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Method of producing rooted cuttings or mother trees for collection of cuttings

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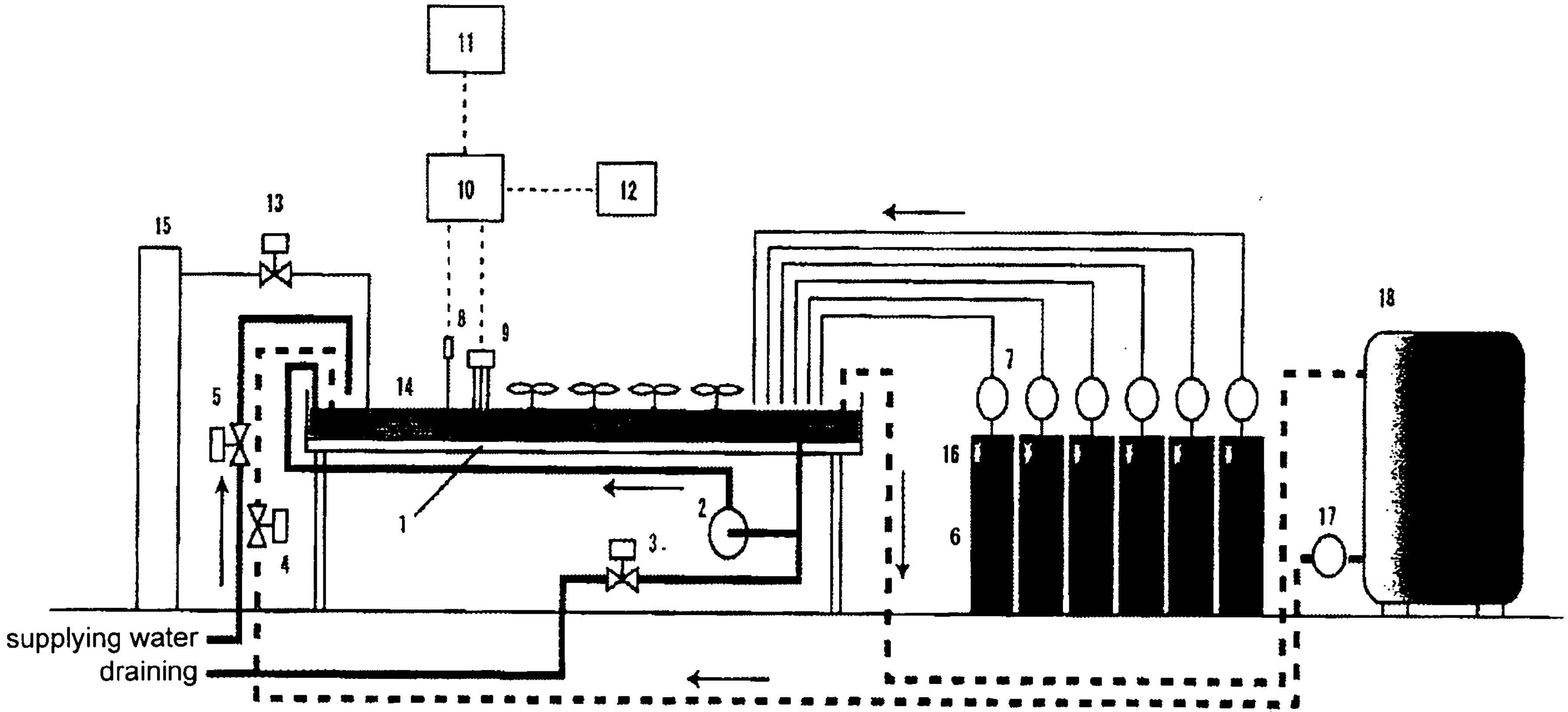
2007202477 30 May 2007

