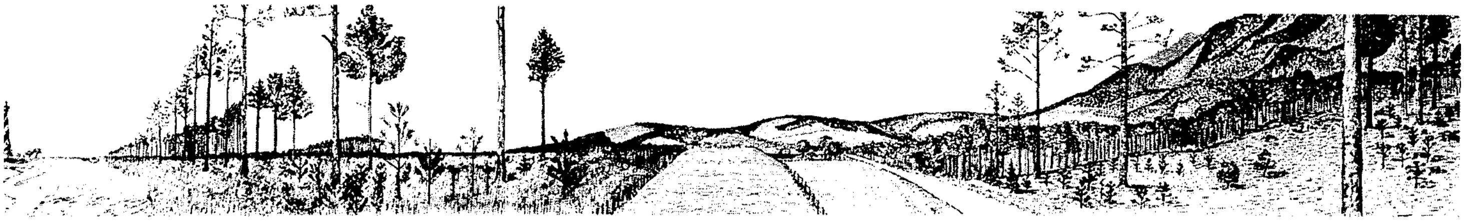

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FERTILIZER TABLETS STIMULATE EUCALYPTUS IN FLORIDA TRIAL

Abstract. --Eucalyptus plantings in south Florida must grow rapidly to withstand first-year frosts and dominate herbaceous competition. Fertilizer tablets in the planting holes of E. camaldulensis stimulated immediate growth, resulting in stems 50 percent taller and 83 percent thicker than check trees at 6 months. Effects of tablets persisted after 4 years, with two tablets offering no advantage over one tablet per hole. Progenies of three seed families responded consistently to tablets, but failed to respond to trace elements applied after 2 *years.*

In south Florida trials, several eucalyptus species show vigor, adaptability, and promise for amenity plantings or for pulpwood production. But frost injury or stagnation from competing vegetation threaten unless early growth is rapid and sustained the first year in the field. Can fertilizer tablets in the planting holes aid stand establishment by speeding early growth?

In August 1964 we planted Eucalyptus camaldulensis seedlings with and without fertilizer tablets in the planting holes. The planting site is located in Glades County, Florida, on a deep-phase Immokalee fine sand, an acid soil common to the longleaf pine-palmetto-wiregrass association and characteristically deficient in phosphorus.

Three tablet levels--one, two, or no tablets per planting hole--were applied to lo-tree row-plots separated by untreated buffer rows. Nine row-plots represented each treatment in a completely randomized arrangement. Tree spacing was 3.5 m. between rows and 2.4 m. within rows.

In addition to being a fertilizer tablet trial, this study was also a comparison of three seed families. The seed were collected from three open-pollinated mother trees selected for exceptional straightness and vigor in the Murray River Valley of Victoria, Australia. Each lo-tree plot consisted of three seedlings from one family, three seedlings from another family, and four seedlings from the remaining family--all mixed in completely random arrangement. The field layout was therefore a split-plot design with tablets as main-plot treatments and seed families as subplot treatments.

We planted seedlings from l-liter pots into holes dug with post-hole diggers. Tablets were pressed into the holes' sidewalls at about 2/3 the

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depth of the root systems, or about 7 cm. deep. Two tablets per hole occupied opposite sidewalls. After backfilling, about 3 cm. of soil separated roots from tablets.

The tablets,[1] bonded of urea-formaldehyde resin, weighed 9.72 g. and contained:

Element	Amount (mg.)
N	2,722
P	339
K	323
S	194
Fe	97
Zn	19

At 6 months (the first frost season) one-tablet trees had grown 50 percent taller and had 83 percent thicker stems than no-tablet trees. After 4 years, one-tablet trees stood 30 percent taller with 37 percent broader canopies, 64 percent thicker stems, and 175 percent more basal area than no-tablet trees. Two tablets per seedling stimulated no more growth than did one tablet (figures 1 and 2).

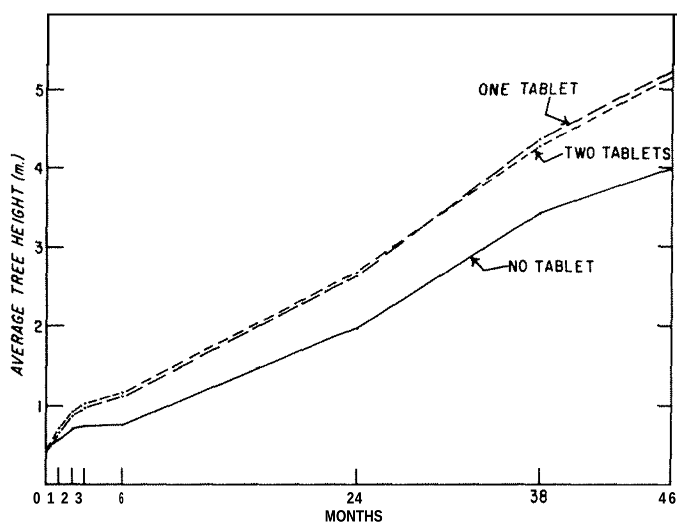

Figure 1. --Height growth of Eucalyptus camaldulensis seedlings with one, two, or no fertilizer tablets in the planting holes. Trees planted with tablets averaged significantly taller than no-tablet trees at every post-plant measurement (99-percent confidence level).

