

Clonal Propagation of *Eucalyptus* by Cuttings in France¹

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Genus *Eucalyptus* is so broad and so varied that one should avoid any generalization : However it seems possible to state that a revolution is setting on in afforestation thanks to the development of the technology of the horticultural propagation by cuttings.

This technology which has proved successful on thousand hectares in tropical countries (Congo, Brasil) is now developed under very different climates as countries like France or Morocco have chosen to create or to regenerate their forests by cuttings. There is not doubt that this trend is going to increase in the near future and reach the most part of the afforestation not only with *Eucalyptus* but also with other species.

The advantage of the propagation by cuttings depends, for *Eucalyptus*, on several factors

- It is a genus heavily employed as an exotic in afforestation with as main objective a strong biomass production from short rotation coppice. The stands are planted at final spacing : It will not be possible to improve the quality of the stand by silvicultural interventions so it is important to start from an homogeneous and high quality vegetal stock.

- The exotic characteristic implies that many afforestations are set up in zones where it is difficult to find both adapted and productive species. The possibility to hybridize adapted species with productive species allows the synthesis of high performance hybrids on marginal sites : afforestation of poor savannahs in Congo, dry sites in Morocco, cold sites in France. The mass propagation of these hybrids is only possible by cuttings.

- The particularity of the flowering of *Eucalyptus* induces a proportion of inbreds in the progenies which may be important. These trees, supply of heterogeneity and of lack of production, cannot

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Abstract : A.FO.CEL has developed a technique for mass propagation by cuttings of *Eucalyptus* in France. This technique is described from the selection of the ortet to the mass propagation of the clone for afforestation : the first stage is the mobilization of the ortet, the second stage is called pre-propagation which includes rejuvenating and rooting conditioning, the third stage is mass propagation. The mass propagation is realized from successive propagations of mother trees; the number of which increases from generation to generation by including the new rooted cuttings. We give practical advices on atmosphere, treatments depending on the season which govern the success of the technique.

be detected in the nursery, the propagation by cuttings will allow to exclude them.

- It exists, in this genus, species or hybrids with a good rooting ability in rather simple conditions for allowing to develop the technique into economical conditions.

The consequences of the use of this type of propagation must be well understood : we will have to adapt an accurate and intensive silviculture to the clonal stands which will have to be at the level of the quality of the vegetal stock.

This evolution will change the aspect of the forest investment : its often weak considered rentability can reach a very attractive level while the lowering of the rotation is a favourable agent for the research of investment. At the wood product level, the industrial will profit by a rigorous homogeneous and well fitted material.

SELECTION OF VEGETAL STOCK

The exact copy of clones by cutting propagation assure the best valorization of a breeding program.

From the ortet selection to the mass propagation of the clone one can distinguish three successive stages

- The "mobilization" or first propagation allows to obtain the first vegetative copies and to assure the transfer of the clone to the nursery.

- The "pre-propagation" is the stage during which the first copies are handled so as to obtain new juvenile and more reactive copies suited to the conform mass propagation.

- The mass propagation is the final stage which allows to use the clone in afforestation.

Mobilization

Ortets are selected at a stage which permit them to express their qualities ; at this stage the vegetal has lost its rooting ability (this one disappears between two months to one year old according to the species).

One can choose between two ways to mobilize the clone

Grafting

This way has the advantage to conserve the entirety of the ortet. The scions are taken off during the winter on a part of the tree in potential active growth.

The root-stock grown in a green house is cut at the level where the section of its stem corresponds to the section of the scion.

We use the cleft grafting by effecting an incision at the top of the rootstock in which we introduce the bevelled scion.

The good contact between the root-stock and the scion is secured by a tying with a cellophane bound.

The grafted plant is put in a warm green house and confined under a plastic cover ; the union between the root-stock and the scion is effective during the fortnight after the grafting operation, the growth of the grafted plant will occur one month after grafting.

The scion, which showed an adult morphology, can return during a short period to a juvenile stage (rejuvenating action of the root-stock) but will quickly show again senile features.

The rejuvenating effect of the root-stock is the more lasting as the level of the graft is the lower.

Felling down the ortet

It is a more destructive technique which presents advantages to simplify the "pre-propagation" stage.

The ortet is cut down at the end of the winter or at the beginning of the spring (March) at fifteen centimeters high. Sprouts will develop on the stump and will be cropped on June. The shoots are removed as soon as the rooting ability is set, each removing allows the departure of new shoots.

We have stated that the first emission of sprouts generally have a lesser rooting ability than the following ones. Sprouts can be cropped as soon as the foliage get a good chlorophyllian pigmentation; the emergence of axillary shoots on the sprouts is often the sign of a decreasing rooting ability.

