecutive years, half in May and half in September, broadcast on the soil surface within a circle with a radius in feet equal to one, plus half the tree dbh in inches ($r = 1 + \frac{dbh}{2}$).

Nitrogen was added as ammonium sulfate, phosphorus as superphosphate, potassium as potassium sulfate, calcium as ground limestone, and magnesium as magnesium sulfate.

Study trees (Table 2) were released immediately after the first fertilization and annually for the duration of the study, by removing all trees and woody brush within a circle with a radius in feet equal to four, plus the dbh in inches of the sample tree. Conversion of pounds per acre values listed in Table 1 to pounds per tree in the 1-tree plots, therefore, assumed each tree dominated a hexagon with a diameter in feet equal to four, plus the tree dbh expressed in inches (D = 4 + dbh).

Two blocks were established at each of eight locations, but one block was destroyed in 1963, leaving 15 for analysis.

All study trees were pruned to a height of 20 feet or to 40 percent of total height, whichever was lower, approximately 10 months after the first release and annually as needed to extend the clear length or remove the occasional epicormic sprouts.

A variety of measurements were made, but final analyses were only of increment in basal area at breast height and growth in total height.

Results

Fertilized Trees

Basal Area.--Increment in basal area was correlated with a variety of factors considered (Table 3). Specific relationships found are as likely to be misleading as helpful elsewhere, but the general relationships are listed below:

1. Larger trees grew more rapidly. Statements below assume trees of equal size.

2. Trees in Puerto Rico grew more rapidly than those on St. Croix.

3. Trees in Puerto Rico growing on an andesite-derived alluvium grew more rapidly than those on residual limestone soils.

4. Addition of phosphorus increased growth rate (probability 80 percent).

5. Basal area increment in this study was not correlated with application of nitrogen or potassium, nor with supplements of calcium or magnesium.

Total Height.--Patterns of growth in total height (Table 4) were similar but not the same as those for basal area increment:

1. Smaller (younger) trees grew more rapidly. Statements below assume trees of equal size.

2. Trees in Puerto Rico growing on an andesite-derived alluvium grew more rapidly than those on residual limestone soils.

3. On limestone soils in Puerto Rico, trees in the moist area (annual rainfall 80 inches) grew more rapidly than those in the dry area (annual rainfall 50-60 inches).

4. Addition of potassium increased the growth rate.

5. Growth in total height was not correlated in this study with application of nitrogen or phosphorus, nor with supplements of calcium or magnesium.

Release

The effect of release of the fertilized trees was evaluated by comparing each to a randomly selected nearby tree which was not released. If only the unfertilized (treatment 18) control trees are considered, the final basal area of released trees was 51 percent greater than that of non-released trees, a difference which was statistically highly significant. If all trees are considered, basal area of released trees was somewhat more superior--53 percent compared to 51--considering only the trees from the heaviest treatments (4, 5, 6, 10, and 14) the margin was slightly more--54 percent. However, the net benefit of fertilization is revealed even more clearly than in tables 3 and 4 as being of minor importance in this study.

Discussion

Response to fertilization was considerably less than expected, particularly when the extremely heavy dosages applied are considered. Possibly the combination of small plots with surface application permitted washing away of substantial amounts of the fertilizers. However, response was obtained to applications on 1-tree plots elsewhere (Steinbrenner 1968[1/], Viro 1967[2/] and only nitrogen showed no effects. Correction of this defect in technique, if it is a defect, will not be simple; the complete occupation of the topsoil by teak roots prevents disturbing the soil without damaging the roots.

For the practicing forester, however, the overall results are highly encouraging. The most favorable single action for increasing tree growth of teak was thinning, and the growth increase from thinning averaged more than 50 percent.

1/ Steinbrenner, E.C. Research in forest fertilization at Weyerhaeuser Company in the Pacific Northwest. Forest Fert. Symp., Gainesville, Fla., pp. 209-215. TVA Nat. Fert. Development Ctr., Muscle Shoals, Ala., 1 ref.

2/ Viro, P.J. One-tree plots in manuring mature stands. 14th IUFRO Congress, Munich, Vol. 4, Section 23: 597-607, 5 refs. 1967.

