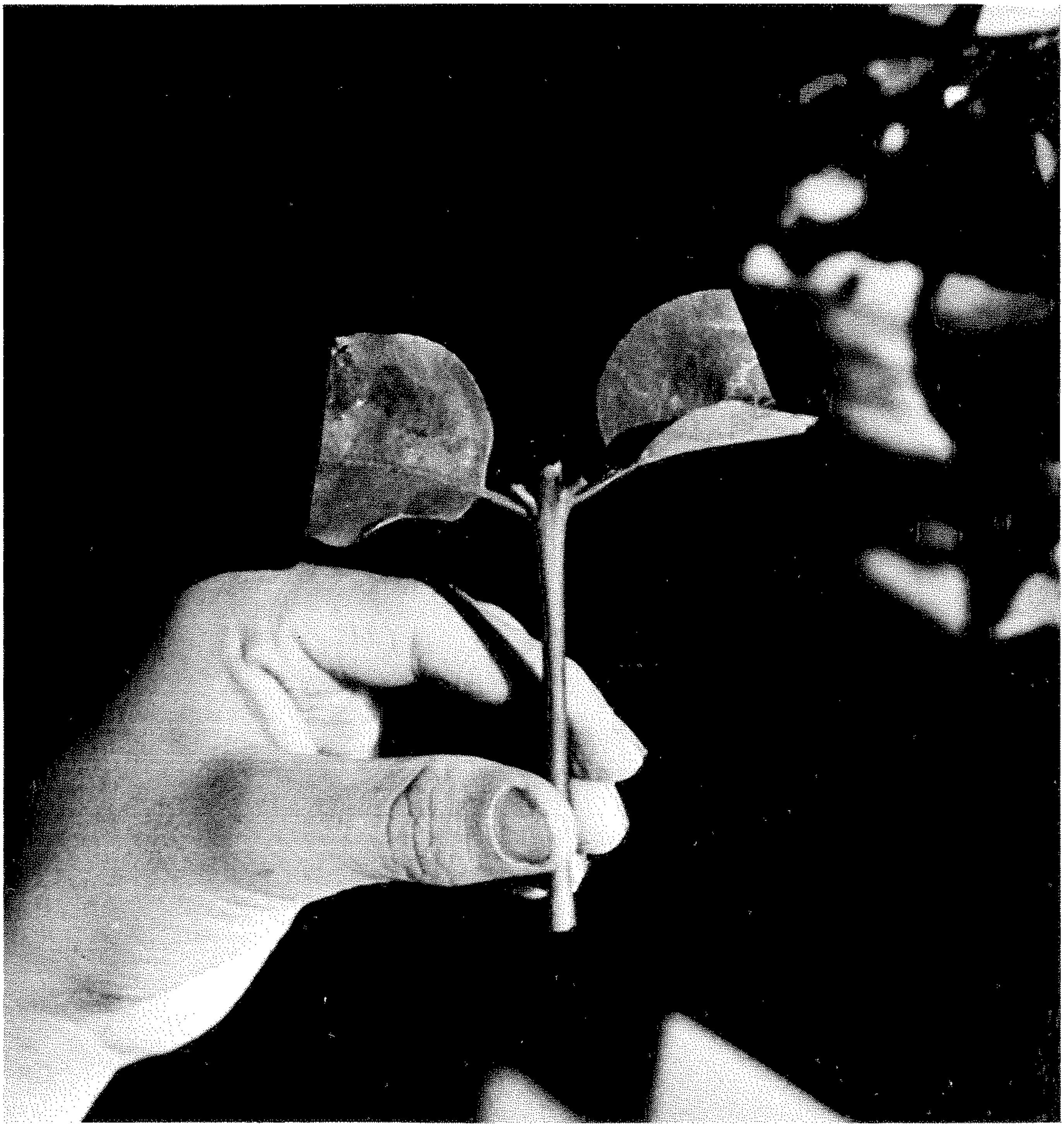
The Marcus Wallenberg Foundation Symposia Proceedings:

1. THE NEW EUCALYPT FOREST

Lectures given by the
1984 Marcus Wallenberg Prize Winners
at the Symposium in Falun, Sweden,
on September 14, 1984



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INTRODUCTION
by Bruce J. Zobel

It is my privilege and honour this afternoon to introduce the members of the team from Aracruz who are the recipients of the Marcus Wallenberg Prize for 1984.

Their accomplishments are those of individuals that are noteworthy in their own right but particularly noteworthy is that they are working as a team and this is going to be the emphasis of my presentation.

The Marcus Wallenberg Prize was not awarded simply because the team learned how to grow high-quality trees very quickly and relatively inexpensively. It was given because, to achieve this goal, they had to develop methods and techniques that were new and different and in many instances techniques that people said could not be done. After achieving these goals the Prize winners then went ahead and perfected the methods and made them operational so that they could be applied on a large scale.

Currently the most discussed and the most researched activity in forest regeneration deals with vegetative propagation. This interest is built upon the faster gains and the greater gains that can be obtained by use of this particular method. I, along with a number of others, have been working for over thirty years in vegetative propagation. We made some gains but the results were never spectacular.

Now, with the developments with the team from Aracruz, there is suddenly a surge of interest in vegetative propagation world-wide and there is a great deal of money and effort being expended in this type of work. To put it in another way, the work of the Aracruz team has been a catalyst for a new and revolutionary method in forest regeneration and it has been effective throughout the world.

In addition to the scientific improvements that the team made there were some social spin-offs that are of great importance. As you well know, Brazil and most of the tropical and subtropical countries are having strong pressures on the utilization of their native forests. For a number of years there was a concept that was called "replacement forests". This consists of growing trees on the grasslands, on the savannas, on the scrub-lands with the idea that this would take the pressure off the need to harvest the natural forests. The work done by this team from Aracruz has now made replacement forests not a theory but a practicality, something that has now been realized. And we will see through the years much less emphasis on going to the tropical forests and exploiting them. The emphasis will be to produce the needed wood on these lands that formerly were marginal or submarginal for forest production.

What I will do this afternoon is introduce each member of the team and he or she will then explain the kind of work that they have done. The stages of development and the contribution that were made will be explained by them. But prior to this I want to say just one word that I am sure that all of you are aware of, about a special friend and dedicated forester, Ney dos Santos. The untimely and tragic death of this team member shocked and saddened us all. During the presentations the three members who are here will cover somewhat Ney's work and I have asked Edgard Campinhos at the end of his presentation to say a few words about Ney's special contributions.

PRESENTATION
by Dr Leopoldo Garcia Brandão

The Aracruz project started in 1967, with the planting of *Eucalyptus* forests at Aracruz on the eastern coast of Brazil, in the State of Espirito Santo, 400 kilometers north of Rio de Janeiro city. The seeds used were those of *Eucalyptus grandis*, *E. saligna* and *E. alba* from Brazil, these being the species that afforded the best results for production of bleached pulp in São Paulo.

Eucalyptus had been introduced into Brazil by Navarro de Andrade in 1907 and 1909, using seeds brought from New South Wales, Australia. The ecology of this area is different from that of the Aracruz region in Brazil (1). In addition, many successive uncontrolled, inter- and intra-specific hybrids had been produced, resulting in some undesired characteristics. These were the only seeds of *Eucalyptus* available in Brazil up to 1972. The Aracruz Project had no alternative nor option other than to use the seed available. In fact, the project would never have been carried out if it had been necessary to take the time required to do the research essential for the best forestry in the Aracruz area.

The company took a calculated risk and planted the *Eucalyptus* available to form the Aracruz forests. We trusted our feelings, intuition and common sense that any problems involved could be solved through research and good forest management.

In 1973, after 26,650 hectares of *Eucalyptus* forests had already been planted, it was possible to make observations of the older forests to obtain an evaluation in depth as to the way the eucalypts were developing in Aracruz. This was done with the

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*) Numbers in brackets refer to photos, tables and diagrams at the end of this book

assistance of scientists from Brazilian and foreign universities and the FAO. Though the yield obtained - from 26 to 39 m^3/ha/yr - were quite high in relation to other regions in Brazil, we faced two serious problems, namely: a) lack of resistance of the forests to disease, especially cancer caused by fungi, and b) the low percentage of re-coppicing of trees after felling. Those two facts, on a medium term basis, would lead to a shortage of wood to supply the pulp plant that had already been defined for an annual output of 400,000 tons of bleached pulp.

The company definitely supported the conclusion arrived at by the scientists that the genetic material of Eucalyptus available in Brazil would not be good enough for the Aracruz region to produce the wood needed.

Two lines of action were adopted simultaneously, namely:
a) import Eucalyptus seeds from South Africa and later from Zimbabwe, and to go on planting, even though it was realized that those seeds did not provide a definitive solution, and b) with the aid of FAO and the full support of CSIRO, to obtain seeds from Australia, Indonesia and Timor. Material of potentially usable species from those areas was introduced at Aracruz, and a start was made on the establishment of a new genetic base for Eucalyptus in Brazil.

Forest improvement activities proceeded uninterrupted and received the utmost attention.

In 1975, after extensive and prolonged analyses of the whole of the technical alternatives available, we reached the conclusion that we did not have enough time available to obtain improved and selected seeds. We needed to reform the Aracruz forests starting with the cutting operations that were scheduled to commence in 1978/1979. The technology of using seed - the sexual route - could not meet the time frame for our requirements.

The asexual approach employing rooted cuttings was not yet being used very widely. A literature search along with contacts with scientists and forestry experts in Brazil and abroad, especially from Australia and France, gave us important guidance and helped in our decision, but failed to supply the complete solution to our needs.

We supported the conclusion of our technicians that large-scale vegetative propagation would be the best approach to achieve Aracruz's goals, being most feasible in technical, operational and economic terms. Among the various reasons for this was the observation that it was possible to make short-term simultaneous selection for a number of different criteria, the characteristics of which would occur in the new forest produced by clonal multiplication. Thus, the challenge of working out the technology needed for the large-scale use of vegetative propagation was accepted by Aracruz. This was a very difficult period, requiring considerable concentration of effort and true teamwork amongst scientists, operational foresters and administrators.

The challenge to go with vegetative propagation presented a number of obstacles which required that we make a series of adaptations if we were to achieve the technological progress needed to cope with the situation prevailing in the Aracruz region. In order to master it, every phase of the complex operation had to be developed on a sound scientific basis.

There was widespread disbelief and doubt on the part of the forestry and business communities that we would succeed. However, we had confidence in our efforts because of the quality and determination of the forestry team, which displayed a great deal of unity and faith that it would succeed in meeting a major challenge.

The decision to use species and hybrids of unknown genetic origin from the Aracruz forest did not appeal to many of the more orthodox scientists. It was, however, an important way to obtain good results on a short-term basis. It made it possible to achieve the objectives of Aracruz several years earlier. The new forest established from rooted cuttings is bearing out how correct that decision was.

As was expected, the new genetic material that we started introducing in Aracruz in 1973 will take time to produce the anticipated results but it is now being used. The genetic base for Eucalyptus at Aracruz was expanded so there is now a total of 54 species, 1,254 provenances or families, along with the 5,000 selections from established plantations (2). Every major aspect of the development of better genetic stock and the introductions was done by field research at Aracruz, with the objective of achieving broad-scale solutions on a short-term basis. To do this, we had to take a number of calculated risks.

Continuing interchange with scientists in Brazil and abroad, including visits to Australia, USA, Sweden, Germany, France and the Congo was extremely useful. In the Congo, where vegetative propagation of Eucalyptus has been in use for a number of years, we received most valuable assistance from the French scientists from the CTFT.

The difficulties that we had to overcome in producing rooted cuttings were numerous. Although only a few can be mentioned here some of the most important were:

- Identifying the most suitable growth medium in which to root the cuttings.

- Producing in Brazil the best kind of container for the rooted cutting operation.

- Controlling the environment, which would enable the production of rooted cuttings all year long, despite variations in climate. Some of the factors dealt with were humidity, temperature, intensity of sunlight, moisture content and many others.

- To determine the best fertilization in the containers in the nurseries in which rooting is done.

- How to prepare at Aracruz the rooting stimulants (hormones) that it was necessary to import ready-made at a high cost.

- How to determine and control the ideal physiological conditions of the plant material to be propagated, such as: age of the sprouts, size of the sprouts, time elapsed between harvesting from the stump, and planting in the containers and placing them in the shade houses.