Cuttings correspond with the lower part of the shoot from which we can prepare a four leaves cutting. The less coloured and hard to root upper part of the sprout is not used.

The cuttings prepared in this way have a good rooting ability and one can obtain as early as the mobilization stage juvenile and exact copies of the ortet.

Pre-propagation

This stage presents two different aspects according to whether the clone was mobilized by grafting or by felling down the ortet.

Pre-propagation after grafting

The clone is now represented by some grafted copies which can have shown a fugitive juvenile stage. The cuttings that one could crop on the grafts are unfitted for rooting : the clone must be rejuvenated.

The rejuvenation can be realized in two different ways

- Successive grafting : if we take off a scion on the first graft during the juvenile stage and if we make a new graft (as low as possible), we notice that this new graft exhibits a more lasting juvenile stage followed by a new reversion to adult stage. By taking again a new scion on this second graft in its juvenile stage, we will obtain a new progress in juvenility. At the fourth or fifth successive grafting, we can generally obtain a sufficient juvenility for considering the rooting of the cuttings taken off from the graft. This method is relatively long and costly.

- Felling down of the initial grafted plant, followed by the rooting of the new shoots initiated on the scion : instead of realizing successive grafting, one can prefer to let the grafted plant develop during one year or two years. The graft will be cut on March fifteen centimeters upon the grafting point in order to initiate new shoots. If the grafting level is sufficiently low, the rejuvenating influence of the root-stock allow to root the lower part of the new shoots.

In these two pre-propagation ways the rejuvenating of the clone is not complete : the rooting is possible but difficult and the rooted cuttings do not have a satisfactory growth.

A complete rejuvenating will occur by the complementary use of *in vitro* propagation or by successive horticultural propagation by cuttings : we have stated that *in vitro* propagation leads more quickly and surely to juvenile and reactive mother trees suited for mass propagation.

Pre-propagation after felling down the ortet

The rooting of the sprouts of stump allows to obtain exact and juvenile copies of the ortet. These copies have a good rooting ability and will be used as mother trees for a successive cutting propagation. The rooting ability is increasing from a generation to the following generation of cuttings, showing the improved reactivity of the mother trees. It seems that the best rooting is obtained after an *in vitro* propagation cycle which allows to obtain mother trees the quality (homogeneity and reactivity) of which answers the

requirements of a mass propagation by successive cuttings.

The propagation by successive cuttings can lead to the same result if we take care to select at each generation of cuttings the mother trees of best quality.

Mass propagation

It is the final stage during which a mobilized, rejuvenated and rooting conditioned clone is commercially propagated. The set up technique is the horticultural successive propagation by cuttings which is explained in the following developments.

The easiest way to reach this stage consists in cutting down the ortet then to root the shoots. The safest way for pre-propagation is the preparation of the clone by in vitro technology.

SUCCESSIVE PROPAGATION BY CUTTINGS

The mother trees

Origin

They originated from the pre-propagation stage which must give exact, juvenile and rooting conditioned mother trees.

These mother trees will be propagated by cuttings and give rooted cuttings which will be used as mother trees in their turns.

During the successive generations of cuttings, one will notice the apparition of a certain proportion of cuttings with a weak root system : it is important to avoid the propagation of this type of plants if we want to avoid to create, inside the clone, bad rooting ability lines.

The keeping of the quality and of the homogeneity of a clone during the successive generations of cuttings supposes either to be conspicuous to quality of the mother tree or to plan a periodical replacement of the mother trees (once a year) for mother trees produced by in vitro propagation.

The cycle of the successive propagation by cuttings is described in the diagram n° 1.

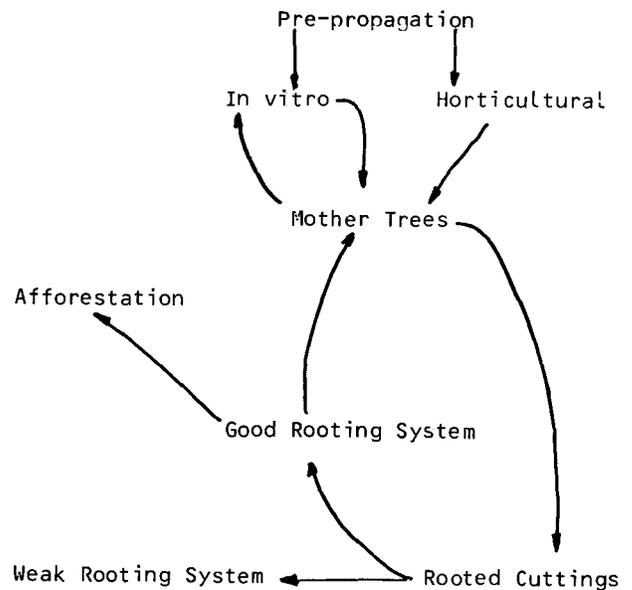


Diagram 1--Successive propagations by cuttings.

