The Use of Coco Peat as a Potting Medium for *Pinus caribaea* var. *hondurensis* and a corresponding Fertilizer Regime.

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ABSTRACT

Coco peat (ground coconut husk) was compared to forest mix (50o/o peat, 50o/o vermiculite) as a potting medium for containerized *Pinus* ***caribaea*** var. *hondurensis*. When initial tests indicated no difference between the two, fertilizer trials were conducted using weekly applications of varying amounts of nitrogen, phosphorus, and potassium to seedlings grown in coco peat. Although no patterned response to phosphorus and potassium was noted, seedlings receiving a weekly application of 1 pound of 20o/o to 30o/o nitrogen per 300 square feet of bench space consistently showed greater height and diameter growth than those seedlings receiving only 10o/o nitrogen.

INTRODUCTION

Pinus caribaea var. *hondurensis* Barrett & Golfari is widely used for pine production throughout the tropical and subtropical regions of the world. It is native to Guatemala, Belize, Honduras, Nicaragua, and Costa Rica (Little et al, 1974), but it is planted in Africa, Australia, Malaysia, New Zealand, Sri Lanka, South America, and Central America (Bacon and Hawkins, 1979; Briscoe, 1962; Little et al, 1974; Sundralingham and Ang, 1975). In Honduras, where it reaches sawlog size in 20 to 40 years, it is exported to Europe and Japan. Before

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reaching harvest size, it is often tapped for 5 to 7 years for resin production.[1]

Pinus caribaea is artificially regenerated in three ways: (1) direct seeding, (2) bare-root plantings, and (3) seedlings grown in 2—inch x 4—inch or 4—inch x 3—inch polyethelene bags.

Direct seeding is currently in the experimental stage in Honduras. However, at present, the results do not look promising.[1]

Bare-root planting has had mixed results. Bacon and Hawkins (1979) had good results by planting seedlings that had been root pruned monthly. Casey and Parkin (1976) found that heeling the seedlings in sand under 100o/o shade with daily watering would allow seedlings to be kept for up to 8 days without affecting survival. Transporting seedlings with the roots immersed in water has given good field survival, although transport by this method is difficult (Venator et al, 1977). In northeastern Honduras, bare— root seedlings are packed in plastic bags for transport and planted in the field on the same day in which they are lifted.[2]

By and large, however, little success has been found with bare-root seedlings. In general the field survival has been extremely poor (Bacon and Hawkins, 1979; Barres, 1965; Briscoe, 1962; Monteith, 1969).

Planting bagged seedlings in the field has been extremely successful and is by far the most widely used method of artificial regeneration (Bacon and Hawkins, 1979; Cardenas, 1973; Herrera, 1975). Field survival of over 90o/o is not uncommon. The roots are not disturbed or exposed to drying, as is the case with bare—root seedlings. If, due to a communications breakdown between the nursery and planting site, planting crews are

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[1]Personal communication with Henry Tschinkel, FAO, COHDEFOR, Tegucigalpa, Honduras, October 1978.

[2]Personal communication with Albert Merkel, formerly head forester, Mosquitia District, COHDEFOR, Honduras. Presently with FWR, University of Idaho, Moscow, September 1980.

caught unprepared, bagged seedlings may be safely held, while bare—root seedlings which have been lifted and packed will receive undue stress which will probably result in high seedling mortality.

The disadvantage of bagged seedlings is the bulk and weight of the seedling and growing medium contained in the bag. Not many seedlings can be carried at one time in a pickup, the most common mode of transport in Central America. In rugged terrain with limited access, a pair of planters may carry 30 to 60 seedlings to the planting site, plant them, then return to the truck for 30 to 60 more.