- Achievement of a minimum overall success rate of 70 % in the production of rooted cuttings.

- Selection of methods and areas suitable for laboratory and field testing, and establishment of clone banks and vegetative multiplication areas. This is a slow process destined to continue for a number of years.

- Defining the several criteria desirable and viable for selection and approval of the methods used to select outstanding trees from the existing forest and from the seed orchards as well as the best genetic combinations for the new genetic base, was and still is a dynamic activity. As these develop, new criteria will be introduced as valuable things are located.

Problems related to the company's social policy, in which training and development of human resources rate a great deal of attention was a fundamental problem and objective at Aracruz. When the program in the northern part of Espirito Santo state, where Aracruz is located, was initiated in 1967, the area was extremely poor. It is difficult for some people in the developed countries, where extreme poverty is rarely witnessed, to appreciate the abject desolation and illiteracy and the related human realities prevailing in the poorer regions of areas such as existed at Aracruz.

Because of Aracruz's operations, there are now visible signs of improvement in living conditions. It was essential for the company to participate in the efforts being put forth by other communities in the region to improve housing, education, electric lighting, drinking water supply, communications and so on. Many workers hired by the company displayed serious health deficiencies so it was necessary to supplement their nutrition, combat vermin and parasites, and mount a major program of preventive and curative medicine.

The safety program at Aracruz has given excellent results and the authorities recognize Aracruz on having set industrial safety records. We are now going into the first ergonomics project in Brazilian forestry activities, with the aid of Brazilian scientists.

The company has always remained aloof from political activities, while still improving the living standards of the workers and their families, as well as of the population in neighbouring communities. Such activities have received close attention and participation, and include helping the community make its own solutions, often with considerable financial support by Aracruz. There had been no skilled labour in the region, so Aracruz mounted a major program for vocational training and development. Seven thousand workers have been trained and transformed from manual labourers into skilled workers in the past ten years. While the Brazilian economy was still functioning at a satisfactory level, many of these migrated to the more industrialized urban centers, such as Sao Paulo. At present, however, there is little turnover, and the presence of skilled people trained by the company is a major reason for the high level of productivity found at Aracruz. This result bears out our confidence of the competence of the Brazilian worker, if given proper training and the necessary support.

Following is a summary of the main results obtained by Aracruz as they affect Brazil, the region around Aracruz and the company itself. Some of the results achieved amount to solutions of problems previously faced, which are now incorporated into day-to-day activities and currently are even taken for granted:

- Development of the technology of vegetative propagation which is being used by other forestry companies in Brazil and Latin America (3, 4). This has even affected Brazilian agriculture, as in coffee plantations.

- Transformation of unproductive land into a highly productive state by good management (5), including fertilization.

- Establishment of a complete infra-structure in a region where such formerly was absent, which will enable on-going economic and social development.

- Construction of a large bleached pulp plant (6), scheduled to produce 460,000 tons in 1984, which is highly competitive in both Brazilian and foreign markets.

- Production of pulpwood and wood for energy, at competitive costs, resulting from the considerable increase in productivity of Aracruz's forests which makes it possible to meet market requirements (7).

- Generation of jobs for thousands of workers, many of whom had not received proper schooling. This currently amounts to 6,000 direct jobs, involving 20,000 family members who live under greatly improved and constantly improving conditions.

- Increasing exports of pulp from Brazil, which is a decisive importance for improving the present balance of payment problems.

- Promotion and giving financial assistance for social development in the region, especially in terms of housing, which now includes 2,200 homes self-owned or obtained under agreement with the authorities, as well as schools, hospitals, highways, means of communication, security and electric energy (8).

- Because of improved conditions there have been increased tax collections by the municipalities, the State government and the Federal government.

- Developing and disseminating modern technologies, such as combatting pests such as leaf cutting ants, that cause such heavy losses to the country.

- Preservation of over 20 % of the gross area of the land at Aracruz in native stands in which a program is under way for biological enrichment and planting of fruit trees to boost the availability of food for wildlife. This program, aimed at maintaining a biological equilibrium, enables controlling pests through their natural enemies, thus reducing and/or eliminating the need for agro-toxic substances in forest protection.

- Making it possible to preserve the native Brazilian forests, because boosting the productivity of the planted forests makes it feasible to meet market requirements.

From the point of view of the forest industry, the main results from intensive management and the use of genetically improved rooted cuttings are as follows:

- There is a reduction in the area of forest land necessary to supply the timber needed. Following is a quotation illustrating this: "a complete supply of wood for the production of one million tons of bleached short fiber pulp a year from Eucalyptus, using the forest technology Aracruz has now mastered for a region with soil and climatic conditions resembling those of Aracruz, will take only 90,000 hectares of forest land (net area)" (9). That is just half as much as Aracruz would have needed ten years ago, and this will result in major benefits to the forestry industry.

- There is a reduction in forestry investments and the cost of wood which is of special importance in countries facing a high rate of inflation.

- There is a reduction in the distances which the wood must be hauled, resulting from the smaller size of the forest area, which considerably reduces costs of transportation and consumption of petroleum products that are so scarce and costly in Brazil.

- There is a reduction of manufacturing inputs used to make pulp, thanks to the higher content of fiber per cubic meter of wood from the improved trees. The wood from the new Aracruz forest provides 50 kilos more fiber per cubic meter of wood than does the normal unimproved Eucalyptus.

- There is an improvement in the quality of the pulp, resulting from the greater uniformity of the wood, and the possibility of producing several products with requirements for specialty markets.

- There is the possibility of selecting clones that are less demanding for nutrients, which reduces the minerals taken from the soil and the cost of fertilizers that would be necessary to keep a positive nutritional balance. At Aracruz the nutrient in short supply is phosphorus. Aracruz is already utilizing the large beds of phosphates which are found in Brazil.

- There is a considerable reduction in the risks of disease and attack by pests by means of using clones selected right in the Aracruz forests and then being multiplied by vegetative propagation. Monoclonal forests can be managed much more efficiently regarding disease than forests planted from seed because the areas planted to a clone that is susceptible to a given disease can be harvested and replaced with other clones that possess the needed resistance.

- There is only a relatively short time period needed for establishing the clonal banks and vegetative propagation areas necessary for large-scale production of cuttings (this requires seven years) compared to a program depending on seed production.

- There is a flexibility in the harvest cycles for production of pulp from six to nine years, which enables a diversification of the ultimate uses to which the wood is put; sawtimber, pulpwood, fuel, or posts and poles.

- The gains achieved by the Aracruz program using rooted cuttings is summarized in the following table:

ARACRUZ FORESTRY PROGRAM

FOREST PRODUCTIVITY AND PULPWOOD QUALITY

(Results from intensive forest management and genetic improvement established by means of rooted cuttings.)

	Initial forest 7 years	Today's forest 7 years	Change Quantity	Change Percent	
Yield (m^3/ha/yr)					(10)
minimum	26	54			
maximum	53	113			
average	33	70	+ 37	+ 112	
Pulpwood characteristics					(11)
(average)	(300-900)	(500-600)*			
Basic density					
(kg/m^3)	460 avg.	575 avg.*	+ 115	+ 25	
% pulp	48	51	+ 3	+ 6	
Pulp content					(12)
(kg pulp/m^3s with bark)	238	293*	+ 55	+ 23	
Specific consumption					
(m^3s with bark/ /t pulp)	4.20	3.41*	- 0.79	- 19	
Forest productivity					
(t pulp/ha/yr)	7.85	18.45	+ 10.60	+ 135	
Mill production capacity					
tons/year	400,000	?	?	?	

(*) Wood without bark

Questions have often been raised as to whether the forestry activities at Aracruz will continue to improve in the future. They may be answered as follows:

- There will be a continuation of the introduction of species and provenances. Through genetics there will be continued development of better trees from which better selections will be made. New criteria of selection of trees most desirable for manufacture and for the market will be determined; these include characteristics of the wood fiber. The work has an immediate goal of one hundred of the highest quality clones but such activities are continuous.

- As techniques are evolved, there will be use of the technologies of in-vitro cultivation of Eucalyptus using tissue culture and the development of new genotypes by somatic hybridization.

- The fertilization program will be refined, using macro- and micro-nutrients, so as to fertilize for the needs of individual clones and by soil type, always with the objective of maintaining the nutrient balance.

- The technology and mastery of the techniques necessary for the use of bacteria, fungi and viruses in the biological control of forest pests will be pursued enabling abandonment of the agro-toxic chemicals.

- There will be an expansion of the use of ergonomics, to be extended to all activities at Aracruz.

- An improvement of the technology of various energy uses for wood and forest residues.

- Working out methods of manufacture and developing trees suitable for sawmill products from Eucalyptus.

- Expansion of knowledge of the tropical Pinus forests and the wood produced by fast growing tropical conifers (13).

PRESENTATION

by Yara Kiemi Ikemori

Selecting desired parent trees

The Aracruz forests from 1967 to 1979 were planted with seed sources from Brazil, South Africa and Zimbabwe, mainly *Eucalyptus grandis*. Based on forests five or more years old, considerable genetic variation was observed between and within populations, being most marked in the material from the Brazilian source (14). But, it was from those populations that we initially selected phenotypically superior trees (15), which subsequently formed the genetic basis of our program of vegetative propagation using rooted cuttings (16). Selection normally is made at harvest age (7 years), at which time the following forest and utility characteristics are taken into account (17):

- The selected tree must have a volume of more than 1 m^3, including bark, and be free of diseases and insects.

- The selected tree must be immune to the bark disease caused by a fungus known as *Cryphonectria cubensis* which occurs in trees not ecologically well adapted to grow at Aracruz.

- Selected trees must be straight and have small limbs, which enhances self-pruning and avoids tension wood normally associated with thick branches and crooked trees.

- Bark should be smooth, not rough.

- The crown should be well shaped, having a large leaf volume which provides better and earlier shade over the ground which suppresses weeds and other competitive vegetation.

After the trees are evaluated by the above five criteria, they are felled and the wood is sampled and analysed for its basic density (which we use from 500 to 600 kg/m^3), its pulp yield (which we use when it exceeds 50 % based on dry weight of wood) and on its bark content which should be less than 10 %.

Following the felling of the tree, the coppicing ability from the stump is also taken into account. In Eucalyptus, when vegetative propagation using rooted cuttings is employed the capacity and intensity of coppicing is what determines the number of cuttings that will be obtained. And how easily these cuttings will root is of key importance too. The rooting capacity of cuttings derived from stump sprouts should exceed 70 %.

After that, rooted cuttings from the selected trees must be tested for their genetic suitability. Then, ramets obtained are planted in different types of soil on the lands of Aracruz in order to test their growth potential, resistance to pests, wood properties and adaptation to the soils. The test areas (called clonal test areas) are the ones in which forest and utility characteristics of the selected trees are confirmed.

Assessment in clonal test areas is made after half rotation (3 to 4 years); following this, the best clones are propagated for multiplication with more rooted cuttings. These are subsequently planted in larger areas called clonal multiplication areas (18), which provide sprouts for the operational rooted cutting production. This requires considerable areas to produce sufficient cuttings since the company's planting program was 15 million rooted cuttings in 1984.

The morphological and anatomical analyses of the wood from the selected trees include the length of fibers, wall thickness, specific gravity, cellulose yields and other properties. Some of those analyses are done in the Aracruz Industrial Research Center. We are improving wood qualities as well as yields.

As new information is obtained, new criteria for selection are then put into practice. Therefore, the present criteria (which included 15 characteristics) will be changed with time.

Studies about adaptations for the use of vegetative propagation started in 1975 with mass production of rooted cuttings for field planting, which was first done in 1979. Until now, we have selected 5,000 trees from 36,000 hectares of original plantations. From these we have selected 150 clones considered to be suitable for final selection; of these 31 of the very best are being used in plantation programs. Clones with good characteristics but which do not have the best wood for pulp are preserved in clonal banks, to be used as a basis for breeding and developing clones with desirable characteristics.

Producing vegetative propagules in the nursery

Vegetative propagation of *Eucalyptus* by rooting of cuttings can only be successfully done using young or juvenile plant material; the sprouts obtained from coppiced stumps are juvenile. The trees must be cut slightly above the soil level at approximately 12 cm height. If the stump is taller, the sprouts arising at points distant from the soil root poorly or do not root at all. The cuttings need to be obtained in a certain and clearly defined stage of growth if rooting success is to be assured. When shoots are harvested too early, the number of cuttings available for rooting will be small. If obtained too late, the cuttings become too lignified and their rooting capacity diminishes. We have found that the best at Aracruz is to harvest the shoots 45 to 55 days after the tree has been cut (19).