ABSTRACT OF THE DISCLOSURE

There is provided a system capable of stably and healthy producing rooted cuttings, or mother trees for collection of cuttings, in large quantities. Specifically, this invention provides: (1) a method of producing a rooted cutting for plantation of trees, which comprises planting a cutting obtained from a mother tree onto a solid medium, allowing the cutting to take root, and subjecting the cutting to a water culture with immersing the root portion in water; and (2) a method of producing a mother tree for collection of cuttings, which comprises subjecting a cutting obtained from a current shoot or coppice shoot of a tree to a water culture, wherein in each method, it is preferable to measure the pH of a nutrient solution used in the water culture over time, to maintain a pH value within a predetermined range by automatical addition of a pH adjuster, and to maintain the electric conductivity of the nutrient solution used in the water culture over time, with automatically adding a fertilizer nutrient solution to the above nutrient solution when the electric conductivity is lower than the set electric conductivity value. These methods can preferably be applied to trees belonging to Eucalyptus or Acacia.

Fig. 1



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METHOD OF PRODUCING ROOTED CUTTINGS OR MOTHER TREES FOR COLLECTION OF CUTTINGS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention mainly relates to a method of producing a rooted cutting for use in planting trees such as Eucalyptus and Acacia. The present invention also relates to a method of producing a mother tree for collection of rooted cuttings therefrom.

Background Art

A tree (or nursery plant) for afforestation is grown from seeds, tree cuttings, grafted trees, etc., such that it is suitable for transplantation. As a medium, soil is used. In order to adapt to the environment after transplantation, it is important for such trees (or nursery plant) to have robust aerial parts and enriched root parts, and a cultivation period ranging from several months to several years is required, although such a cultivation period depends on the type of the tree.

In general, since trees (or nursery plant) for afforestation are based on the assumption that they are to be transplanted to an afforestation area and the amount of soil at their root parts is controlled, the amount of water or nutrient that can be retained in such a small amount of soil is limited. Accordingly, periodic irrigation and fertilization are essential for the growth of cuttings, and so there may also be cases where irrigation and fertilization are required after transplantation. It is generally difficult to control such irrigation and fertilization, and thus, it is difficult to stably produce healthy trees (or nursery plant) in large quantities.

A cutting method is advantageous in that trees (or nursery plant) directly inherit genetic traits from parent trees. Thus, such a cutting method has widely been used as a method capable of proliferating trees (or nursery plant) that are genetically and phenotypically excellent and have uniform traits. For example, in order to produce timbers for construction or chips for papermaking, what is called "clonal plantation," which comprises selecting elite trees as parents that have good genetic characters such as good growth potential or large weight per volume, collecting cuttings from the elite trees, and then transplanting them, has been practiced.

For the clonal plantation, the known method comprises planting the above cuttings collected from such elite trees onto a solid medium, without directly planting them onto soil, so as to grow them for a certain period of time, thereby obtaining mother trees for collecting cuttings, from which the cuttings are collected, followed by planting them onto soil. Hereinafter, such a mother tree, from which cuttings are collected, is referred to as "mother tree for collection of cuttings," or simply as "mother tree."

An important problem in such a cutting method is that if the mother tree for collection of cuttings is not sufficiently nourished, then the potential number of cuttings collected or the yield of tree cuttings is reduced. On the other hand, even if such a mother tree is well nourished and thus grows rapidly, if the cutting is soft, then it is damaged by plant diseases or insect pests after plantation. As a result, the rooting percentage of tree cuttings is decreased. So the mother tree for collection of cuttings needs to have sufficient branches.

Moreover, since a turion also has a low rooting percentage, it requires adequate treatments such as periodic fertilization or prevention from plant diseases or insect pests, as with trees (or nursery plant). Such a mother tree for collection of cuttings is exclusively cultivated by soil culture, and so the suitable nutritional management of the mother tree is extremely difficult.

In particular, it is known that *Eucalyptus globulus*, which grows rapidly and is often used as a tree that is a raw material for papermaking, is problematic in terms of a low rooting percentage of tree cuttings. Hence, various methods for improving the rooting percentage have been proposed.