Table 1.--Levels of fertilization, and mean plot values

Treatment Number	Nutrient added[1/] N	P	K	Ca[2/]	Mg[3/]	dbh[4/] original	i 5-yr.	h original	i 5-yr.
	Pounds/acre					Inches		Feet	
1	0	100	400	500	125	5.9	2.8	45	8
2	100	100	400	600	150	6.5	2.6	49	6
3	200	100	400	700	175	6.6	2.6	50	7
4	400	100	400	900	225	7.2	2.5	48	7
5	800	100	400	1300	325	6.2	2.9	46	7
6	800	200	800	1800	450	6.4	2.9	48	7
7	400	0	400	800	200	6.0	2.7	46	7
8	400	50	400	850	212	6.6	2.7	48	7
4	400	100	400	900	225	7.2	2.5	48	7
9	400	200	400	1000	250	6.4	2.8	46	7
10	400	400	400	1200	300	6.4	3.1	48	6
11	400	100	0	500	125	6.8	2.7	49	6
12	400	100	100	600	150	6.1	2.8	49	4
13	400	100	200	700	175	6.4	2.7	46	7
4	400	100	400	900	225	7.2	2.5	48	7
14	400	100	800	1300	325	6.4	3.4	47	11
4	400	100	400	900	225	7.2	2.5	48	7
15	400	100	400	900	0	6.2	2.4	48	5
17	400	100	400	0	225	6.0	2.9	48	8
16	400	100	400	0	0	6.6	2.6	51	5
18	0	0	0	0	0	6.0	2.1	45	7

1/ Pounds per acre of element added.

2/ Applied at rate of 2000 pounds Ca per ton of (N+P+K).

3/ Applied at rate of 500 pounds Mg per ton of (N+P+K).

4/ Arithmetic average of individual tree measurements; not dbh of tree of mean basal area.

Table 2--Stand descriptions at time of study establishment

Location	Block	Age	Dbh	Height	Underlying Rock	Approx. Annual Rain	Soil Characteristics, 0-6 inches[1] pH	% Total Nitrogen	P_2O_5	Potassium
		Yrs.	Inches	Feet		Inches			lbs/acre	ppm
Cambalache-So. Entrance	01	9.5	6.7	50	limestone	55	5.4	0.2	20	114
	2	9.5	6.2	51	"	55	6.0	.2	27	110
Cambalache-Abra Ortiz	01	9.5	6.0	47	"	55	5.2	.2	24	94
	2	9.5	6.0	46	"	55	5.9	.2	41	100
Cambalache-Piedra Gorda	01	10.5	5.5	41	"	55	6.5	.4	44	121
	2	10.5	5.6	44	"	55	6.1	.2	16	75
Río Abajo-Igartúa	01	16[2]	9.5	74	"	80	6.0	.2	33	212
Río Abajo-Sta. Rosa	01	16[2]	10.7	71	"	80	6.7	.3	66	131
	2	16[2]	10.3	69	"	80	5.5	.3	39	228
Río Abajo-Gallinero	01	15[2]	9.6	61	"	80	5.6	.3	20	112
	2	15[2]	10.7	68	"	80	5.7	.3	20	220
Sabana	01	5.5	4.2	33	andesite	90	5.7	.3	--	75
	2	4.4	4.3	36	"	90	7.8	.3	46	144
Estate Thomas	01	5	3.3	22	limestone	35	8.3	.2	63	292
Plessen	01	3	1.0	9	basic volcanic	40	6.4	.2	35	82

1/ Composite samples, analyzed by the Central Analytical Laboratory, University of Puerto Rico Agricultural Experiment Station.

2/ Approximate.

Table 3.--Analysis of variance for basal area increment

Source of variation	Degrees of freedom	Mean square	Variance ratio	Level of confidence
Original basal area of tree	1	1188	16.4	99.9%
Puerto Rico *vs* St. Croix	1	772	10.7	99
Puerto Rico Limestone *vs* andesite	1	963	13.3	99.9
Moist *vs* dry, limestone	1	226	3.1	90
Deep *vs* shallow, dry limestone	1	62	0.9	-
Phosphorus added	1	158	2.2	80
Residual	68	72		

Table 4.--Analysis of variance for height growth

Source of variation	Degrees of freedom	Mean square	Variance ratio	Level of confidence
Original basal area of tree	1	1539	63.6	99.9%
Puerto Rico *vs* St. Croix	1	3	0.1	-
Puerto Rico Limestone *vs* andesite	1	216	8.9	99
Moist *vs* dry, limestone	1	162	6.7	95
Deep *vs* shallow, dry limestone	1	9	0.4	-
Potassium added	1	98	4.1	95
Residual	66	24		