Currently, field trials with containerized nursery stock are being carried out, the idea being that containerized stock will have the survival of bagged stock without the weight and transportation problems. This has been successful in both Puerto Rico (Venator and Rodriguez, 1977) and Honduras.[3]

Given that containerized seedlings can work, the problem remains as to what potting mix to use. Top soil at the nursery is often used, but in a nursery with a limited amount of terrain, the top soil is also limited. Marrero (1965) found that sphagnum moss produced seedlings with greater stem diameters than various mixtures of sawdust and coco peat (ground coconut husk). While seedlings grown in vermiculite were not inferior to those grown in sphagnum, they were not superior to seedlings grown in the other mixes either. The problem lies in the fact that sphagnum and vermiculite must be imported to many of the countries where *Pinus caribaea* is raised. Coconut husk, however, is readily available in many of these countries. It has been used successfully in Honduras.[4]

The next major obstacle is what fertilizer mix to use. Very little work has been done in this area. Phosphorus seems to increase height and/or diameter growth of seedlings, both in the nursery and in the field (Cadiz and Atabay, 1979; Geary, 1971; Sundralingham and Ang, 1975), but little has been done with a complete fertilizer. Tinus and McDonald (1979) and Carlson (1979) recommend saturating the potting mix with

[3]Ibid. [4]Ibid.

a solution of 223 ppm N, 27 ppm P, 155 ppm K, and 125 ppm N, 60 ppm P, 159 ppm K, respectively for seedlings from the northwestern United States and western Canada, but the applicability of these recommendations to tropical pines is questionable.

The purposes of this study are: (1) to compare coco peat as a potting medium to a standard potting mix, and (2) if coco peat compares well to a standard potting mix, to compare seedlings grown with various fertilizer mixes to determine which mix or mixes seem to be best.

METHODS AND MATERIALS, OBJECTIVE 1

The first objective was to compare coco peat as a potting medium to forest mix as a potting medium. One styroblock No. 2 (200 cavities, each with a top diameter of 2.5 cm, a depth of 11 cm, and a total volume of 30 cc per cavity) was partially filled, 40 cavities with the forest mix used at the University of Idaho, Moscow, consisting of 50o/o ground peat and 50o/o fine vermiculite, and 40 cavities with coco peat. The small quantity of filled cavities was due to the limited amount of coco peat available at the time. Three seeds were planted in each cavity and covered with No. 2 chicken grit. The styroblock was then kept in the Forestry Greenhouse, where it received minimum temperatures of 60^{o}F (15^{o}C), 24 hour photoperiods, and biweekly fertilization with 18-12-12-7 (NPKS) at a rate of 1 pound per 250 square feet of bench space applied in a liquid form.

One month after planting, seedlings were thinned to one per cell. No transplanting was done to fill empty cells.

Three months after planting, seedling height was measured from the cotyledons to the shoot apex. Stem diameter was measured just below the cotyledons.

RESULTS AND DISCUSSION, OBJECTIVE 1

Thirty-four of 40 seedlings survived in the coco peat, and 33 of 40 in the forest mix (Tables 1 and 2). The mean heights were 5.3 and 5.2 cm, respectively, the difference between the two not being significant at a 95o/o confidence level. The mean

Table 1. Analysis of variance, coco peat versus forest mix height comparison.

Height comparison	Coco peat	Forest mix
n (samples)	34	33
Σx (sum of heights)	180.5	171.125
$\bar{x}$ (average)	5.309 cm	5.186 cm
$\Sigma(x-\bar{x})^2$	22.572	40.736
$S^2_{\bar{x}}$ (variance)	.684	1.273
df (degrees of freedom	33	32

d (difference between the means) = .123

$$S^2 = \frac{\Sigma(x_1-\bar{x}_1)^2 + \Sigma(x_2-\bar{x}_2)^2}{df_1 + df_2} = .974$$ Overall variance

$$S^2_d = S^2\left(\frac{1}{df_1} + \frac{1}{df_2}\right) = .060$$ Variance of the difference

$S_d = .245$ Standard deviation of difference

$t = 1.96$

$d \pm tS_d$ = 95o/o confidence interval around the difference

$$-.3572 \leqslant u_d \leqslant .6032$$

This includes zero, so there is no difference between the two mean heights.

Table 2. Analysis of variance, coco peat versus forest mix diameter comparison.