The sprouts are removed with pruning shears and are placed in a bucket of water, deep enough to cover the bases so as to avoid wilting (20). Since it is necessary that the stumps remain alive and vigorous for future production of cuttings or wood, one or two properly located and vigorous shoots from the stump are left to develop into a new tree (21).

A special covered truck is used to transport the shoots from the clonal multiplication area to the nursery (22). Doing that, they are protected from direct sunlight, wind and excessive heat. At the nursery, the buckets are put in a shady place and the shoots are irrigated while awaiting processing (23).

The shoots are collected, prepared and planted in the nursery the same day. They are severed with shears into cuttings (24) which contain one or two pairs of leaves (25, 26), depending on the internode length. The leaf area is diminished to less than half the original leaf size so as to avoid the large heavy leaves from falling and overlapping with others and to reduce the amount of transpiration. The bases of the prepared cuttings are treated with a fungicide for 15 minutes to prevent rotting (27). After that, they are treated with indolebutyric acid diluted with talcum powder, which stimulates root formation (28). Following this, the cuttings are ready to place in containers where they will root. Although plastic bags were formerly used we have found that polyethylene tubes in polystyrene trays are the best containers (29); in them vermiculite is used as the growing medium.

The planted container is submitted to intermittent mist in a shade house (30) with 50 % shade for five weeks until a good root system is developed and top growth starts (31, 32). Within 25 days the rooted cuttings receive fertilization using N-P-K with a 5-17-3 formulation. After this period, the cuttings are removed from the shade house into full sunlight to continue to develop and to harden off (33). After ten days outside, a selection is made (34), in which the rooted cuttings are separated into two different classes by size and the unrooted cuttings and dead individuals are discarded. Since cuttings usually develop with more than one bud, all excess auxiliary buds are cut, leaving only the largest and best one. The smaller rooted cuttings which have been separated out receive a second fertilization.

20 to 40 days after the rooted cuttings have been moved into the sunlight they are ready to be planted in the field (35). Thus, the total rooting process takes about 130 days prior to planting the cuttings in the field.

Developing the program

Aracruz also has a long-term breeding program (36) consisting of studies and trials with species, hybrids (37), provenances (38), progenies, selections and controlled pollinations (39, 40). The selected material is in clonal banks and seed orchards (41) where it is used to produce genetically improved plants both from pure species and hybrids.

The proper development of a program requires a broad genetic base, which is constantly being expanded to obtain new genotypes (42). For example, collections have been made of over 300 of the best mother trees of *Eucalyptus grandis* from Australia and an equally large number of selections of *E. urophylla* from Indonesia. These will be developed into advanced, greatly improved strains which will then be crossed to produce super-hybrids. Since this material is so strategically important, the company's policy is to increase constantly its genetic base for future generations of growth and wood quality.

In addition to the biological needs, training of workers for nursery operations must be carefully done. When they become skilled and have satisfaction with the job, success in production and quality of rooted cuttings obtained are achieved.

PRESENTATION

by Edgard Campinhos, Jr

We have learned from Miss Ikemori's talk what a large complex of activities needs to be developed to obtain improved trees for use in cloning, using vegetative propagation by rooting cuttings. The improved trees can be pure species or hybrids.

Eucalyptus has a number of major advantages; it is a fast growing species, it has the ability to regenerate by coppicing following harvest, it roots easily from stump sprouts, hybrids are easily produced.

The eucalypts are an ideal group of trees to manipulate in forest management, including obtaining large genetic improvements.

Cloning has the major advantage of transferring the whole genetic potential so that the new plant displays the same behaviour as the original tree, when grown in the same environment. It is evident that the success of clonal planting does not end with the development, or selection, of a mother tree. All aspects of regeneration and forest management must be the best to develop a high productivity forest.

I will now describe and illustrate with slides some of these activities.

Nursery

A uniform treatment of the new plants during their development in the nursery is a critical factor (43).

To achieve this, we produce the rooted cuttings in containers of constant volume and shape (44). The growing medium, which consists of vermiculite, is very homogeneous in composition, making it easy to obtain uniformity.

The combination of a standard container and homogeneous growing medium, makes it possible for many of the nursery operations to be mechanized, enabling uniformity in production which results in reduced costs (45, 46, 47). Savings are large when one deals with an output of 15 million rooted cuttings each year (48).

Some aspects, like the preparation of the cuttings and placing them in the containers, require manual operation; this is performed by well-trained workers.

Preparation of the site for field planting

First, the heavy brush must be removed from the area to be planted (49).

Following this, it becomes possible to use suitably adapted equipment for a number of simultaneous operations which included ploughing, discing (50), spreading of fertilizer, marking of planting locations and row alignment (51). This latter greatly facilitates subsequent management operations such as cultivation, fertilization, ant control, inventory taking and protection from fire.

Special care is taken for proper soil preparation to give the very best growing conditions for the *Eucalyptus* rooted cuttings which are sensitive to competition when young.

Soil fertilization and conservation

The necessary foundation for good growth and production of wood is the soil. Its qualities must be conserved by proper management and its productivity maintained by fertility improvement.

The individual rooted cuttings are fertilized on a cutting by cutting basis at time of planting. Besides this, 500 kg of rock phosphate are added per hectare (52).

When forest trees are harvested some mineral elements are removed, although nutrient loss is much less than for agricultural crops because wood per se contains very little nutrients; most are in the leaves and small branches.

However, enough fertilizers are added to the soil to maintain a positive and suitable nutrient balance.

As Miss Ikemori mentioned, we are now in the phase of selecting plants that show good metabolic efficiency; that is, developing trees that can achieve good development using a minimum of nutrients and water. This result can be achieved more easily with cloning than when using seed, by using cuttings of individuals selected in the locality, in which they are to be planted, thus reducing the interaction between genotype and environment.

To develop these more efficient individuals, the better clones are being studied in the greenhouse to determine the natural requirements of each one. These will then be used in field planting to achieve maximum efficiency.

In the future, each clone will receive specific nutrition determined by the nutrients available in the soil and the specific clonal requirements. Our studies will result in using the maximum production potential of each clone.

Growth of the trees is very rapid. In the first thousand days of life Eucalyptus may reach a height of twenty meters; calculated another way, they grow an average of two centimeters a day. As a result of this fast growth, a considerable amount of dry matter in the form of leaves, fruits, seeds and twigs is deposited every year on the soil; our studies show this amount to seven tons per hectare per year.

When added to the phosphate fertilizers, this material assures that the nutrient and physical properties of the soils at Aracruz are being properly preserved.

Planting

Planting must be done with a great deal of care, since it is key to the success of development of Eucalyptus forests (53). It is done by hand, with special precautions being taken with every rooted cutting (54), which may well occupy the site for the next 35 years, generating up to five different coppice cuts on a 7 year rotation.

No mistakes can be tolerated in the planting operation since we aim to achieve a 99 % survival rate (55).

Rainfall is well distributed throughout the year in the region near Aracruz and there is rarely a three weeks period unaccompanied by rain in normal years. Taking advantage of these good climatic conditions, we developed in 1969 the technique of irrigating plantings (56), which consists of adding a certain quantity of water to the rooted cuttings at the time of planting (57, 58).

We plant up to 17,000 hectares each year (59), and the costs are moderate. The quality of the operation has greatly improved in relation to planting done (60, 61, 62) only when the soil is wet, which normally does not afford suitable working conditions for the persons planting (63, 64).

Forest protection (65)

There are many pests that affect the Eucalyptus forests. I will discuss only two of the most important.

Weeds: Eucalyptus is highly sensitive to competition from weeds and brush for water nutrients (66), and the growth of a Eucalyptus forest is inversely porportional to the presence of weeds (67). Hence, the planted area is kept clean by cultivation (67) or chemicals until the crowns of the trees have closed, which stops the growth of the competition (68).

Ants and other insects: Eucalyptus is subject to attack by several different insects (69). Leaf cutting ants are pests occurring all over Brazil, attacking a number of crops and causing tremendous harm to the country. These ants have a marked preference for most species of Eucalyptus. If they are not kept under control, entire forests may be wiped out from one year to the next (70). Toxic chemicals are normally used to destroy them, but this entails hazards to human beings and the environment. Ant control is difficult because insects are dynamic and are capable of adaptation to new situations.

Therefore, to better manage against ants, using methods of biological control, we have underway at Aracruz in-depth studies of ants. We also have some leads on ant resistant trees (71). As of now we are developing, along with university people, a biological bait consisting of a fungus (72).

Insects other than ants cause problems, which we are also trying to control biologically. For example, in minor outbreaks of weevils we have used bacilli as a means of control.

Thus, we are orienting insect control measures in the forest towards utilization of biological media which we hope will be total in the future.

Planting spacing

The spacing currently used in the plantations is 3 x 3 meters (73), which is maintained up to cutting time, at the seventh year, with no thinning. At time of harvest the entire forest is cut down.

Following harvest, the stumps will coppice and a new forest will be stablished. Each stump gives rise to a number of different shoots (74) which are thinned about the fifth month after cutting, leaving only one major stem in place (75, 76).

Coppicing will be used from our genetically better material now being planted which produces over 100 cubic meters per hectare per year (10). The original, unimproved material, which grows 35 cubic meters per hectare per year, is being replaced by the good genetic stock until all of Aracruz's plantations will produce at the high rate.

The spacing used results in maximum forest productivity in the seventh or eighth year. At that age, the wood has yield and properties desirable for the production of pulp, according to a number of studies.

Composition of clonal planting operations

Our objective is to select 100 clones that combine the best characteristics, but which will be replaced as new and better ones are developed. The clonal planting operations are well identified. Each clone is planted in a separate compartment, whenever possible, because there is always the risk of a pest attacking a number of individuals of a particularly vulnerable clone planted in a number of different compartments spread throughout the entire area.

If this occurs, all compartments containing the same clone will receive the same treatment, which might consist of combatting the pest or cutting for purposes of replanting. Planting of a mix of clones (or poly-clonal planting) in the same compartment would make such management impossible. To avoid excess danger of monoculture, we plant several clones by blocks in a compartment in a mosaic pattern.

Research versus operational integration

We feel that a major factor which has greaty contributed to obtaining rapid results in research and their application in practice has been to have the same person and team of foresters in charge of both research and forestry operations insuring a well integrated approach. Thus, research and operations are in full harmony to achieve the major objective of maximum production of high quality wood as cheaply as possible.

This has been possible since we have received the full backing from top management in the company which believes and invests in research and research workers.

Also, it is important that the research staff has responsibility and authority for controlling the quality of the field operations, in which the research results are being applied.

Research and development are never-ending activities. The goal is to achieve new improvements which are environmentally sound.

Operations are dynamic and evolve all the time, progressively absorbing new technologies.

The policy at Aracruz is to develop new methods, keep up with those produced by others and then using them in operational planting.

ORATION

by Edgard Campinhos, Jr

*****

NEY MAGNO DOS SANTOS

Professionally trained as a statistician and company administrator, he always held a position of leadership and participated actively in the establishment and development of the operational and research teams at Aracruz Florestal.

His character, ability and qualities of leadership fostered the existence of well-knit teams dedicated to harmonious and effective work, making it possible for Aracruz Florestal to achieve a satisfactory level of scientific and technological development in its forestry activities.

Modest at all times, he never claimed recognition of his merits nor bid for honours, despite the results obtained by him and by the teams under his guidance.

Thanks to his loyalty, analytical and critical sense, and modesty, particularly the latter quality, those teams received from Ney Magno dos Santos the backing, competence and confidence necessary to the development of their activities and to putting drive into new research in both the operational and the forest management areas.

Receptive in every case to innovative trends, he sought to stimulate technological progress, adapting such advances to the realities prevailing in the Company and making it easy for technicians to acquire new knowhow.

He believed in research and repeatedly stressed his support for it, feeling this was the only way in which the developing countries could achieve scientific, technological and economic self-sufficiency.

Married, aged 52, with three daughters, extremely generous with his parents, brothers and friends, he dedicated his entire capacity for affection and his moral strength to the welfare of his loved ones.