As we can see in the diagram, a light proportion of weak rooting system cuttings are eliminated from the cutting cycle. These cuttings can create a new convenient rooting system during the nursery breeding ; if it is the case one will send them for afforestation.

We use to make direct cuttings in the container used in afforestation (containers with roots permeable walls) because the advantage of the technique lies in not distinguishing the mother trees from the cuttings for afforestation. These mother trees are periodically cropped as soon as the shoots reach the size and the development level corresponding to the best rooting ability. When we obtained a sufficient number of cuttings (including the mother trees) corresponding to the afforestation program, we let the mother trees grow in order to reach the required size for afforestation.

The diagram 2 allows a better understanding of the successive propagations by cuttings.

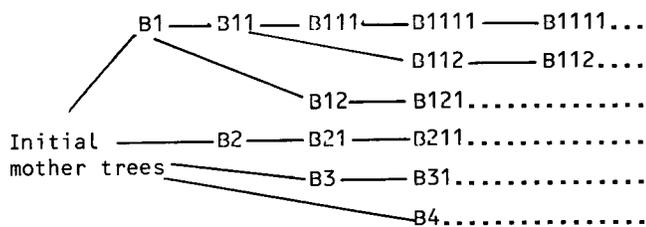


Diagram 2

The advantage of this system lies in its great flexibility.

- The successive propagation by cuttings permits to quickly obtain a great number of copies from a limited number of initial mother trees (multiplication rate superior to one hundred during a year).

- We can change the composition of the multi-clonal variety at every moment without financial losses because there is no immobilization in mother trees bank in the field. If a clone becomes obsolete all the mother trees can be used for afforestation before the mass propagation of a new clone.

Growing atmosphere

The growth conditions of the mother tree are essential for the rooting success : the mother tree must have a vigorous growth (appropriate level of water, light, warmth, fertilization) and it is recommended to avoid to multiply mother trees exhausted by too many crops.

The growing atmosphere of the mother tree is determined by the season and the rooting atmosphere : from a general point of view, the mother trees must grow in the same atmosphere used for rooting.

In winter, the mother trees are grown in greenhouses with a soil heating (substratum temperature 18°) and under a plastic cover (confined atmosphere). In Spring, mother trees are grown in greenhouses without soil heating and extra plastic cover, in Summer the mother trees are grown in the open air.

We will see later that these conditions correspond to the rooting atmosphere.

Rotation of crops of mother trees

The rotation on mother trees should be as short as possible : the shoots are cropped as soon as they reach a development level compatible with the propagation by cuttings.

In practice the rotation is fifteen days long and we can prepare on average one and half cuttings per mother tree.

It is important to know that mother trees are weaker in winter than in summer : their growth conditions should be more precise, the removal of cuttings should be made carefully and the number of crops

restricted in order to avoid to exhaust them.

Crop of the cuttings

The decision of cropping the cuttings on a mother tree is governed by a certain number of parameters which determine the rooting ability

- The minimal size of the cuttings allowing its handling is near five centimeters,
- The minimal number of well coloured and developed leaves is fixed to four (without counting the bad coloured and young leaves).
- The rooting ability decreases quickly as soon as ramifications appear on the shoots : one must imperatively propagate by cuttings before this stage.

The morphology of the shoots moves according to the season : in winter the internodes are short, the leaves small and well coloured ; from spring to summer the internodes grow longer, the size of leaves increases and they take their coloration more slowly.

The shoots are cut off just above the leaves of the lower part in order to initiate two new shoots at this level.

For avoiding a too great ramification of the mother tree which would lead to the production of shoots unsuited to rooting, the level of the size is lowered from time to time.

The cuttings are immediately placed in a water filled up vessel to avoid their fading.

Cuttings preparation

In winter the cutting is constituted by the whole shoot cropped on the mother tree. There is no special preparation unless the ablation of the leaves of the lower part when they impede the insertion of the cuttings in the substratum. The cutting corresponds generally to a four to eight leaves shoot.

In summer the cutting corresponds to the lower part of the shoot (we remove the bad coloured upper part). The cutting has generally four leaves.

The cuttings are dipped in a fungicide solution (six grams Benlate per ten liters water) then drained before hormonal treatment. This treatment [sic] is essential : the lower part of the cuttings is dipped in a commercial powder which contains one per cent Indol butyric Acid. Then the base of the cutting is inserted in the rooting medium after we made a hole in order to avoid to wound the herbaceous stem or to remove the hormone.