Diameter comparison	Coco peat	Forest mix
n	34	33
Σx	69.6	78.7
$\bar{x}$	2.047 mm	2.385 mm
$\Sigma(x - \bar{x})^2$	6.171	7.904
S_x^2	.187	.247
df	33	32

$$d = .338$$

$$S^2 = .75$$

$$S_d^2 = .046$$

$$S_d = .215$$

$$t = 1.96$$

$$-.0834 \leqslant u_d \leqslant .7594$$

This includes zero, so there is no difference between the two mean diameters.

diameters were 2.15 and 2.39 mm, respectively. Again there was no significant difference. It was noted that there was more variability in the measurements of the forest mix trees than in the coco peat trees.

An attempt was made to determine the root/shoot ratios. However, the coco peat was fibrous to the point that it was not feasible to separate the fibers from the fine roots. Either fibers were left intertwined with the roots, or roots were broken off trying to remove the fibers. Both situations gave false readings. It was not practicable to compare such measurements to root/

shoot ratios of trees grown in the forest mix, which easily rinsed away from the roots. I did observe that roots were numerous and well distributed throughout both media.

The final color of all seedlings was good. Shortly after germination, chlorosis was noted in the coco peat seedlings, but this disappeared when regular fertilization began.

A disadvantage associated with the use of coco peat was that the seedlings seemed to pull harder from the cavities than those planted in forest mix. This could be averted by using containers with larger cavities, by using a biodegradable container such as the Japanese paperpot, or by using containers which fold open, such as the Spencer—Lemaire rootrainers.

Since the coco peat seemed perfectly suitable as a potting medium in our trials and has been used in Honduras, it was decided to proceed with the fertilizer trials on *Pinus caribaea* var. *hondurensis* grown in coco peat.

METHODS AND MATERIALS, OBJECTIVE 2

The second objective was to compare seedlings grown with various fertilizer mixes to determine which mix or mixes seem to be best. One hundred sixty-eight Spencer—Lemaire rootrainers (4 cavities with top dimensions of 4 x 4 cm, a depth of 11 cm, and a total volume of 150 cc per cavity) were filled with coco peat. Five *Pinus caribaea* var. *hondurensis* seeds were planted in each cavity and covered with No. 2 chicken grit. The containers were then kept in the greenhouse and watered as necessary.

Six weeks after planting, the seedlings were thinned to one per cell, the most vigorous seedlings being the one left. At this time, each group of 8 seedlings was assigned one of 28 fertilizer formulations (Table 3). The seedlings were then arranged into three blocks, with a random assignment of each of the 28 treatments in each block, resulting in a random block design replicated 3 times with 8 trees/treatment/block.

It was decided to apply each of the fertilizer formulations at the rate of 1 pound per 300 square feet of bench space (1 kg per 62 square meters), as is the practice at the University of Idaho Forest Greenhouse, which applies 18-12-12-7 (NPKS) at the rate of 1 pound per 300 square feet of bench space.

Each of the fertilizer formulas was then mixed with sufficient water to saturate each cavity. The parts per million formulation which was actually applied appears in Table 3.

The sources for each of the nutrients in the fertilizer were urea (45o/o N), treble superphosphate (45o/o P_2O_5), and potassium sulfate (50o/o K_2O, 18o/o S).

Urea was chosen as a nitrogen source because of its availability and the high percentage of nitrogen. Although normally highly volatile, it becomes more stable when mixed with water, as was the case in this experiment, hydrolizing to ammonium carbonate ($(NH_4)_2CO_3$), which quickly decomposes to ammonium (NH_4) and carbon dioxide (CO_2) (Tisdale and Nelson, 1975). The ammonium can then be converted to nitrate or, in the case of conifers, be taken directly by the plant (Wilde, 1958).

The treble superphosphate and potassium sulfate were both chosen on the basis of their availability and their high concentration of nutrients. Potassium sulfate also provided sulfur which, if lacking, not only stunts plant growth, but causes the available nitrogen to be improperly utilized (Tisdale and Nelson, 1975).