[1]Forest Starter Tablets (28-8-4) supplied by Agriform International Chemicals Inc., Newark, Calif. The use of trade, firm, or corporation names in this publication is for information and does not constitute official endorsement or approval by the USDA of any product or service to the exclusion of others which may be suitable.

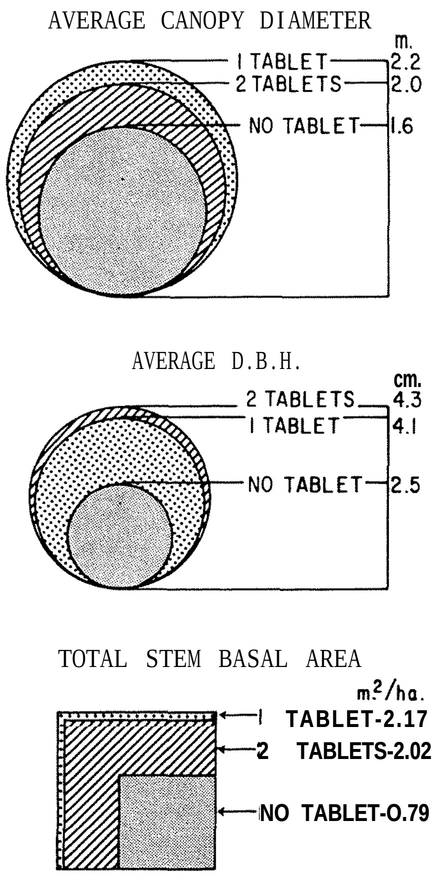

Figure 2.--Four years after planting, canopy diameter, d. b. h., and basal area were significantly greater for tablet-fertilized trees than for no-tablet trees (99-percent confidence level). Two tablets offered no advantage over one tablet.

TABLETS SUPPLEMENT ROCK PHOSPHATE

In 1963, while preparing for a planting that froze, we had cross-disked the site and broadcast 1,009 kg. /ha. of ground rock phosphate, a slow-release fertilizer which breaks down under soil acids over a period of years. Our application rate supplied the following elements:

Element	Kg. /ha.
P	156
Ca	346
Fe	10
K	2.1
Mg	1.8
S	6.1
Cu	0.8
Zn	0.4
Mo	0.02
B	0.03

We redisked the site before planting for the tablet study, and all trees shared the influence of rock phosphate.

IMMEDIATE GROWTH RESPONSE, NO TOXICITY

To observe the beginning and cessation of growth responses, we periodically measured seedling height and basal stem diameter. By subtracting successive measurements, we calculated growth rates for the following intervals: 1st month, 2nd month, 3rd month, 4th through 6th months, 7th through 24th months, 25th through 38th months, and 39th through 48th months.

During the first month, seedlings with tablets had growth rates 88 percent faster in height and 138 percent faster in diameter than no-tablet seedlings; both rates were statistically significant (fig. 3). This magnitude of response suggests that within days roots had penetrated the soil barrier and encountered abundant nutrients available from the tablets. Despite ready availability, there was no evidence of fertilizer burn or excessively luxuriant growth, and no visible difference between one- and two-tablet seedlings.

In other trials with tablets, fertilizer salts have sometimes burned seedlings and reduced survival of coniferous species, especially under