Cutting environment

The environment for the propagation by cuttings varies depending on the season for fitting the

needs of the plant in water, warmth and light.

We can discern the following periods

- From January to March : Winter cuttings,
- From April to Mai : Spring cuttings,
- From June to the 15th of August : Summer cuttings,
- From the 15th of August to October : Fall cuttings.

In November and December, the natural conditions are very bad for the growth of the mother trees and the rooting of cuttings : we have to bring a great quantity of additional [sic] heat and light to obtain weak results. So we recommend to stop to propagate at this time.

Winter cuttings

The cuttings are put in an enclosed atmosphere by covering them with a polyethylene film just over the leaves.

This plastic cover keeps a good atmosphere humidity. Substratum humidity is weekly controlled when we do the phytosanitary treatments : the rooting medium must be always humid without excess (obligatory draining), the humidity is increased from January to March.

Rooting medium temperature is maintained at twenty degrees at the base of the cuttings : a too high temperature increases the risks of rotting, a too weak temperature inhibits the rotting.

Atmospheric temperature is not controlled.

Light is very important for rooting : we verify that the rooting percentage is directly proportion to the insolation duration. The minimal insolation duration is estimated to one hundred hours per month to obtain good results. This minimum is generally reached in the South West of France from January. Below this point we have to foresee an additional artificial illumination. From February we are obliged to reduce the natural light by a whitening of greenhouses in order to avoid the sun burn or an excessive temperature rising.

Spring or fall cuttings

The propagation by cuttings is realized in a greenhouse under a mist system. The mist is started by a clock fifteen seconds every ten minutes at the warm hours of the day in order to always maintain an humid film on the leaves.

The temperature of the greenhouse is controlled by aeration and whitening. We have to avoid the sun burn on the cutting leaves by arranging just above them a plastic shade (fifty per cent shade).

The overheating of the greenhouse (temperature superior to 30°) risks to lead at first to a too high substratum temperature (rotting) then necrosis of

the aerial part.

The temperature and the humidity of the substratum are not specially controlled.

Summer cuttings

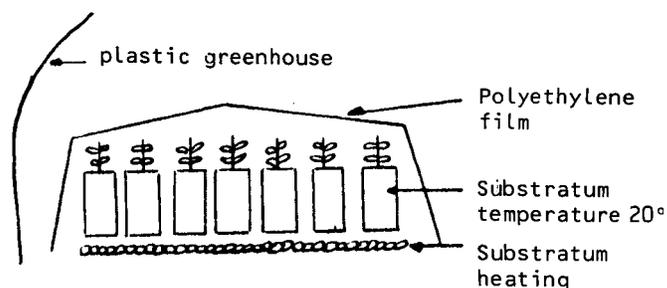
From June the increasing of the mean mensual temperature (20°) allows to propagate by cuttings in the open under a mist started by a clock at the warm hours of the day. This mist falls on a shade (fifty per cent) spread nearby the cuttings and which appears to have a double action

- to avoid sun burns which induce the depigmentation of the Eucalyptus leaves,
- to maintain a humid atmosphere near the cuttings.

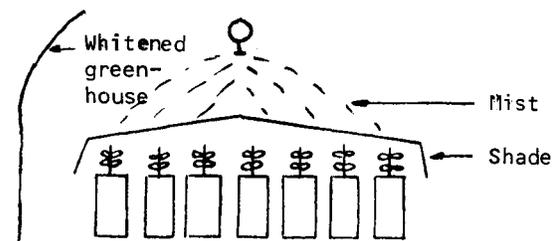
Rooting medium temperature and humidity are not specially controlled.

The three cuttings environments are described in the diagram n° 3.

Rooting percentages are good in each of this three environments but we have noticed that simplicity and cost of the propagation become better from winter to summer.

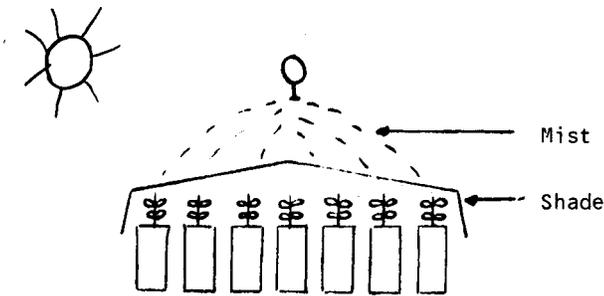


Winter cuttings



Spring cuttings

Diagram 3--



Summer cuttings

Diagram 3--(continued)

Rooting medium - Container

Rooting medium composition may change into large proportions without damage on rooting.