Fertilizer applications began 8 weeks after planting. Applications continued on a weekly basis for 8 weeks. Approximately every 3 weeks, a foliar application of micronutrients (Ortho Greenal) was made. Two weeks after the last fertilizer application, surviving trees were counted, and both height and diameter measurements were made as in Part 1. Because some treatments had lost one tree, the measurements of the weakest tree in those treatments which had 8 survivors were thrown out. This prevented a bias towards larger measurements in those treatments in which a seedling died rather than remaining stunted.

The height, diameter, and survival data were then tabulated, the variance analyzed and, where differences occurred, subjected to Duncan's new multiple range test to determine which treatments were statistically superior.

Table 3. Fertilizer formulations and corresponding parts per million.

Fertilizer (NPK) applied at 1 lb per 300 square feet of bench space	Fromulation in ppm (NPK) when mixed with water for application
00-00-00	000-000-000
10-10-10	134-058-124
10-10-20	134-058-249
10-10-30	134-058-371
10-20-10	134-119-124
10-20-20	134-119-249
10-20-30	134-119-371
10-30-10	134-177-124
10-30-20	134-177-249
10-30-30	134-177-371
20-10-10	270-058-124
20-10-20	270-058-249
20-10-30	270-058-371
20-20-10	270-119-124
20-20-20	270-119-249
20-20-30	270-119-371
20-30-10	270-177-124
20-30-20	270-177-249
20-30-30	270-177-371
30-10-10	402-058-124
30-10-20	402-058-249
30-10-30	402-058-371
30-20-10	402-119-124
30-20-20	402-119-249
30-20-30	402-119-371
30-30-10	402-177-124
30-30-20	402-177-249
30-30-30	402-177-371

RESULTS AND DISCUSSION, OBJECTIVE 2

Seedling survival was not affected by fertilizer treatment (Table 4). Seedling height and diameter varied significantly with different amounts of fertilizer (Tables 5 and 7). The combinations of 20-30-20, 30-20-10, 30-10-10, and 20-20-20 (NPK) gave the best responses when considering both categories (Tables 6 and 8). It is interesting to note that, of those height comparisons using 20o/o or 30o/o N per 300 square feet of bench space, only four (20-30-20, 30-20-10, 20-20-10, and 30-20-30) differed significantly from the rest (Table 6)..

Those treatments using 10o/o N per 300 square feet of bench space were, without exception, smaller in both height and diameter than treatments using 20o/o or 30o/o N (Tables 6 and 8). Where coco peat is used, increased nitrogen levels resulted in increased growth with the limits of this trial.

There was no response to additions of phosphorus or potassium. A soil analysis of the coco peat (Table 9) indicates large initial amounts of both P and K, which explains this result. Added phosphorus and potassium fertilizer did not produce toxic amounts of either.

RECOMMENDATIONS

To assist seedling growth of *Pinus caribaea* during the first months of growth in coco peat, these studies indicate a fertilizer solution containing 20o/o to 30o/o nitrogen at 1 pound per 300 square feet of space, diluted to between 270 and 400 ppm N should be used. There should be sufficient solution to saturate the containers.

Further trials need to be made. Coco peat from different sources should be tested to determine if phosphorus and potassium are consistently found in large amounts, thereby lessening or even eliminating the need for their addition to the fertilizer solution. Fertilizer trials should be extended and the response of *Pinus caribaea* to large amounts of nitrogen studied. Also, the seedling response to nitrogen in the form of nitrate or a combination of nitrate and ammonium nitrogen should be investigated.

Field trials should also be conducted. How well does a seedling started in coco peat transfer to the field? Does the breakdown of coco peat tie up the available nitrogen or do the trees continue to grow well? These and other questions are suggested by this study.

Table 4. Average number of surviving trees with each fertilizer treatment and the analysis of variance.

