Effects of Irrigating Tree Seedlings with a Nutrient Solution[1]

by

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SUMMARY

Subsurface irrigation with nutrient solution was found to be biologically feasible under the conditions tested Growth of seedlings was satisfactory, but not unusually good.

On the bases of total height growth and growth in fresh weight, the various fertilizers tested produced statistically different results.

The species tested, members of three different families and native to three different continents, reacted similarly to the nutrient solutions tested.

The highest root-to-shoot ratio obtained was in plain tap water.

RESUMEN

Se encontró que bajo las condiciones ensayadas el riego subterráneo con una solución nutriente es biológicamente factible. El crecimiento de las plantitas fue satisfactorio, pero no excepcionalmente bueno.

Basándose en la altura y el peso fresco, los distintos fertilizantes probados produjeron diferentes resultados.

Las especies usadas, miembros de tres diferentes familias y naturales de tres continentes distintos, reaccionaron de manera similar a las soluciones nutrientes ensayadas. Resultó mejor la proporcion 7-6-19.

La relación más alta entre la raíz y el tallo se obtuvo usando agua corriente.

Fertilization in the nursery has long been an accepted practice for improving the vigor of tree seedlings (Hansen, 1923; Wilde *et al*, 1910; Vlamis *et al.*, 1957).

Presumably there is an optimum combination of nutrients, possibly a different optimum for each species. In soil, however, the search for an optimum is complicated by the fluctuation of nutrient levels with time and by the varied interaction of soils with applied fertilizers.

One apparent means of minimizing these complications is growing seedlings in an essentially sterile medium and supplying nutrients in a frequently-replenished water solution. To eliminate possible toxic effects of fertilizer solution on the foliage and simultaneously avoid possibilities of oxygen deficiency in the root zone, subsurface irrigation appears more promising than surface flooding or sprinkling, or than water culture.

A study was undertaken (a) to test the feasibility of subsurface irrigation with nutrient solutions, (b) to determine the relative effects of several readily-available commercial fertilizers, and (c) to determine whether effects varied with species.

PROCEDURE

Forty-four vigorous seedlings approximately 2 weeks old of *Afrormosia elata* Harms from Nigeria, *Eucalyptus alba* Reinw. from Australia via Brazil, and *Cedrela mexicana* Roem. from Mexico were transplanted to perforated 5 x 9½-inch polyethylene bags filled with firmly packed vermiculite. Firm

1/ Begun as a special report for the 1962 Syracuse Forestry Summer Course, conducted by New York State University College of Forestry at Syracuse, in cooperation with the U. S. Forest Service Institute of Tropical Forestry.

cotyledons still remaining on the *Afrormosia* seedlings were clipped off at the time of transplanting. During the initial 6 days after transplanting seedlings were kept under a light shade and irrigated daily with plain tap water. Treatment started August 2, 1962.

TREATMENTS

Each species was irrigated with three different solutions of liquid fertilizer, plus a control of plain tap water. The fertilizers and their composition are listed in Table 1.

Table 1.—*Fertilizers and their composition*[1]

Fertilizer	Grams per gallon Nitrogen	Phosphorus	Potassium	Total
Water	0	0	0	0
18-18-18[2]	1.57	1.57	1.57	4.71
15-5-5	1.76	0.59	0.59	2.94
7-6-19	0.49	0.46	1.46	2.41

1/ Proprietary preparations the sources of which are available upon request.

2/ Numbers refer to percentages of nitrogen, phosphorous, and potassium, respectively.

Twenty gallons of each fertilizer solution and the control treatment were prepared initially and replenished periodically.

Each solution was applied to 11 seedlings of each species every day for 60 days and twice weekly thereafter. The seedlings were placed in a perforated polyethelene pail which was immersed slowly into the fertilizer solution to a level assuring complete saturation of the vermiculite without wetting the stems. When the vermiculite was saturated the pail was lifted out of the solution and allowed to drain. The three solutions using the commercial fertilizers were stirred thoroughly each day before irrigation, to disperse a precipitate which formed in the bottom of the container. A plastic and meshwire screen was kept over the plants to reduce solar radiation and prevent leaching of the nutrients by heavy rains. The groups were re-positioned daily to minimize the effect of variations in the microenvironment.