To all around him, spouse, daughters, relatives, friends, companions and underlings, he was an open-handed, loyal and cooperative friend.

His passing leaves in our midst a great void which we feel will be most difficult to fill.

But, the banner under which he strove, did not disappear with his passing.

It has been taken up by all of us, and will remain ever vigorous and effective.

CHARACTERISTICS OF THE ARACRUZ REGION

LATITUDE	19°48'S
LONGITUDE	40°17'W
ALTITUDE	5 TO 50 m
AVERAGE ANNUAL RAINFALL	1,364 mm
AVERAGE ANNUAL TEMPERATURE	23.6°C
AVERAGE OF MAXIMUM TEMPERATURE	29.3°C
AVERAGE OF MINIMUM TEMPERATURE	19.1°C
RELATIVE HUMIDITY	80%

1

ARACRUZ

FOREST TREES
INTRODUCTION OF SPECIES AND PROVENANCES

SPECIE	QUANTITY OF SPECIE	QUANTITY OF PROVENANCES AND/OR FAMILIES
EUCALYPTUS ALBA	01	52
E. CAMALDULENSIS	01	29
E. CLOEZIANA	01	49
E. GRANDIS	01	451
E. SALIGNA	01	57
E. TERETICORNIS	01	43
E. UROPHYLLA	01	387
E. PELLITA	01	06
OTHERS EUCALYPTUS SPP	46	180
PINUS CARIBAEA VAR. BAHAMENSIS	01	19
P. CARIBAEA VAR. CARIBAEA	01	07
P. CARIBAEA VAR. HONDURENSIS	01	288
P. OCHOTERENAI	01	93
P. OOCARPA	01	468
P. TECUNUMANII	01	109
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ACACIA SPP	11	19
ARAUCARIA CUNNINGHAMII	01	08
TECTONA GRANDIS	01	14
OTHERS SPECIES	26	50
INDIGENOUS SPECIES	10	10
TOTAL	114	2.427
EUCALYPTUS (HYBRIDS) FOR ROOTING OF CUTTINGS	-	5.000

MAY, 1984

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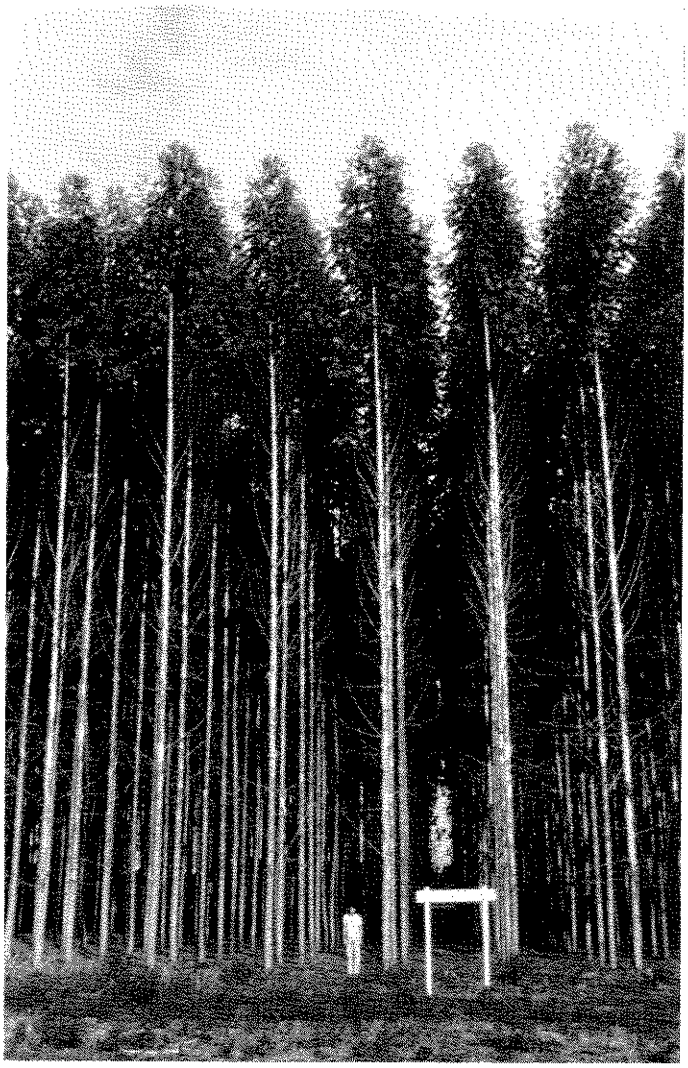

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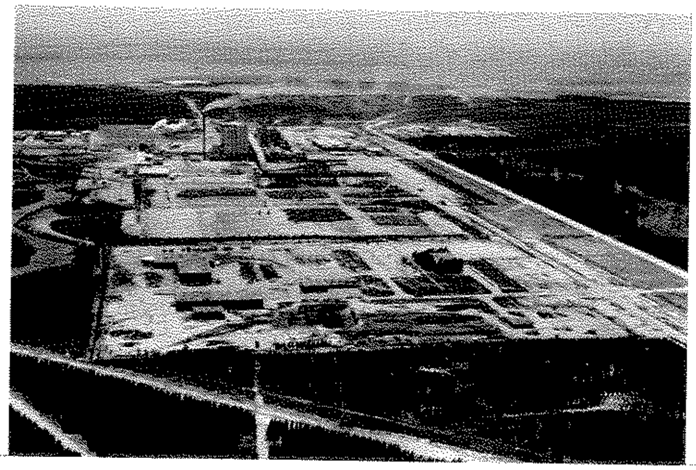

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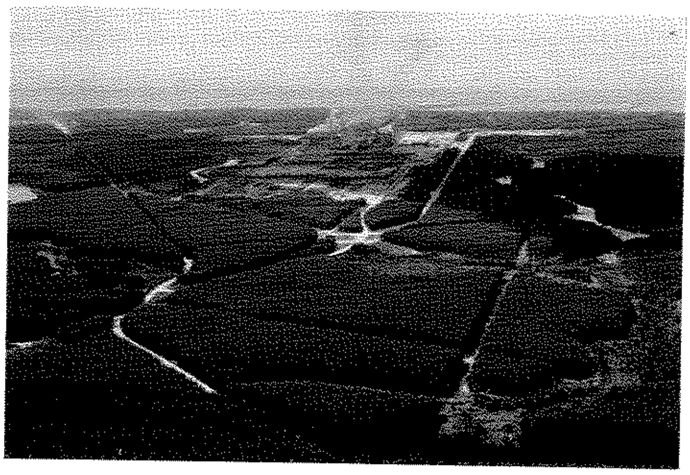

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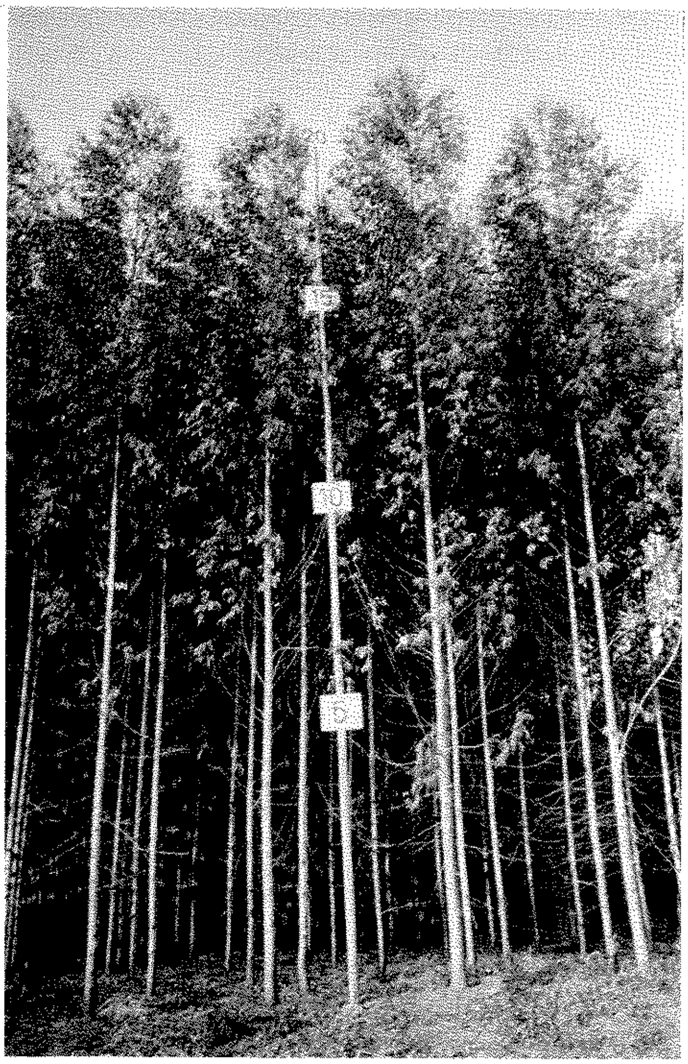