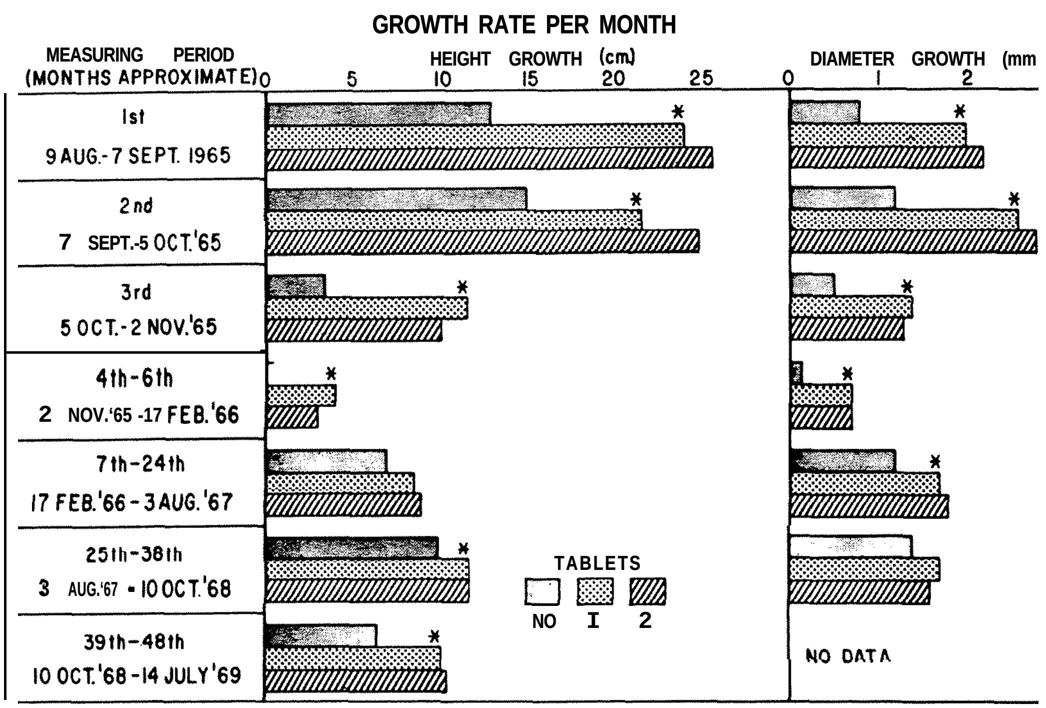

Figure 3. --Periodic response to fertilizer tablets. Bars depict growth as rate of increase for an average month of 30.4 days (to reconcile measurement intervals of different durations). *Growth was significantly faster with tablets than without them, as tested at the 95-percent confidence level with Tukey's w-procedure (Steel and Torrie 1960, p. 109); one- and two-tablet differences were never significant.

droughty conditions, or with two tablets per seedling, or with potassium included in the formulation (White 1965). Our design did not allow statistical analysis of survival, but all seedlings were alive at 3 months; after 4 years survival averages were 89 percent with no tablet, 97 percent with one tablet, and 96 percent with two tablets. We undoubtedly minimized the risk of fertilizer burn by hand planting container-grown stock during the rainy season and providing a soil barrier between roots and tablets. When bare-root seedlings are machine planted, however, precise control of a soil barrier--if needed--could be difficult. Urea-formaldehyde resins have undergone refinement to reduce toxicity, and direct contact of roots and tablets did not injure seedlings of Pseudotsuga menziesii in well-watered pots (Strand and Austin 1966). Therefore, the need for a soil barrier should be established where soil moisture varies after planting.

Early, substantial growth is encouraging because lag between application and maximum growth response has been one of the inconsistencies in trials with fertilizer tablets. Byrnes (1966) measured no growth for seedlings of Juglans nigra during the first season but a significant response to tablets the second year. Austin and Strand (1960) reported a significant first-year growth response in one of four trials of tablets with Pseudotsuga menziesii, but two of the other three tests showed better second-year responses. Similarly, seedlings of Abies procera and Abies grandis responded little the first year but improved the second. Two trials with Picea sitchensis showed greater responses the second season. In contrast, hybrid seedlings of Pinus attenuata x radiata lost their significant height growth response between the first and second seasons in a single test.

Nutrients combined in urea-formaldehyde resin become available through bacterial conversion as well as in simple solution, so soil pH, moisture, aeration, and temperature all affect availability. These factors were probably satisfactory during the warm, wet August when we planted on the moderately drained site which had been supplemented with calcium and phosphorus in the previous year's application of rock phosphate. Also, our container-grown seedlings suffered little transplanting shock and their roots were capable of immediate nutrient uptake.

UNCERTAIN DURATION FOR TABLET EFFECT

In our periodic measurements, growth responses did not end as definably as they began. Tablet trees grew significantly faster than no-tablet trees in both height and diameter during the first four measuring periods (through the 6th month). But during the 7th through 24th months, height growth differences lost statistical significance while the diameter growth response remained significant (fig. 3). The situation reversed somewhat in the next period (25th through 38th months) as the height growth response resumed significance and diameter growth differences narrowly missed significance. Height growth differences remained significant during the final measuring period (39th through 48th months), but diameter growth could not be computed because we changed the measuring point from the base of the trunk (because of butt swell) to breast height.

During the series of seven measurements spanning 4 years, there was never a statistical difference in growth rates between one- and two-tablet trees.

Figure 1 depicts continued, increasing divergence of height curves for tablet trees and no-tablet trees after 4 years. Similarly, figure 3 shows a 58-percent height growth superiority for tablet trees during the final measurement period (39th through 48th months). But this apparently persistent response requires cautious interpretation.