We have to watch over the rooting medium possesses the following qualities

- intermediate granulometry assuring a good draining, a good aeration and sufficient water retention. The granulometry will be also of importance on the architecture of the new root system,
- organic matter contents rather poor (rotting risks),
- free of pathogen elements or adventitious seed (desirable disinfection).

We obtained good results with a medium containing seventy five per cent crushed and composted bark, twenty five per cent Perlite and five kilograms Osmocote per cubic meter.

When the rooting mean percentage exceeds seventy per cent one can consider to propagate by cuttings directly in the container in order to avoid transplanting which is a costly and damaging operation.

The propagation by cuttings has no particular influence on the choice of the container. That may be .

- a rigid walled container with a special design to avoid root deformations,
- a permeable root walled container (nonwoven material).

The successive propagation by cuttings supposes a prolonged keeping in the nursery (to six months): the container volume should be big enough to assure a good growth to the cutting during this period. For the same reasons, we have to study carefully the medium fertilization during this period.

Rooting

Time for rooting is depending on the vegetative conditions of the mother tree and on the rooting atmosphere : this time varies from ten days in

good conditions to three weeks in bad conditions. It decreases from January to July then increases from July to October.

Hardening-off

The hardening corresponds to the period between the acquisition by the cutting of a functional root system and the recovery of an active aerial growth. This duration varies between three weeks and one month.

The hardening atmosphere is as near as possible of the rooting atmosphere

- In winter, the hardening consists to move away the plastic sheet from the contact of leaves (rooting atmosphere) to a certain distance (growing atmosphere). This modification is very light and can be done without any particular care.

- In spring and summer, we shall wait the aerial start of the cutting to suppress first the shade then for lessening the ON periods of the misting system.

The end of the hardening takes generally place two months after the insertion of the cutting in the rooting medium. At the end of this period the rooted cuttings is enough developed [sic] to consider to crop cuttings.

We can estimate that

- the duration between the insertion of the cutting and the first crop on the new mother tree is two months,
- the duration between the insertion of the cutting and its possible dispatch for afforestation (fifteen to twenty centimeters high) is two months and a half.

Diagram 4 indicates the time necessary for each stage

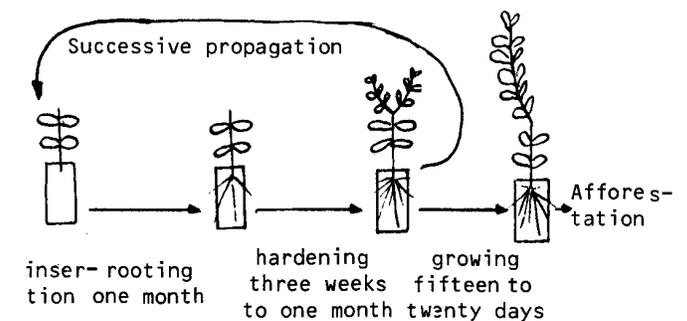


Diagram 4--

Results

Results of the propagation of Eucalyptus by cuttings depend on

- the selection level : it is important to select on the rooting ability which varies in

any great extent from one clone to another inside the same species : in *Eucalyptus gunnii*, the mean rooting success is near fifty per cent and the rooting success of the best clones is near ninety per cent,

- the rooting conditioning of clones : rooting ability of a clone increases after an in vitro propagation cycle or after several successive propagations followed by a selection of reactive mother trees. This "conditioning" of clones allows to increase very obviously the rooting success especially when the first copies of the ortets are not completely juvenile,

- the rooting season : the rooting in the open in June and July gives the better results.

In the best conditions, we reach a mean rooting percentage of eighty per cent for the selected clones in *E. gunnii* and *E. hybrid gunnii x dalrympleana*.

CONCLUSION

Research and development of the mass propagation by cutting of *Eucalyptus* have led to precise a technique of forest plant production which satisfies the economical requirements of afforestation and secure the mass propagation of clones selected for precise purposes.

The success depends on the conjunction of propitious factors

- Selection of the clone not only on production or resistance criteria but also on rooting ability,
- Conditioning the mother trees for the supplying of high rooting potential cuttings,
- Choice of the cutting environment adapted to the season.

The keeping of every factor at the optimal level governs the success of the technique but it is certainly the management of the mother trees which constitutes [sic] the more critical point : the propagator must have the perpetual care to keep the quality and the homogeneity of the mother trees by the elimination of the degenerating ones. The cyclic return to mother trees produced by in vitro propagation allows to avoid every risk of degeneration.

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