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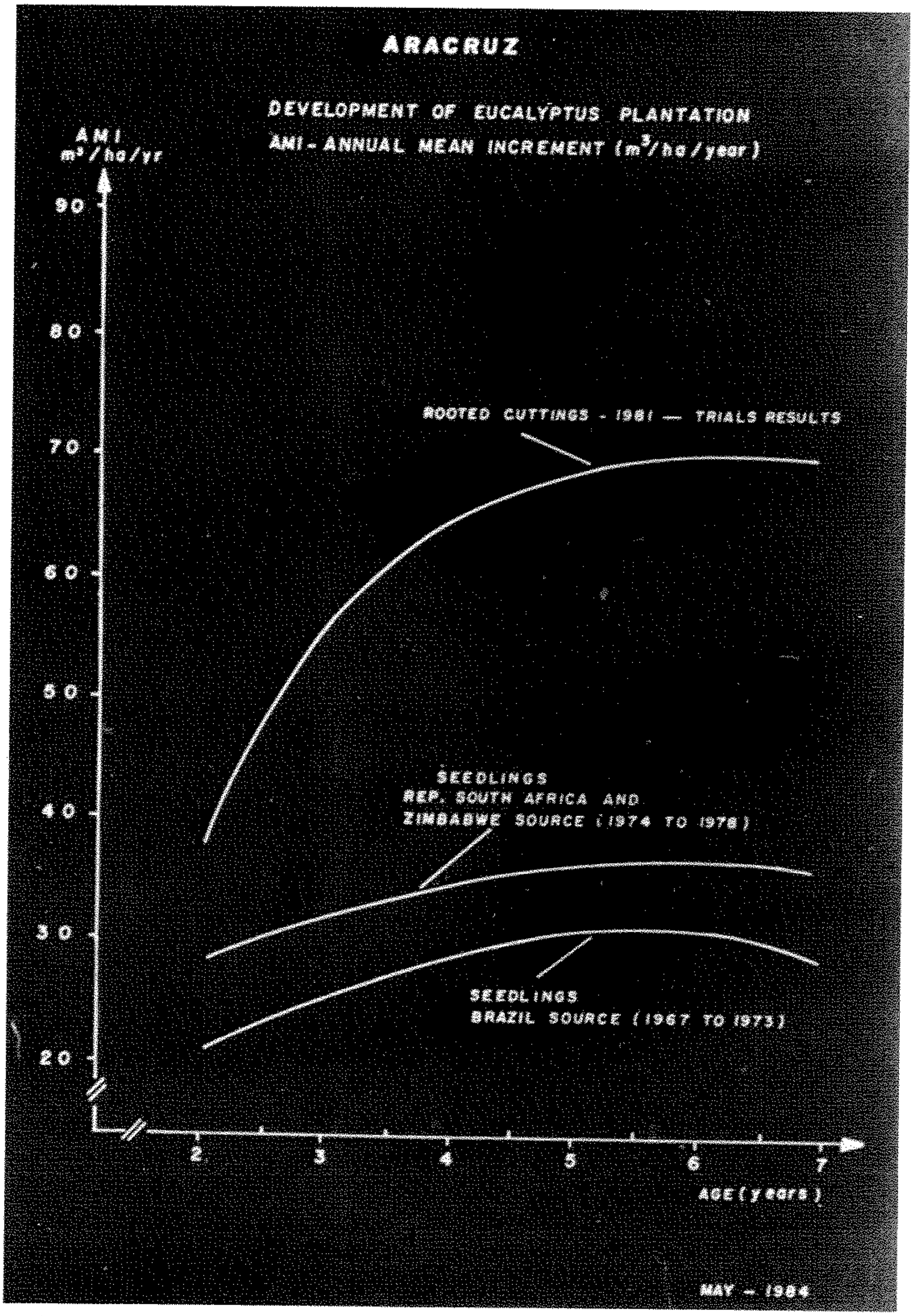
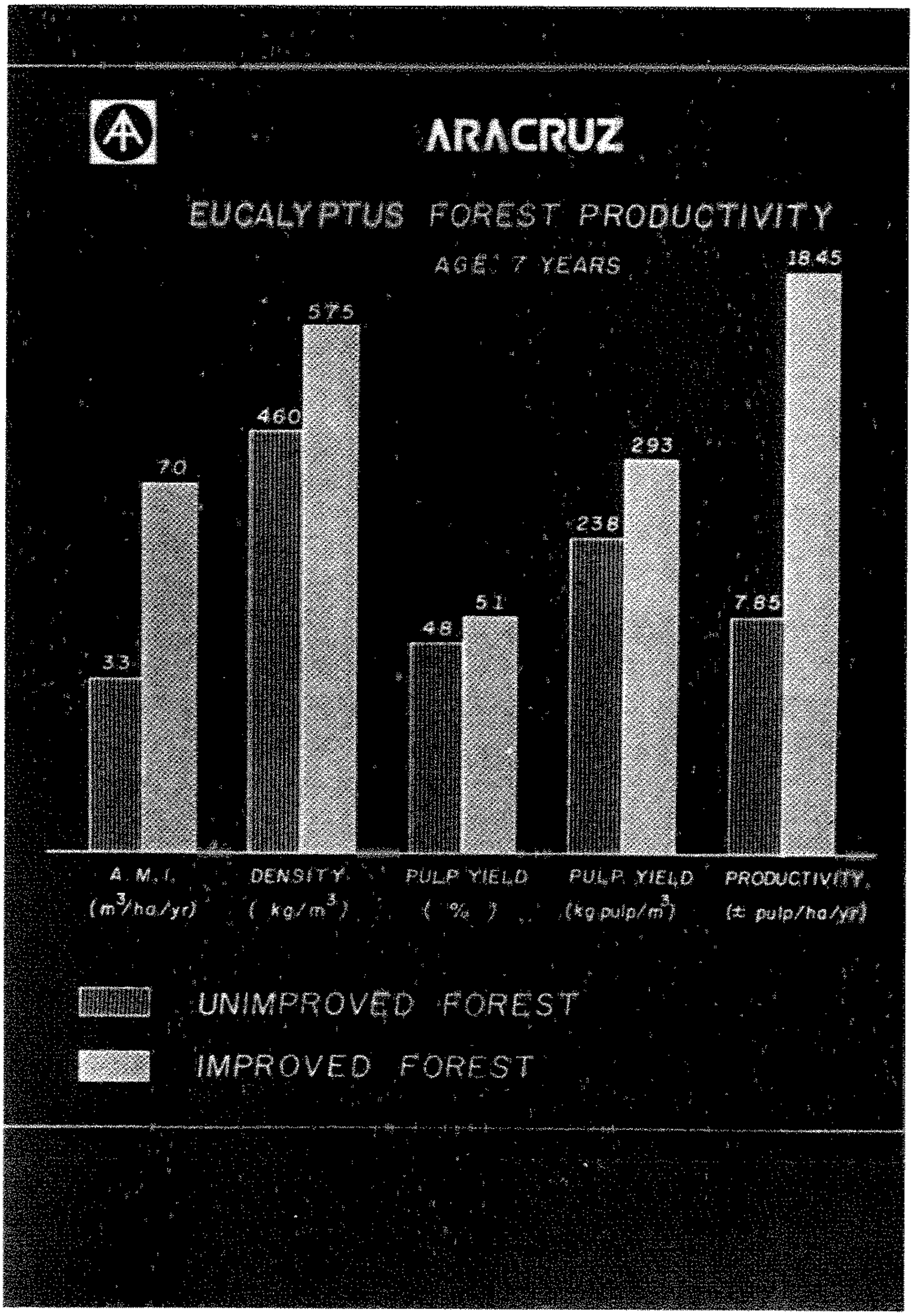


ARACRUZ
DEVELOPMENT OF EUCALYPTUS PLANTATION
AMI - ANNUAL MEAN INCREMENT (m³/ha/year)
AMI
m³/ha/yr
90
80
70
60
50
40
30
20
ROOTED CUTTINGS - 1981 — TRIALS RESULTS
SEEDLINGS
REP. SOUTH AFRICA AND
ZIMBABWE SOURCE (1974 TO 1978)
SEEDLINGS
BRAZIL SOURCE (1967 TO 1973)
2
3
4
5
6
7
AGE (years)
MAY - 1984


ARACRUZ
EUCALYPTUS FOREST PRODUCTIVITY
AGE: 7 YEARS
33
70
460
575
48
51
238
293
7.85
18.45
A. M. I. (m³/ha/yr)
DENSITY (kg/m³)
PULP YIELD (%)
PULP YIELD (kg pulp/m³)
PRODUCTIVITY (± pulp/ha/yr)
UNIMPROVED FOREST
IMPROVED FOREST

A R A C R U Z

FOREST PRODUCTIVITY - AGE: 7 YEARS

QUANTITY AND QUALITY OF WOOD FOR PULP

	UNIMPROVED FOREST (SEEDLINGS)	IMPROVED FOREST (ROOTED CUTTINGS)	GAINS QUANTITY	GAINS %
AMI (M^3/HA/YR)				
MINIMUM	26	54		
MAXIMUM	53	114	+ 37	+ 112
AVERAGE	33	70		
DENSITY (KG/M^3)				
MINIMUM	300	500*		
MAXIMUM	900	600*	+ 115	+ 25
AVERAGE	460	575		
PULP YIELD (%)	48	51*	+ 3	+ 6
PULP YIELD (KG PULP/M^3)	238	293*	+ 55	+ 23
SPECIFIC CONSUMPTION (M^3/T PULP)	4,20	3,41*	- 0,79	- 19
PRODUCTIVITY (T PULP/HA/YR)	7,85	18,45*	+ 10,60	+ 135
MILL CAPACITY (T/YR)	400,000	?	?	?

(*) WITHOUT BARK

MAY, 1984

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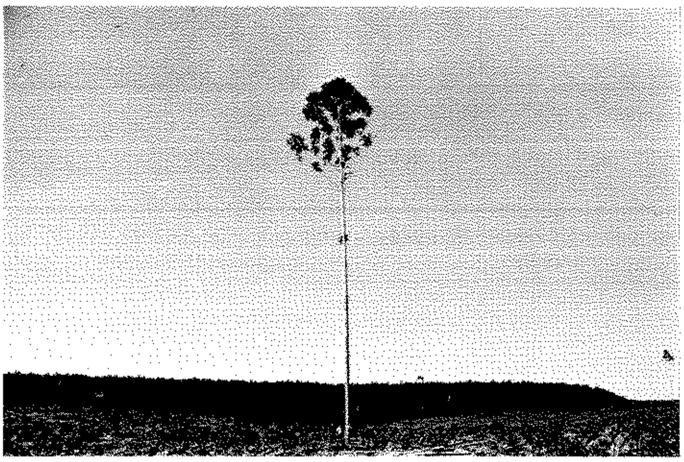

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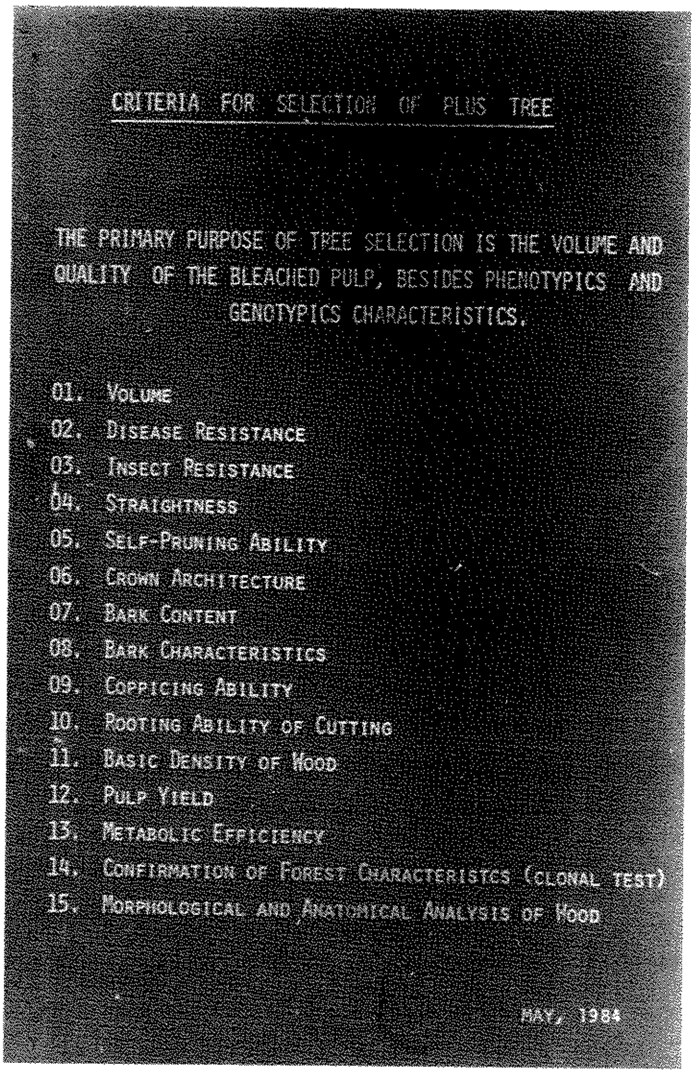
CRITERIA FOR SELECTION OF PLUS TREE
THE PRIMARY PURPOSE OF TREE SELECTION IS THE VOLUME AND QUALITY OF THE BLEACHED PULP, BESIDES PHENOTYPICS AND GENOTYPICS CHARACTERISTICS.
01. VOLUME
02. DISEASE RESISTANCE
03. INSECT RESISTANCE
04. STRAIGHTNESS
05. SELF-PRUNING ABILITY
06. CROWN ARCHITECTURE
07. BARK CONTENT
08. BARK CHARACTERISTICS
09. COPPICING ABILITY
10. ROOTING ABILITY OF CUTTING
11. BASIC DENSITY OF WOOD
12. PULP YIELD
13. METABOLIC EFFICIENCY
14. CONFIRMATION OF FOREST CHARACTERISTICS (CLONAL TEST)
15. MORPHOLOGICAL AND ANATOMICAL ANALYSIS OF WOOD
MAY, 1984

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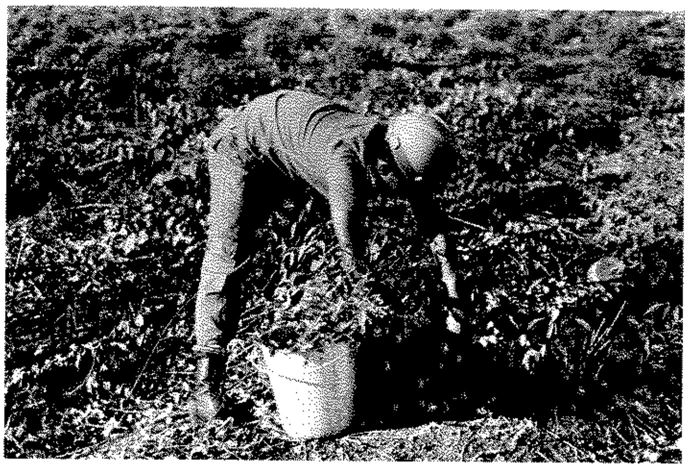

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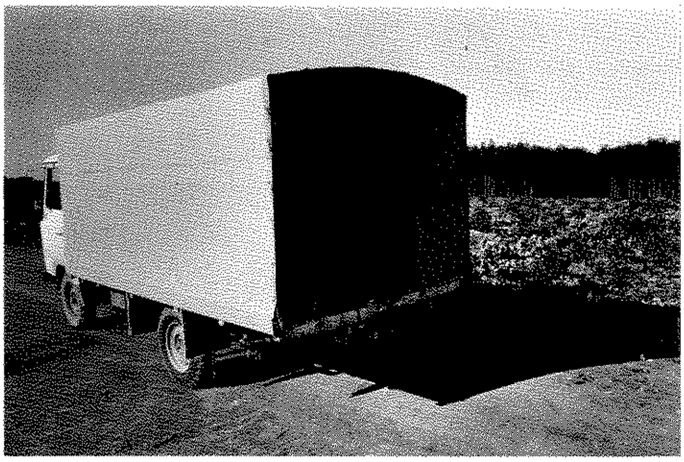