JP 6-98630 A (1994), especially claim 1, discloses a method of immersing Eucalyptus cuttings in a plant hormone-containing solution and then allowing them to take root under high humidity.

JP 2001-231355 A, especially claim 1, discloses a method of previously treating a mother tree for collection of cuttings with a plant growth regulator and then collecting cuttings therefrom.

JP 2002-10710 A, especially claim 1, discloses a method of previously treating a mother tree for collection of cutting with an aluminium salt-containing aqueous solution and then collecting cuttings therefrom.

JP 2005-333854 A, especially claim 4, discloses a method of supplying to cuttings, carbonated water whose pH has been adjusted with carbonate or the like, so as to allow the cuttings to take root.

JP 2001-186814 A, especially claim 1, discloses a method of planting cuttings onto a rooting bed that has been impregnated with a liquid medium, and regulating the concentration of carbon dioxide gas in an incubator, so as to allow the cuttings to take root.

The aforementioned methods exhibit the rooting effect to some extent under certain conditions, while there may be a case where they have the lower effect under different conditions. Thus, it has been desired that the rooting ability be improved.

Besides the aforementioned methods, a clonal plantation method involving the tissue culture of Eucalyptus has been proposed. Regarding this method, a method of improving a rooting ability has also been proposed (JP 2005-102516 A, especially claim 1, and JP 2000-217458 A, claim 1).

On the other hand, a water culture for cultivating plants using an aqueous solution in which nutrients necessary for the plants have been dissolved (hereinafter referred to as "nutrient solution") is able to produce crops regardless of soil conditions. Such a water culture is characterized in that works necessary for soil culture, such as plowing, ridge making, fertilizer spraying or weeding, can be omitted. In addition, the water culture can control the composition of nutrients given to plants more easily than soil culture does. Moreover, a series of injury by successive cropping, such as soil disease or salts accumulation, can be easily avoided. Thus, it is said that the water culture is capable of stable production of crops. In Japan, the water culture is mainly carried out to cultivate a wide range of crops such as Japanese honewort, green onion, tomato, cucumber, strawberry, lettuce, or Japanese basil. Such a water culture system that does not use soil or a solid medium such as rookwool is described in detail in many publications (for example, "*Yoeki Saibai no Shin Manual* (New Manual of Hydroponics)" (edited by Japan Greenhouse Horticulture Association), etc.).

2007202477 30 May 2007

Representative examples of a water culture system, which is currently commercially available, include M-style Water Culture, Kyowa Hyponica, Shinwa NS Water Culture, Sekisui Suiko Mate, Kaneko EK Hydroponic, and JT Rakunojiro. All of these water culture systems are specialized in the culture of the aforementioned vegetables and the like. Thus, such systems do not target trees (or nursery plant), or mother trees for collection of cuttings. To date, trees (or nursery plant), or mother trees for collection of cuttings, have never been subjected to such a water culture for the purpose of plantation.

JP 9-56258 A (1997), especially claims, discloses an apparatus for optimizing plant growth conditions, wherein a sensor is attached to a plant body that is allowed to grow in a water culture apparatus, and the above plant growth conditions are then optimized based on response to an external stimulus that is actively given. In this apparatus, a new sensor is added, which is utilized for controlling the response of a plant to various stimuli from the outside, but not controlling the response in coordination with the growth stage.

JP 7-327515 A (1995), especially claims, discloses a water culture apparatus for cultivating flower vegetables along frames. This apparatus is for fruit vegetables, and so it is difficult to apply this apparatus to a method of producing trees (or nursery plant).