MEASUREMENTS

The height of each plant was measured to the nearest millimeter, after immersion, every fourth day for the first 60 days and weekly thereafter. Each plant was measured from a marked spot on the surface of the vermiculite to the apex of the terminal leader, not including leaves or leaflets.

Immediately after the final measurement at 85 days, each plant was lifted from the pot, cut in two at the ground line, and each part weighed. Oven dry weights were determined for each group. That is, roots of all plants of each species and of each fertilizer were weighed together, not individually.

RESULTS

Cumulative height growth is shown in Figure 1. Although the magnitude of the growth differed greatly, the rank of the fertilizer solutions was the same for all three species. Height growth varied significantly with species and with nutrient solution.

Fresh weights are shown in Table 2. On

Table 2.—*Fresh weights after 85 days*

Treatment	Species Afrormosia	Cedrela	Eucalyptus	Mean
	Shoot Weights, Grams			
Water	1.2	1.4	7.2	3.3
18-18-18	1.0	2.6	8.5	4.0
15-5-5	1.0	1.4	3.2	1.9
7-6-19	2.7	7.7	14.4	8.3
Mean	1.5	3.3	8.3	
	Root Weights, Grams			
Water	0.9	0.8	5.7	2.5
18-18-18	0.7	1.4	5.6	2.6
15-5-5	0.7	0.6	1.5	0.9
7-6-19	1.6	3.3	7.1	4.0
Mean	1.0	1.5	5.0	