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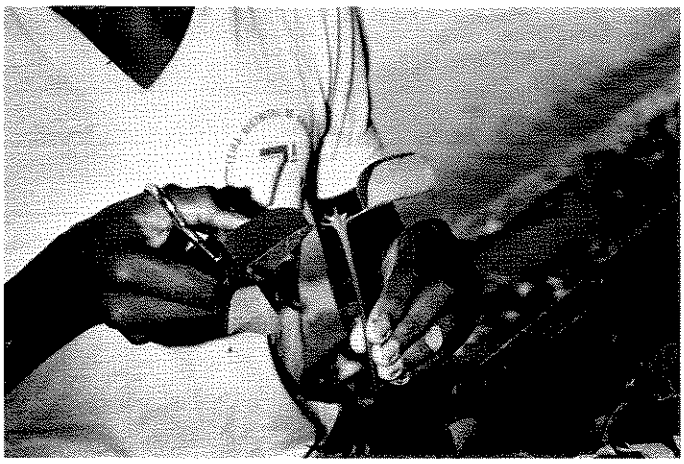

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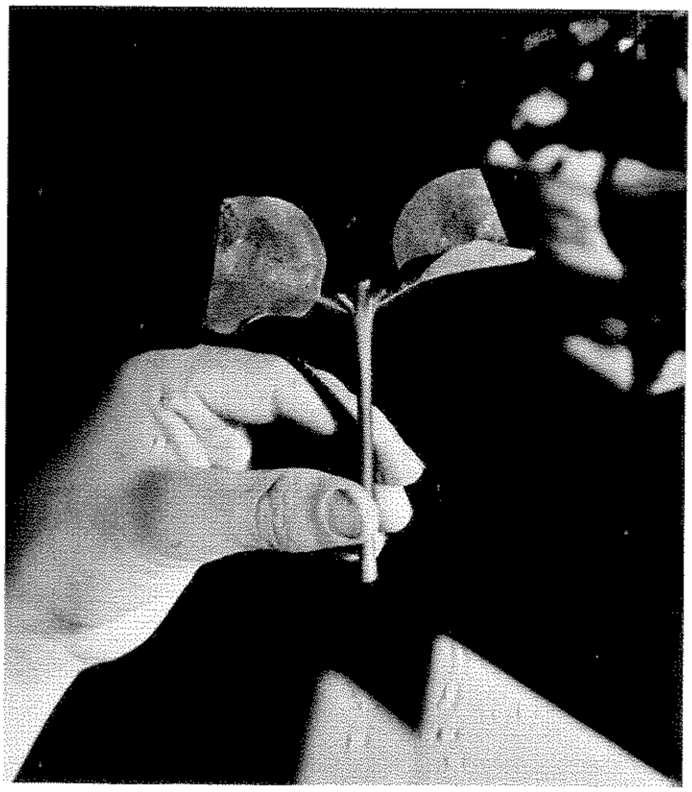

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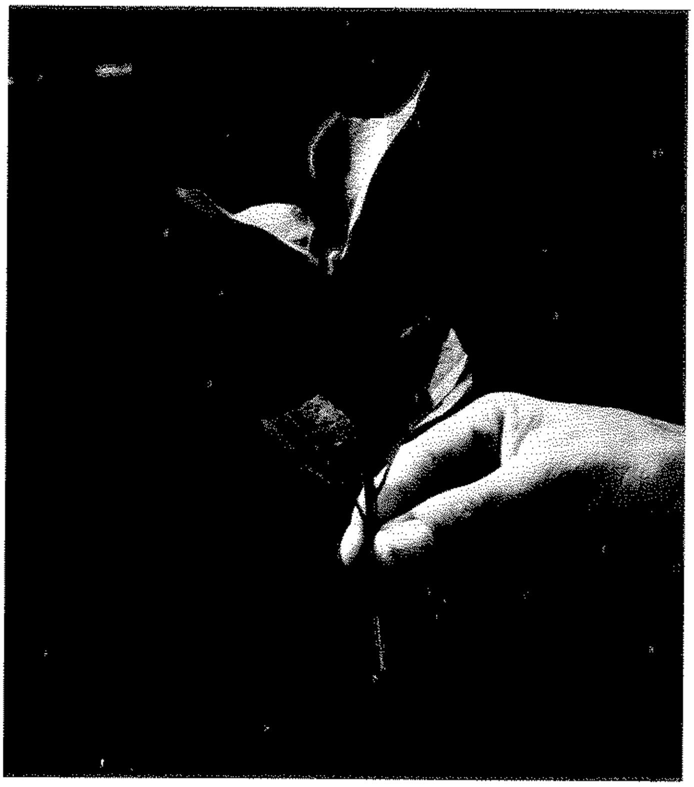

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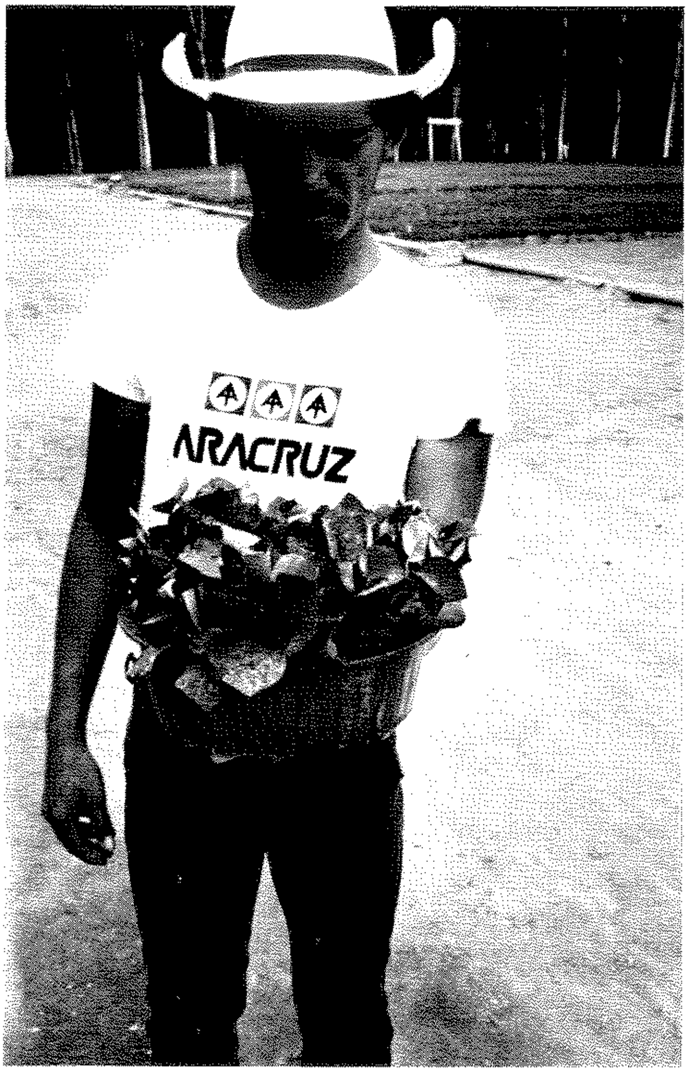

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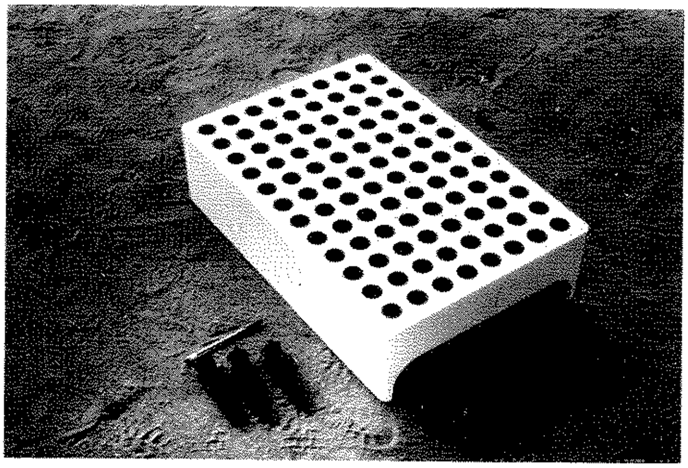
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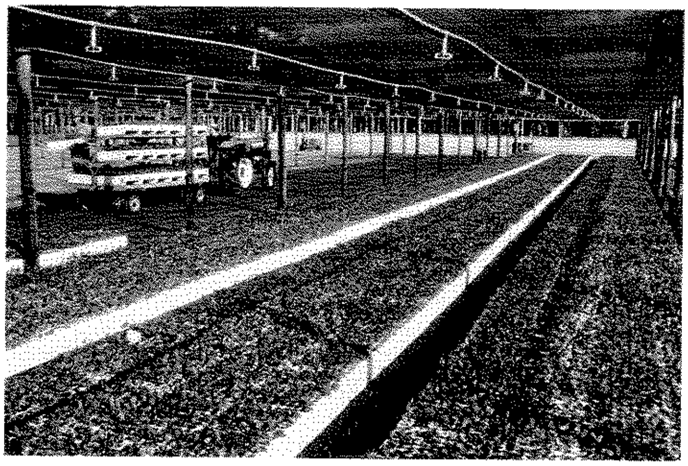
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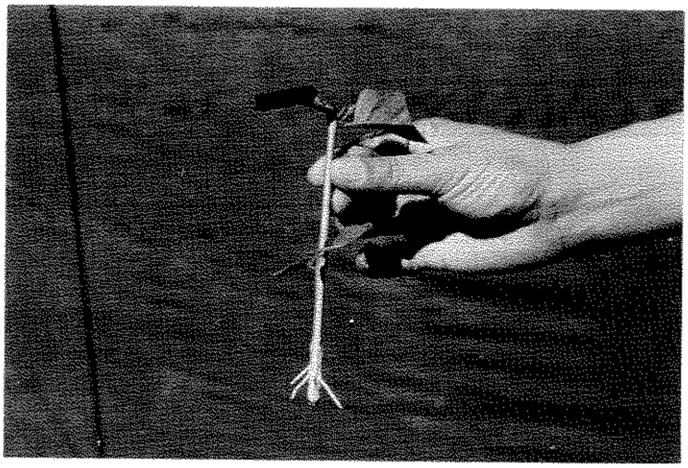
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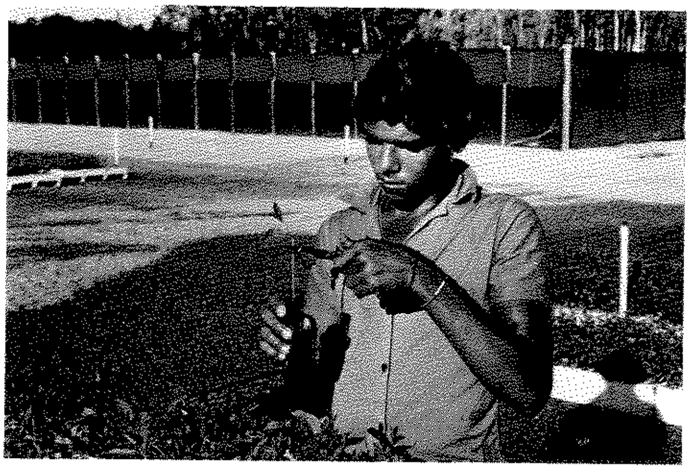