A particular difference in cultivation between trees (or nursery plant) or mother trees for collection of cuttings and the aforementioned crops, is fertilizer applying management. In cultivation of vegetables, a large amount of fertilizer is given for the purpose of an increase in the production amount for early shipment. In contrast, trees (or nursery plant) are not subjected to succulent growth in order to accommodate them to the environment after transplantation, and thus an excessive amount of fertilizer is not given thereto. However, such a reduced amount of fertilizer leads to suppression of the growth rate of trees (or nursery plant), and thus, it is problematic in that a long growth period is required until trees (or nursery plant) become transplantable or until mother trees are available for collection of cuttings. Moreover, since a majority of such trees (or nursery plant) or mother trees have not yet been lignified, their resistance to plant diseases and insect pests is lower than that of mature trees. Thus, it is also necessary to take measures to prevent, for example, root rot caused by soil bacteria.

The mass production of trees (or nursery plant) or mother trees for collection of cuttings is necessary for the economical improvement of forest management. However, such production is limited to soil culture, and conflicting conditions, such as promotion of growth and prevention of a succulent growth state, are required. Thus, the development of technologies, which is directed towards the growth increment and productivity improvement, is not sufficient. Accordingly, there is a demand on the development of a system capable of stably and healthy producing trees (or nursery plant) or mother trees for collection of cuttings in large quantities.

SUMMARY OF THE INVENTION

To solve the aforementioned problems, the present invention has the following characteristic features (1) to (7):

(1) A method of producing a rooted cutting for plantation of trees, which comprises planting a cutting obtained from a mother tree onto a solid medium, allowing the cutting to take root, and subjecting the cutting to a water culture with immersing the root portion in water.

(2) A method of producing a mother tree for collection of cuttings, which comprises subjecting a cutting obtained from a current shoot or coppice shoot of a tree to a water culture.

(3) The method of producing a rooted cutting or a mother tree for collection of cuttings according to (1) or (2) above, which further comprises measuring the pH of a nutrient solution used in the water culture over time, and adding a pH adjuster automatically, thereby to maintain a pH value that has been set within a predetermined range.

(4) The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of (1) to (3) above, which further comprises measuring an electric conductivity of the nutrient solution used in the water culture over time, and adding a fertilizer nutrient solution automatically to the above nutrient solution when the electric conductivity is lower than the set electric conductivity value, thereby to maintain the set electric conductivity value.

2007202477 30 May 2007

(5) The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of (1) to (4) above, wherein the whole or part of the nutrient solution used in the water culture is exchanged with a fresh nutrient solution at least once.

(6) The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of (1) to (5) above, which further comprises automatically controlling the concentration of oxygen contained in the nutrient solution used in the water culture.

(7) The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of (1) to (6) above, wherein the tree is a plant belonging to Eucalyptus or Acacia.

The present invention enables suppression of a succulent growth, while productivity of trees (or nursery plant) or mother trees for collection of cuttings is improved. Thus, it becomes possible to provide a water culture system for trees (or nursery plant), which significantly suppresses plant disease and pest caused by soil bacteria and the like. That is to say, through the water culture, it becomes possible to stably and efficiently produce trees (or nursery plant) for planting or mother trees for collection of cuttings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing an example of an apparatus with which the method of the present invention is carried out.

FIG. 2 is a schematic view showing the relationship among rooted cuttings, pots, nutrient solution, and others, in a bed.

DETAILED DESCRIPTION OF INVENTION

The present invention will be described more in detail below.

The cutting obtained from a tree as described in (1) above in the present invention is obtained from a current shoot or coppice shoot of a tree by any method well-known to persons skilled in the art. Otherwise, such a cutting may also be cut out of, for example, a mother tree for collection of cuttings as described in (2) above in the present invention. The method well-known to persons skilled in the art is described in detail in pp. 237-246 of "Eucalypt

Domestication and Breeding," Oxford University Press Inc., New York, 1993, for example. That is to say, scions that contain 1 to 4 nodes and 2 to 8 leaves are cut out of branches germinated from a stock, by truncation or the like. In general, a portion of a leaf is excised to prepare a cutting. Such a cutting is immersed in a bactericide containing solution such as Benlate. Thereafter, hormone powder used as a rooting stimulator, such as indolebutyric acid, is applied to the proximal portion of the cutting, or the proximal portion is immersed in a hormone solution. Thereafter, the cutting is planted into a medium for tree cuttings, on which a hole has been made.