Treatment N P K	Average number of survivers	Treatment N P K	Average number of survivers
00-00-00	8	20-20-20	7.67
10-10-10	8	20-20-30	8
10-10-20	8	20-30-10	7.67
10-10-30	8	20-30-20	8
10-20-10	7.33	20-30-30	8
10-20-20	7.67	30-10-10	7.67
10-20-30	8	30-10-20	7.67
10-30-10	8	30-10-30	7
10-30-20	8	30-20-10	7.67
10-30-30	8	30-20-20	8
20-10-10	8	30-20-30	8
20-10-20	8	30-30-10	7.33
20-10-30	8	30-30-20	7.33
20-20-10	8	30-30-30	7.67

Analysis of variance

Source	SS	df	MS	F
Treatments	6.29	27	.23	1.05
Blocks	0.74	2	.37	1.68
Error	11.92	54	.22	
Total	18.95	83		

Test for treatments 1.05 $\leqslant$ 1.65 (F table, 95o/o C.I. with 27/54 df). No difference between the treatments.

Test for blocks 1.68 $\leqslant$ 3.15 (95o/o C.I., 2/54 df), no difference between blocks.

Table 5. **Analysis of variance table for height after fertilizer trials.**

Source	SS	df	MS	F
Treatments	203.46	27	7.54	19.84
Blocks	12.68	3	6.34	16.68
Error	20.55	54	.38	
Total	236.69	83		

Differences occur in both blocks and treatments.

Table 7. **Analysis of variance table for diameter after fertilizer experiment.**

Source	SS	df	MS	F
Treatments	1.53	27	.057	9.5
Blocks	0.006	2	.003	0.5
Error	0.33	54	.006	
Total	1.87	83		

Test for treatments $9.5 > 0.65$
Difference exists between treatments.
Test for blocks $0.5 < 3.15$
No difference exists between the blocks.

Table 9. Soil analysis of coco peat before fertilization.

pH	5.59
Available P, μg/g	1096
Available K, μg/g	8760
NO_3-N, μg/g	20.5
NH_3-N, μg/g	11.7
Zn, μg/g	20.48
Mn, μg/g	25.6
B, μg/g	2.2
SO_4-S, μg/g	65
Total salts, mmhos	3.4
Soluble cations, milliequivalents/100 grams of soil	
Ca	0.15
Mg	1.70
K	13.94
Na	23.89
SAR = 23	

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Table 6. Ranking of fertilizer treatments according to height.

Treatment	Mean height (cm) and significance	Treatment	Mean height (cm) and significance
20-30-20	8.69 a	30-30-10	7.40 cde
30-20-10	8.61 ab	30-10-30	7.37 cde
30-10-10	8.12 abc	20-20-10	7.11 de
20-20-20	8.07 abc	30-20-30	6.99 e
30-10-20	7.95 bc	10-30-30	6.17 f
30-30-30	7.88 bcd	10-10-10	5.31 g
30-30-20	7.86 bcd	10-20-20	5.21 g
20-20-30	7.85 bcd	10-10-20	5.19 g
20-30-10	7.77 cde	10-10-30	5.01 g
20-30-30	7.69 cde	10-30-20	4.95 g
20-10-10	7.65 cde	10-30-10	4.76 g
20-10-30	7.61 cde	10-20-10	4.60 g
20-10-20	7.47 cde	10-20-30	4.59 g
30-20-20	7.40 cde	00-00-00	2.31 h

Mean heights with the same letter are not significantly different.

Table 8. Ranking of fertilizer treatments according to diameter.

Treatment	Mean diameters (mm) and significance	Treatment	Mean diameter (mm) and significance
30-20-10	1.46 a	20-30-30	1.32 bcde
30-20-20	1.45 a	30-30-10	1.30 cde
20-10-10	1.44 a	30-10-20	1.29 def
20-20-30	1.44 a	30-20-30	1.27 defg
20-20-20	1.43 a	10-30-30	1.25 efg
30-30-30	1.43 a	10-30-10	1.22 efgh
20-30-20	1.41 ab	10-20-30	1.20 fghi
20-20-10	1.40 abc	10-10-10	1.19 ghi
30-10-10	1.40 abc	10-10-30	1.19 ghi
30-10-30	1.40 abc	10-20-10	1.14 hi
30-20-20	1.40 abc	10-10-20	1.13 hi
20-10-20	1.36 abcd	10-20-20	1.13 hi
20-10-30	1.32 bcde	10-30-20	1.10 i
20-30-10	1.32 bcde	00-00-00	0.89 j

Mean diameters with the same letter are not significantly different.

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