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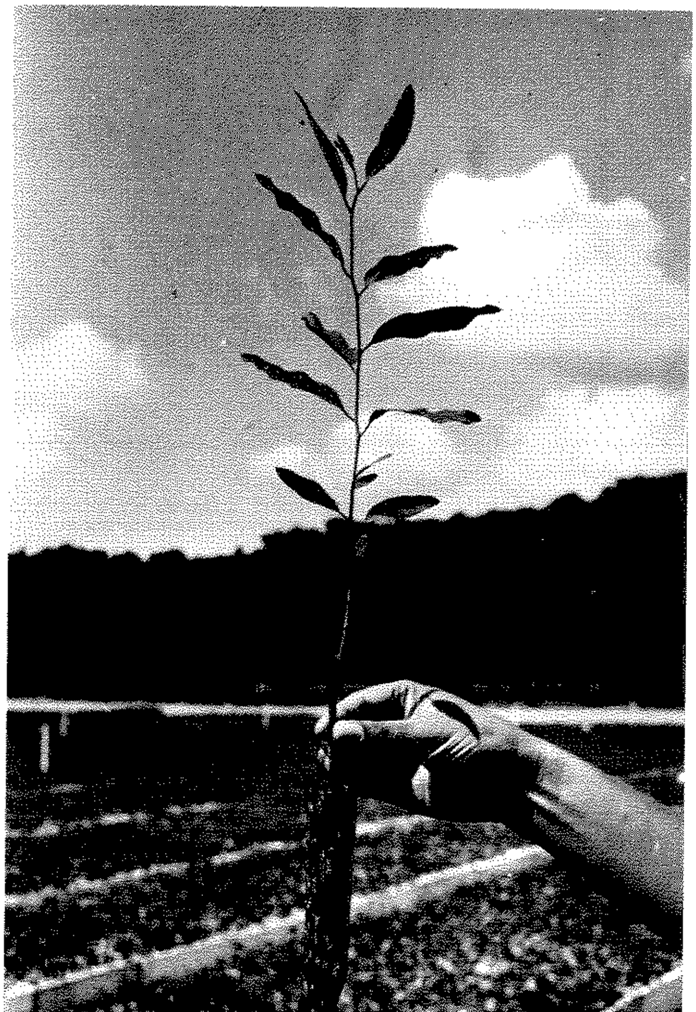

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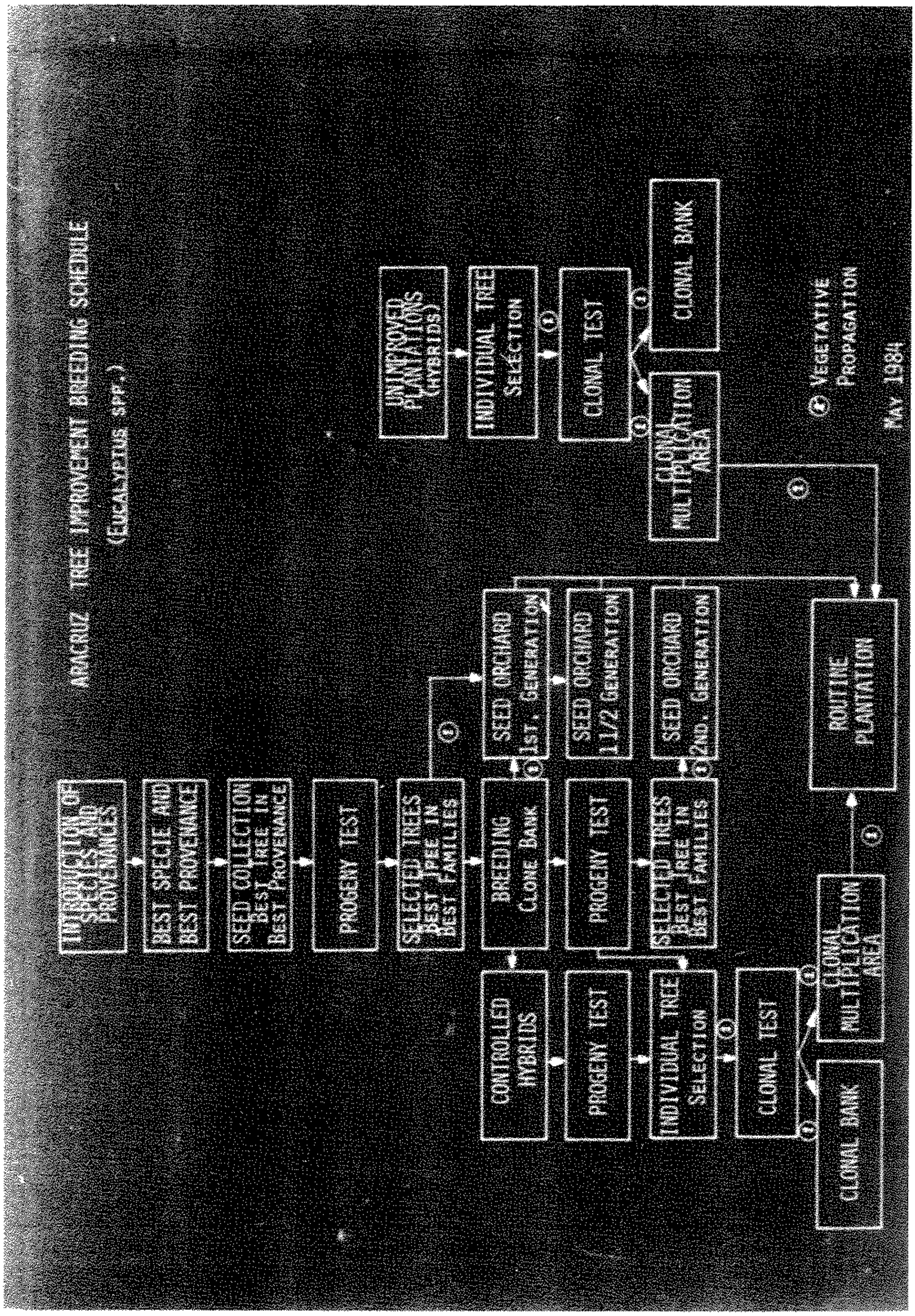
ARACRUZ TREE IMPROVEMENT BREEDING SCHEDULE
(EUCALYPTUS SPP.)
INTRODUCTION OF SPECIES AND PROVENANCES
BEST SPECIE AND BEST PROVENANCE
SEED COLLECTION BEST TREE IN BEST PROVENANCE
PROGENY TEST
SELECTED TREES BEST TREE IN BEST FAMILIES
BREEDING CLONE BANK
PROGENY TEST
SELECTED TREES BEST TREE IN BEST FAMILIES
SEED ORCHARD 1ST. GENERATION
SEED ORCHARD 11/2 GENERATION
SEED ORCHARD 2ND. GENERATION
CONTROLLED HYBRIDS
PROGENY TEST
INDIVIDUAL TREE SELECTION
CLONAL TEST
CLONAL MULTIPLICATION AREA
CLONAL BANK
ROUTINE PLANTATION
UNIMPROVED PLANTATIONS (HYBRIDS)
INDIVIDUAL TREE SELECTION
CLONAL TEST
CLONAL MULTIPLICATION AREA
CLONAL BANK
VEGETATIVE PROPAGATION
MAY 1984

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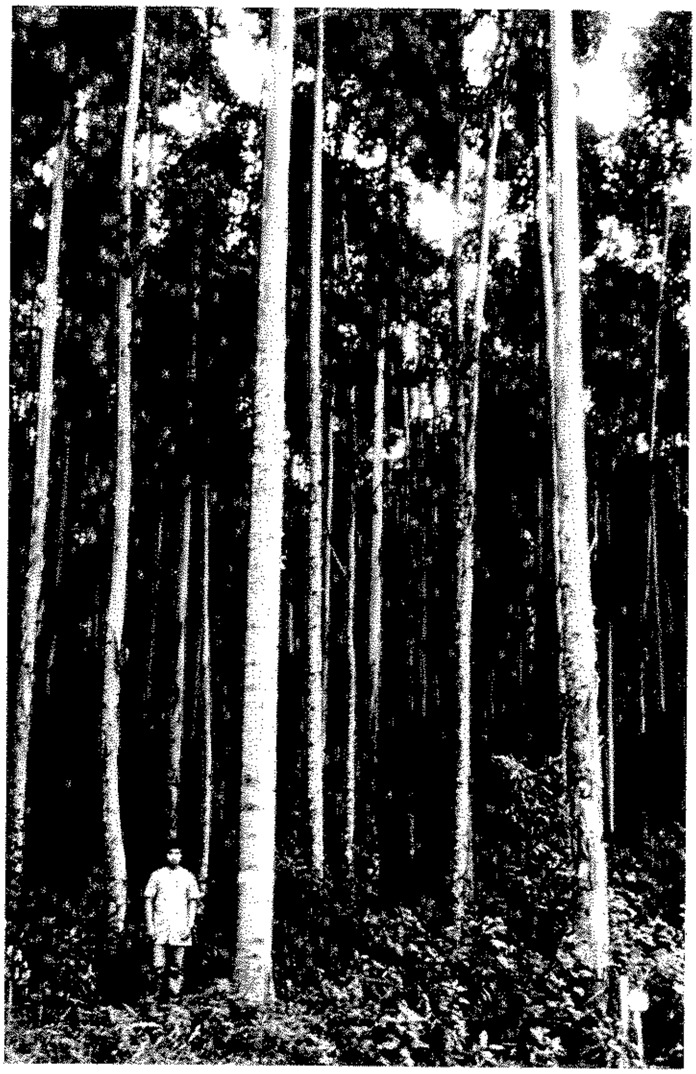

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ARACRUZ

FOREST TREES

INTRODUCTION OF SPECIES AND PROVENANCES

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TOTAL	114	2.427
EUCALYPTUS (HYBRIDS) FOR ROOTING OF CUTTINGS	-	5.000

MAY, 1984

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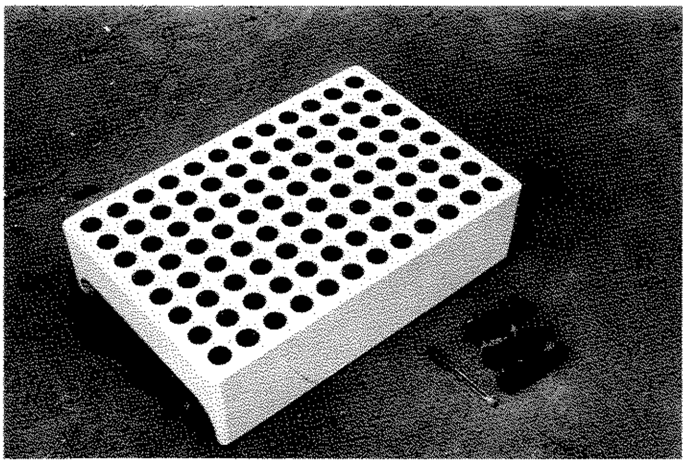

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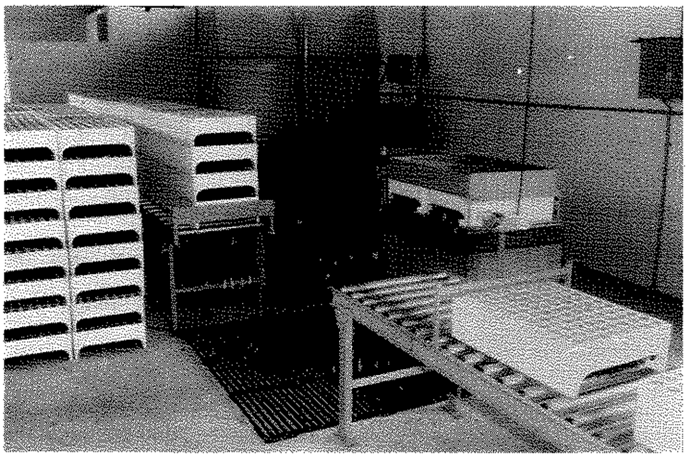

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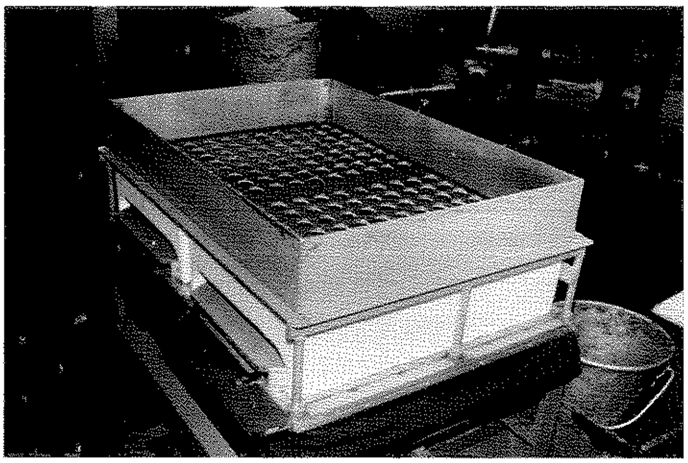