The solid medium as described in (1) above in the present invention is filled in a nursery pot, a plug tray, etc. Examples of materials of such a solid medium include bark, sand, sawdust, peat moss, vermiculite, pearlite, carbonized chaff and the like, and mixtures thereof. Any of these materials can be used, as long as it has appropriate water permeability and water retention ability. The balance between aeration and moisture retention influences the success or failure in rooting. In order to prevent cuttings from putrefaction, it is better that the medium to be used contains no organic substances, and so it is preferable to use a sterilized medium. If necessary, bactericide may be sprayed after the planting. In general, a fertilizer is not given. Otherwise, a delayed release granurated fertilizer may previously be mixed with a medium, or a liquid fertilizer may be given during irrigation. Since an appropriate temperature, a high humidity, and air circulation are necessary for rooting, cuttings are covered with a mist spray, fine mist, a polyethylene sheet, etc. Moreover, techniques such as a cover or bottom heat are also applied in combination with the aforementioned techniques.

When the tree is a forested tree such as Eucalyptus or Acacia, a period of time for cultivation of the tree on a solid medium is around 1 to 3 months.

The nutrient solution for water culture as used in (2) above in the present invention is as described below. A cutting may be directly subjected to a water culture. Otherwise, such a cutting may be cultivated on a solid medium or the like by the same method as that in (1) above to allow it to take root, and then may be subjected to a water culture with immersing the root portion in a nutrient solution.

2007202477 30 May 2007

In both inventions of (1) and (2) above, when the tree is a forested tree such as Eucalyptus or Acacia, the period of time for water culture is preferably about 4 to 10 weeks, and the temperature of the nutrient solution is preferably about approximately 18°C and 25°C.

Components of the nutrient solution can preferably comprise ions of nitrate, ammonium, phosphate, potassium, calcium, magnesium, sulfate, borate, iron, manganese, zinc, copper, molybdenum, etc.

As an example, the water culture apparatus usable in the present invention has a basic structure that is designed such that a nutrient solution contained in a culture bed 1 maintained on a frame is circulated by a circulating pump 2 thereby to homogenize the nutrient solution. The water level that is decreased due to the water use of a plant is detected by a water level sensor 8, and by opening a water-supplying electric-operated valve 5, water is rapidly replenished. The electric conductivity and pH of the nutrient solution are continuously measured by a sensor 9. A change in electric conductivity due to the alimentation of a plant or a change of the pH due to the release of an organic acid is detected, and a certain nutrient solution supplying pump 7 is immediately actuated, so that the changed electric conductivity or pH is replenished or corrected. The present system differs from the conventional water culture apparatus in that it has a plurality of nutrient solution tanks 6, and is able to continuously control either one or both of pH and electric conductivity. This system can be arbitrarily set by changing the control program. In addition, after a certain period of time, by opening a draining electric-operated valve 3, the whole or part of the nutrient solution is automatically discharged from the system. After the draining electric-operated valve 3 was closed, the water supplying electric-operated valve 5 is opened to supply water. After detection of full water stage by the water level sensor 8, the change to an optimal composition of the nutrient solution can be carried out at each plant growth stage by preparing and using another nutrient solution, with monitoring the electric conductivity or pH by the sensor 9. The temperature of the nutrient solution is continuously measured by the sensor 9. When the nutrient solution temperature becomes higher than the predetermined temperature, a cooling electric-operated valve 4 is opened, and thermostated water is flown through a cooling tube by a thermostated water supplying pump 17 thereby to cool the nutrient solution. The main purpose of such thermostatic control is cooling. However, by changing the temperature of a thermostated water tank 18, it is also possible to carry out heating. The concentration of dissolved oxygen is also continuously measured by the sensor 9. If the dissolved oxygen concentration is decreased due to the respiration of a root, a bubbling electric-operated valve 13 is opened, so that air or oxygen is supplied to the nutrient solution by a bubbling apparatus 14. Succulent growth can be suppressed by changing at least one of the composition of the nutrient solution and a dissolved oxygen concentration. When the succulent growth is controlled only by the composition of the nutrient solution, apparatuses 13 to 15 can be omitted. In this case, a sufficient oxygen concentration is supplied only by agitation with the circulating pump 2.