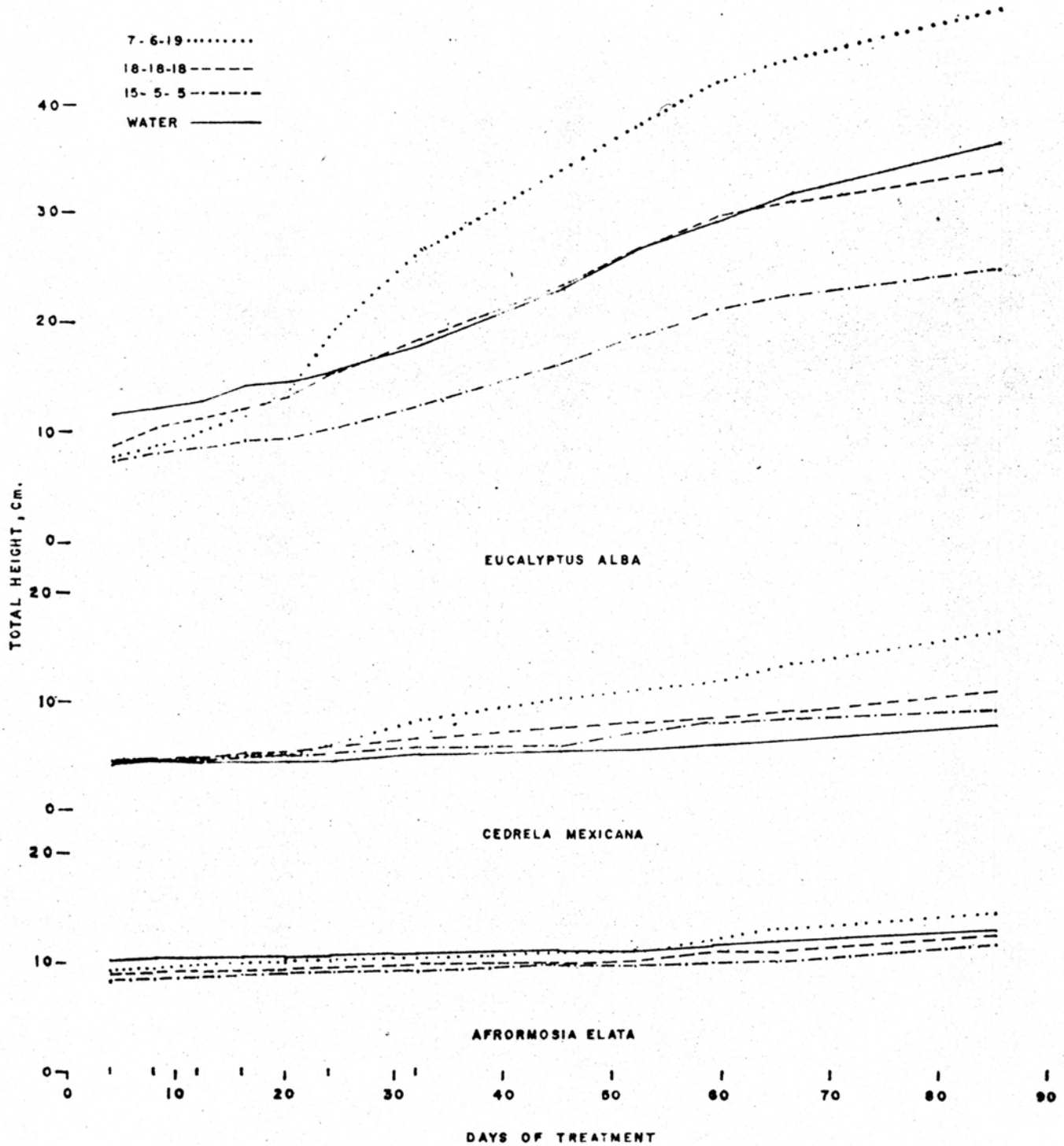

Figure 1. Height growth with subsurface nutrient irrigation.
Crecimiento en altura con riego subterráneo de solución nutriente.

the basis of fresh shoot weight, the three species differed significantly from each other, as did the four treatments.

On the basis of fresh root weight *Eucalyptus* is significantly heavier than the other two species, which are not different from each other. Treatment 15-5-5 is significantly poorer than water and 18-18-18, which in turn are inferior to 7-6-19.

On the basis of root-to-shoot ratio, Table 3, the species did not differ significantly from each other. The plants treated with fertilizer solution did not differ from each other, but, treatment with 15-5-5 and 7-6-19 gave results which differed highly significantly from the Controls.

Table 3.—*Root-to-shoot ratio after 85 days*, fresh weight.

Treatment	Species			Mean
	Afrormosia	Cedrela	Eucalyptus	
Water	0.8	0.6	1.0	0.8
18-18-18	0.7	0.6	0.7	0.7
15-5-5	0.7	0.5	0.5	0.6
7-6-19	0.6	0.4	0.5	0.5
Mean	0.7	0.5	0.7	

The trends in dry weights followed those for fresh weight. However, as noted above individual seedling roots and stems were not weighed dry and differences based only on total dry weights were not statistically significant.

Some visual differences were noted.

Cedrela mexicana produced excellent leaf growth and vigor in solutions 18-18-18 and 7-6-19.

Height and leaf growth of *Eucalyptus alba* were exceptional under treatment 7-6-19. Treatment 18-18-18 produced a reddening of the meristematic regions and a profuse growth of branches. Treatment 15-5-5 produced much less growth and resulted in leaf burn and curling of the tips of the upper leaves.

Afrormosia elata growth consisted primarily of the development of leaves with very little stem growth. In addition the *Afrormosia* seedlings suffered somewhat from what appeared to be sun scald.

DISCUSSION

The three objectives of the study were fulfilled, but the results were somewhat unexpected.

Although the results of Vlamis *et al.* (1957) suggest high nitrogen and phosphorous levels promote rapid growth such was not the result in this study.

Relatively high potassium is expected to stimulate meristematic development (Meyer and Anderson, 1939), but shoot growth was stimulated more by potassium than root growth. The greatest ratio of roots-to-shoot, on a fresh weight basis, was obtained by irrigating with plain tap water.

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