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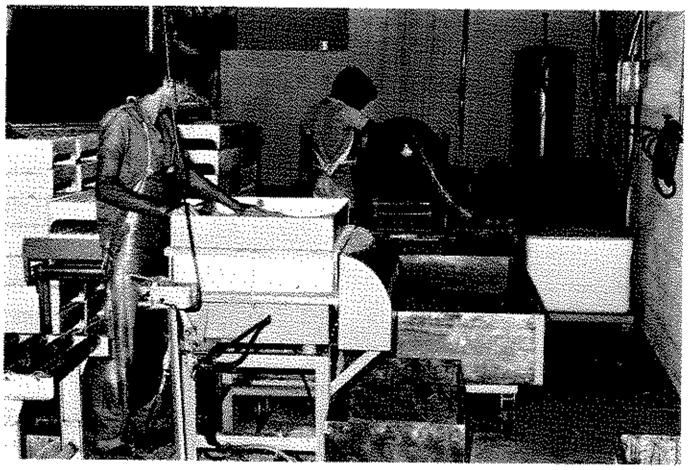

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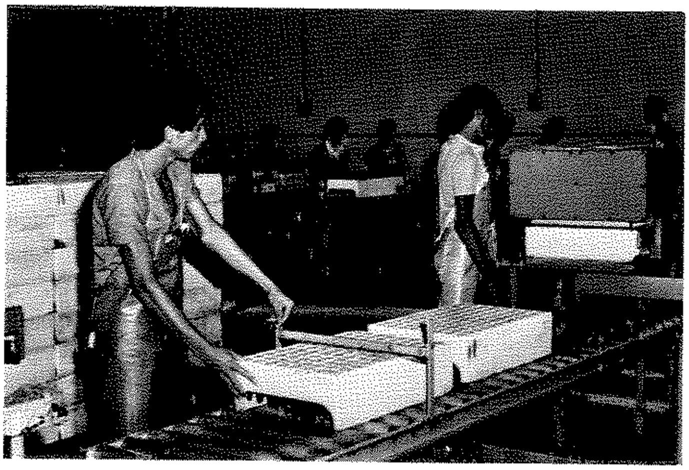

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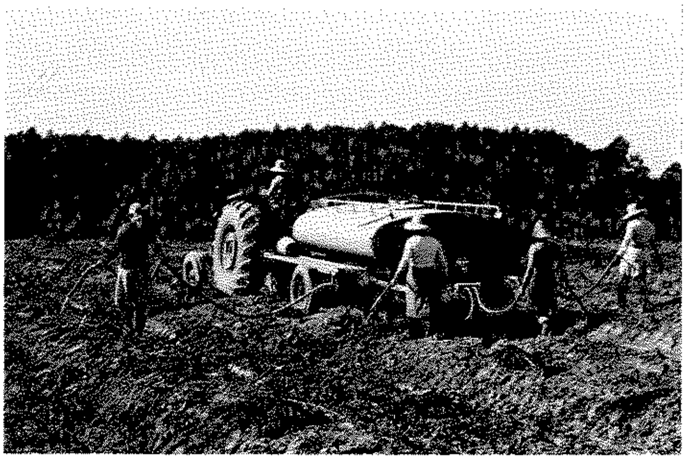

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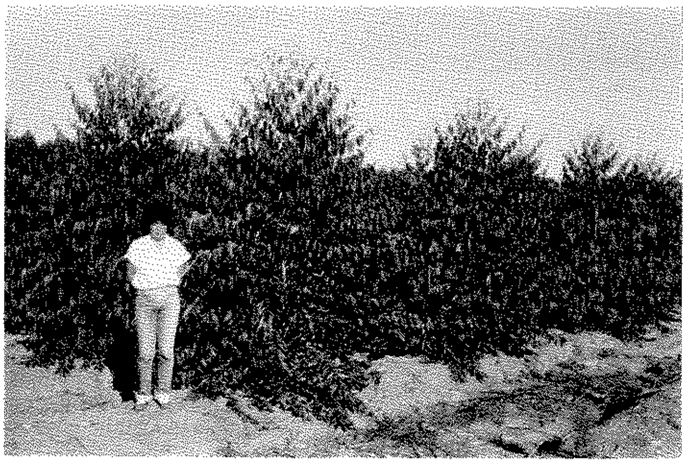

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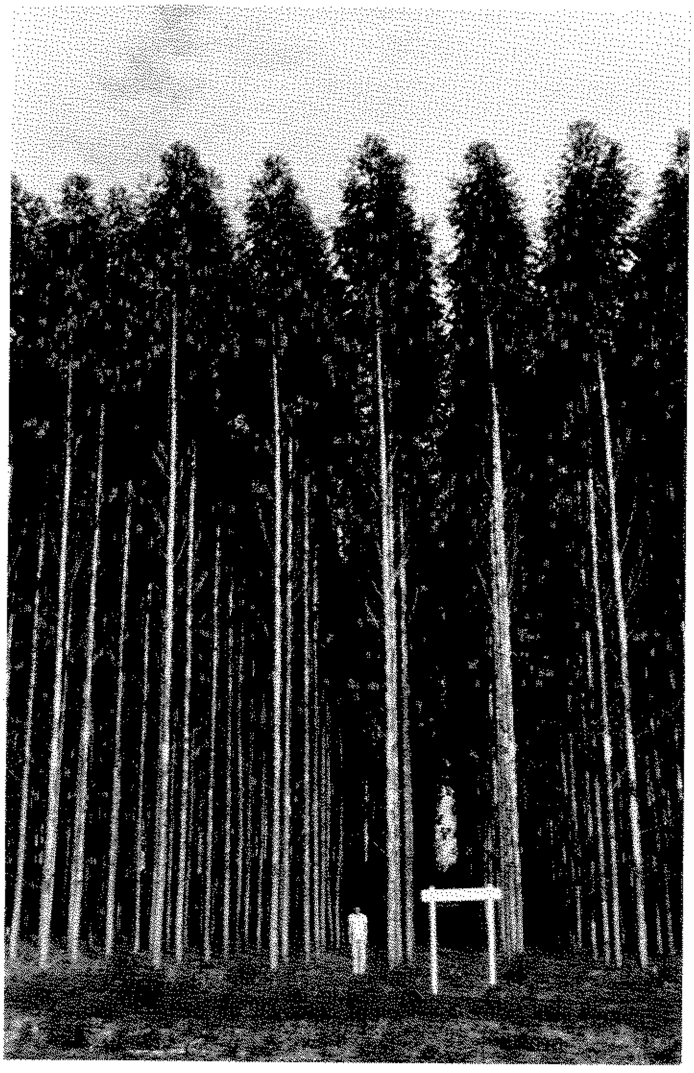

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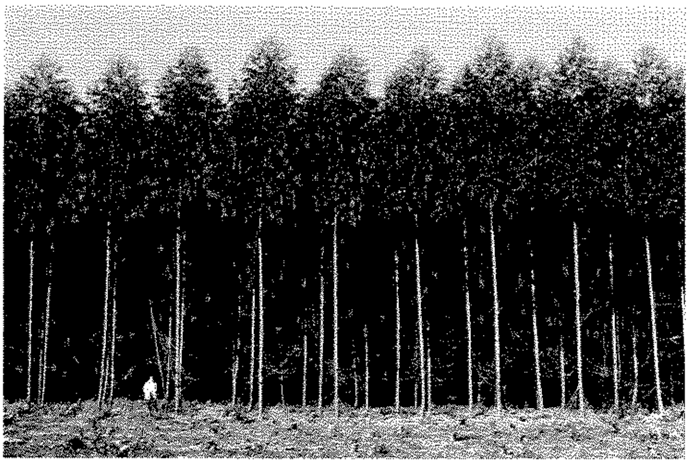

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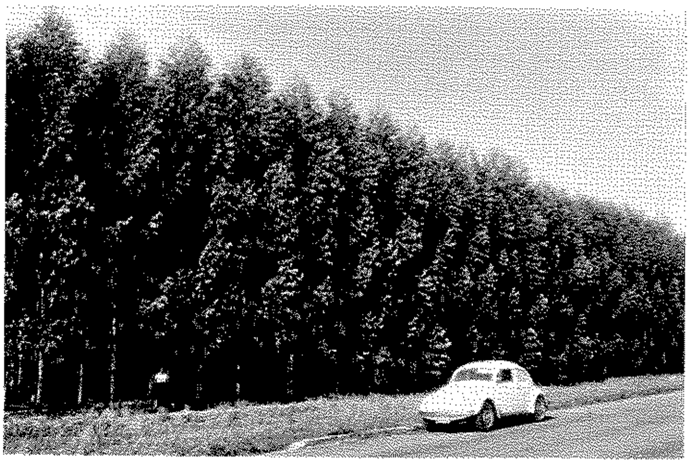

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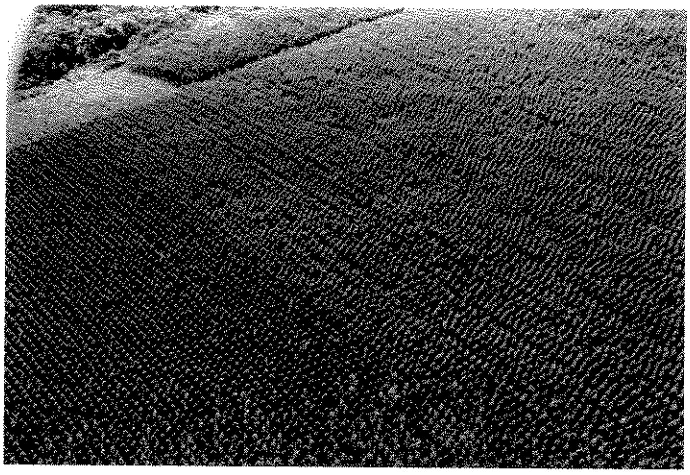

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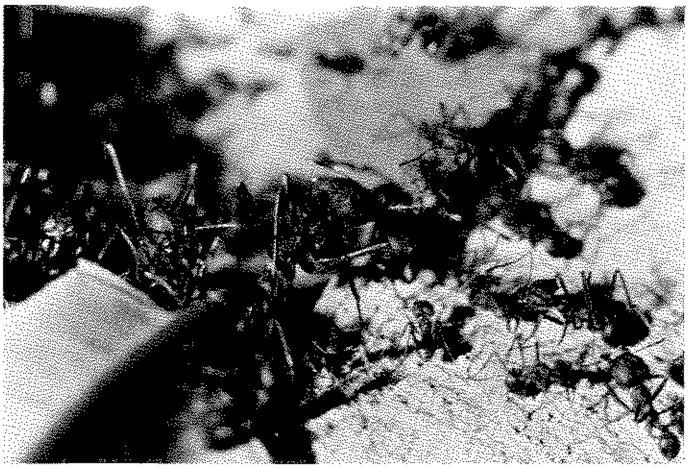

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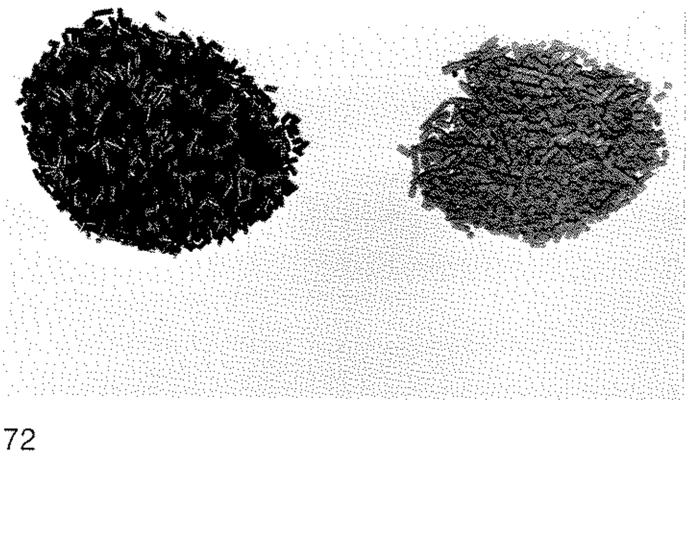

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