Each of the aforementioned set values and control programs are stored in a control unit 10. In this system, such set values can be changed through a touch panel 12 or a data acquisition personal computer 11, which are adjacent to the system. By continuously storing in the data acquisition personal computer 11 the values measured by the sensor 9 that constantly monitors, the history of the measurement values can be inspected for a long period of time. Not only such measurement values, but also the operating time of the electric-operated valves 3, 4, 5 and 13, and the nutrient solution supplying pump 7, can be stored in the data acquisition personal computer thereby to confirm whether the system normally controls motions. Moreover, when one connects the data acquisition personal computer 11 to the internet, unmanned facilities, such as remote control or confirmation of operating conditions from a distance, can be realized.

Furthermore, by providing a liquid depletion sensor 16 at the nutrient solution tank 6, a safety device for preventing the death of a tree (or nursery plant) caused by a system trouble can be set up. Through the safety device, the control can be terminated, for example, when the stock nutrient solution is depleted, when there is no reaction to the water level sensor 8 for a certain period of time (i.e., when the nutrient solution contained in the culture bed 1 is depleted), or when the water temperature exceeds an upper limit, and concurrently an alarm is displayed on the data acquisition personal computer 11 or the touch panel 12 to inform a cultivator of abnormality.

It is important to control pH. It is preferable that the pH is continuously measured by the aforementioned pH sensor. If the pH becomes lower than a predetermined range, then potassium hydroxide (KOH) or sodium hydroxide is automatically added, or contrarily, if the pH becomes higher than a certain range, then an acid such as phosphoric acid or hydrochloric acid is automatically added. The "predetermined range" means pH 5.5 to pH 7.5, where the tree belongs to a forested tree such as Eucalyptus or Acacia.

When water culture is continuously carried out in the same nutrient solution for 4 weeks, the lack of iron ion, ammonium ion, and nitrate ion is observed. In such a case, it is preferable that the nutrient solution is exchanged with a fresh one at least once, after about 4 to 6 weeks. Also, in this case, it is preferable to carry out the exchange of the whole amount. However, about 50 percent of the total amount of nutrient solution may be exchanged, for example, depending on conditions such as the cost or the sharing with other nutrient solutions.

Further, the electric conductivity is measured over time by the aforementioned electric conductivity sensor. When the measured electric conductivity value is lower than the set electric conductivity value, a fertilizer is added, whereby it becomes possible to extend a period of time until the nutrient solution is renewed.

EXAMPLES

The present invention will be described more in detail by the following examples. However, these examples are not intended to limit the scope of the present invention.

In the examples below, an elite tree, which is 10-year-old *Eucalyptus globulus* having excellent growth potential and rooting ability, was adopted as a parent tree. The first-generation rooted cuttings were produced by the following method.

A branch, which had extended, grown and hardened after the spring of the current year was cut out. Thereafter, the lower leaves thereof were removed, and cuttings having a length of 6 to 10 cm wherein only a pair of leaves were left on the tip of each cutting were prepared. Each of the two leaves of the cutting was cut out in half so as to remove the leaf tip side, and the proximal portion of the cutting was cut back with a knife. 600 cuttings were prepared, and each proximal portion was immersed in an aqueous solution, containing 2% sucrose and

1:500 dilution of a benomyl[methyl-1-(butylcarbamoyl)-2-benzimidazole carbamate] wettable powder (trade name: Benlate; Du Pont, USA) over 24 hours. Each of the thus treated cuttings was planted by insertion into vermiculite, which has previously been filled into plastic pots and wetted.