Since we took data from rows separated by untreated buffer rows, tablet trees competed directly with other tablet trees only within a row, never with rows on both sides. Their immediate growth superiority therefore resulted in a competitive dominance over neighboring, untreated buffer rows. Even after fertilizer exhaustion, tablet trees might increase their growth superiority indefinitely at the expense of their competitors in the buffer rows. Consequently, our apparent response to tablets after 4 years could be artificial if extrapolated to plantations where tablet trees would compete with other tablet trees on all sides.

Conversely, rows without tablets were exactly like their neighboring buffer rows and should not reflect competitive bias.

Examining F-values from our analysis-of-variance tests gives some insight into the duration of tablet effect. Comparing the variation between treatments to chance variations expressed by the study's replications yields the F-values. The larger the F-value, the greater our confidence that measured differences stem from treatment effect and not from random variation. Following are F-values[a] computed to test tablet effect on height and diameter growth during each measuring period:

Months	Ht. F-value	Diam. F-value
1	29.24	56.92
2	14.71	55.59
3	19.54	11.90
4-6	19.15	20.32
7-24	2.86	6.85
25-38	4.50	3.35
39-48	3.64	--

F-values greatly exceeded significance requirements during the first 6 months, but then deteriorated to mere fractions of their early levels while remaining significant or nearly so. The big break in F-values of the 7th through 24th months suggests this was the critical period when tablet effect deteriorated in tree-to- tree consistency as well as in magnitude. It's unfortunate that the critical measurement interval was so long; we should have remeasured at 12 and 18 months.

[a]F-values exceeding 3.40 denote tablet effect significant at the 95-percent confidence level; those exceeding 5.61, significant at 99-percent level.

NO RESPONSE TO SUPPLEMENTAL TRACE ELEMENTS

Termination was scheduled at 2 years, but slow growth, leaning trunks, pendulous leaders, and sparse foliage suggested a mild form of boron (or perhaps copper or zinc) deficiency described for eucalypts in Africa (Savory 1962). Consequently, at 28 months we broadcast a powdered frit (FTE 503), supplying the following quantities of minor elements within a 1.2- by 1.2-m. square around each one-tablet tree:

Element	Amount (g.)
B	2.5
Cu	2.5
Fe	15.0
Mn	6.2
Mo	0.2
Zn	5.8

These supplemented the minute quantities of minor elements in the rock phosphate applied 3 years earlier.

Obviously, trace elements and tablet treatments were statistically confounding. We superimposed trace elements over the one-tablet treatment on the rationale that after 2 years in the field single tablets were less likely to stimulate more sudden growth than were two tablets. Therefore, any spurt could be attributed to the supplemental trace elements. But the trees failed to respond visibly in vigor, growth habit, *or* foliage color. Despite confounding, measurements after the 38th and 48th months seem to reflect the original tablet treatments.

SEED FAMILIES RESPOND CONSISTENTLY TO TABLETS

We sought a nutritional explanation of slow growth and poor form because these trees were progenies of phenotypically superior parents. At the final measurement, families did not differ significantly in height, d.b.h., or canopy diameter, and there was never a significant interaction between treatments and families. In other words, all families responded comparably and consistently to the fertilizer tablets.

E. camaldulensis occurs in every mainland state in Australia, with many geographic and climatic races recognized. To the inadequate extent that our three seed families represent the enormous Murray River race, the provenance seems poorly adapted to southwest Florida. Over the 4 years of study, tablet trees averaged 1.3 m. of height growth per year and no-tablet trees just under 1 m.--disappointingly slow growth in an area where adapted eucalypts should grow at least 2 m. annually during their early years (Meskimen 1967, 1970). In adaptability trials on three diverse sites, three other E. camaldulensis seed sources averaged 48 percent greater mean annual height growth than our Murray River families.[3]

CONCLUSIONS AND RECOMMENDATIONS

One fertilizer tablet per planting hole stimulated immediate, safe, and persistent growth responses under our test conditions. Planting with two tablets did not injure seedlings, but neither did it increase response. The growth response seems great enough to be effective in accelerating seedlings through the stage of susceptibility to frost injury and weed competition. Broader interpretations are hampered by the study's specifics--an unadapted seed source, seedling establishment unrepresentative of plantations, and inability to measure effects of rock phosphate or interactions of tablets and phosphate.

Though undeniably expensive, planting-hole fertilizers should be especially useful in amenity plantings where relatively few seedlings are needed to provide rapid shade or visual effect. Enriching forest landscapes often requires planting trees or shrubs without removing the natural ground cover. Eucalyptus seedlings usually fail in that competitive situation. Future research should explore interactions between planting-hole nutrients and the proximity of existing, competing roots and also should define the necessity for soil barriers between roots and tablets.

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[3] Data on file, Forest Resources Laboratory, Lehigh Acres, Florida.

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