The pots were placed on a bench in a chamber, wherein the temperature (23°C to 25°C) and illuminance (15,000 lux) were controlled, and the entire pots were covered with acrylic containers to maintain a high humidity. Irrigation was carried out by supplying water to the bottom for 15 minutes once every two days. Two months after the plantation, survival and rooting states were observed. 150 rooted cuttings, which had well grown and whose height and thickness had been on average, were selected and used as samples of Example 1.

<Example 1>

As described below, the aforementioned cuttings were subjected to soil culture and water culture, and the growth increment of the rooted cuttings was compared between the soil culture and the water culture, the grown trees (or nursery plant) were planted onto the agricultural field, and a half year later, the % taking root was calculated.

The water culture was carried out using the water culture apparatus shown in FIG. 1. A nutrient solution was prepared in this apparatus, at the initial growth stage, using 1/2 Hoagland-Arnon medium composition (medium A: 120 ppm nitrate nitrogen, 9 ppm ammonia nitrogen, 21 ppm phosphorus, 78 ppm potassium, 121 ppm calcium, 25 ppm magnesium, 0.25 ppm boron, 0.22 ppm manganese, 0.025 ppm zinc, 0.01 ppm copper, and 0.005 ppm molybdenum). After the preparation, the solution was adjusted to pH 6.0 with 0.1 M KOH. In this case, the electric conductivity was 0.5 mS/cm. The pH of the nutrient solution was controlled to be pH 6.0 by addition of KOH during the culture, and the electric conductivity of the nutrient solution was controlled to be 0.5 by addition of 400 x medium A.

After the 6-week culture at the initial stage, the composition of the medium was changed at an immediate pre-transplantation stage by nutrient solution automatic renewal program to prepare another medium (medium B: 110 ppm nitrate nitrogen, 121 ppm calcium, and 0.25 ppm boron). After the preparation, the medium was adjusted to pH 6.0 with 0.1 M

KOH. In this case, the electric conductivity was 0.5 mS/cm. The pH of the nutrient solution was controlled to be pH 6.0 by addition of KOH during the culture, and the electric conductivity of the nutrient solution was controlled to be 0.3 by addition of 400 x medium B. The cuttings were cultivated for 2 weeks to obtain 50 rooted cuttings A.

Likewise, using the water culture apparatus, cuttings were cultured in medium A for 8 weeks, thereby to produce 50 rooted cuttings B. In this case, the culture was also carried out with controlling the electric conductivity and pH at 0.5 mS/cm and 6.0, respectively.

In addition, vermiculite was removed from the pot, and after 8-week soil culture on the soil D containing 5 g of a delayed release fertilizer ("High Control 650" manufactured by Chisso Asahi Fertilizer Co., Ltd.) per pot, 50 rooted cuttings C were produced.

The tree height and the % taking root after a half year of rooted cuttings A, B, and C, are shown in Table 1. The growth increment of rooted cuttings A and B, which were subjected to water culture, is higher than the growth increment of rooted cuttings C, which was subjected to soil culture. Rooted cutting A exhibited the same level of % taking root as that of soil culture.

[Table 1]

	Tree height	% Taking root
Rooted cutting A	62.0 ± 4.8	94%
Rooted cutting B	73.2 ± 5.2	78%
Rooted cutting C	54.8 ± 4.9	96%

The schematic view of the water culture of Example 1 is shown in FIG. 1. With regard to the positional relationship between the pot and the water tank, the water level was controlled such that roots that extended from the bottom portions of the pots were immersed in the nutrient solution, as shown in FIG. 2.

Moreover, for stabilization of the pots, holes were made on a Styrofoam plate, and the pots were fixed in the holes.

<Example 2>

In order to compare the water culture with the soil culture in terms of the number of cuttings collected and % rooting, the following experiment was carried out.

8 rooted cuttings having an average growth level were selected from each of rooted cuttings A, B, and C of Example 1 above, and the thus selected rooted cuttings were used as mother trees for collection of cuttings. In the case of mother trees A, 100 cuttings could be collected from the total 8 trees. The collected cuttings were planted in 100 fresh plastic pots that had been filled with soil E as described below.

Also, in the case of mother trees B, 140 cuttings could be collected from the total 8 trees. The collected cuttings were planted in 140 fresh plastic pots that had been filled with the soil E.

Likewise, in the case of mother trees C, 85 cuttings could be collected from the total 8 trees. The collected cuttings were planted in 85 fresh plastic pots that had been filled with the soil E.

Soil E: Cocopeat/Pearlite = 4/6, 9 g/L fertilizer, no hormone treatment

All of these cuttings were continuously cultured in the environment at a temperature of 23°C and a humidity of 63% to 70% for 8 weeks. Thereafter, the comparison was made with respect to the % rooting of rooted cuttings A, B, and C. The number of cuttings collected and % rooting of rooted cuttings A, B, and C are shown in Table 2. Mother trees A and B for collection of cuttings, which were subjected to water culture, had a possible number of cuttings collected greater than that of mother trees C for collection of cuttings, which were subjected to soil culture. The % rooting of cuttings collected from mother trees A was the highest.

[Table 2]

	Number of cuttings collected	% Rooting
Mother tree A	100	55%
Mother tree B	140	28%
Mother tree C	85	32%

2007202477 30 May 2007

As shown in the above-described examples, it was revealed that it is important, in growth of rooted cuttings and in improvement of the % rooting of cuttings from mother trees, to maintain the pH within a predetermined range in water culture, to maintain the electric conductivity of the water culture solution, and particularly to correct a decrease in the concentrations of nitrate ion, ammonium ion, and iron ion, and to renew the nutrient solution at least once to suppress succulent growth, in water culture.

Reference numbers described in FIG.1 and FIG.2 have the following meanings:

1. culture bed
2. circulating pump
3. draining electric-operated valve
4. cooling electric-operated valve
5. water-supplying electric-operated valve
6. nutrient solution tank
7. nutrient solution supplying pump
8. water level sensor
9. EC, pH, temperature, DO sensor
10. control unit
11. data acquisition personal computer
12. touch panel for control
13. bubbling electric-operated valve
14. bubbling apparatus
15. gas supplying apparatus
16. liquid depletion sensor
17. thermostated water supplying pump
18. thermostated water tank
30. pot
31. vermiculite
32. nutrient solution
33. water surface

2007202477 30 May 2007

What is claimed is:

1. A method of producing a rooted cutting for plantation of trees, which comprises planting a cutting obtained from a mother tree onto a solid medium, allowing the cutting to take root, and subjecting the cutting to a water culture with immersing the root portion in water.

2. A method of producing a mother tree for collection of cuttings, which comprises subjecting a cutting obtained from a current shoot or coppice shoot of a tree to a water culture.

3. The method of producing a rooted cutting or a mother tree for collection of cuttings according to claim 1 or 2, which further comprises measuring the pH of a nutrient solution used in the water culture over time, and adding a pH adjuster automatically, thereby to maintain a pH value that has been set within a predetermined range.

4. The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of claims 1 to 3, which further comprises measuring an electric conductivity of the nutrient solution used in the water culture over time, and adding a fertilizer nutrient solution automatically to the above nutrient solution when the electric conductivity is lower than the set electric conductivity value, thereby to maintain the set electric conductivity value.

5. The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of claims 1 to 4, wherein the whole or part of the nutrient solution used in the water culture is exchanged with a fresh nutrient solution at least once.

6. The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of claims 1 to 5, which further comprises automatically controlling the concentration of oxygen contained in the nutrient solution used in the water culture.

2007202477 30 May 2007

7. The method of producing a rooted cutting or a mother tree for collection of cuttings according to any one of claims 1 to 6, wherein the tree is a plant belonging to Eucalyptus or Acacia.

Fig. 1

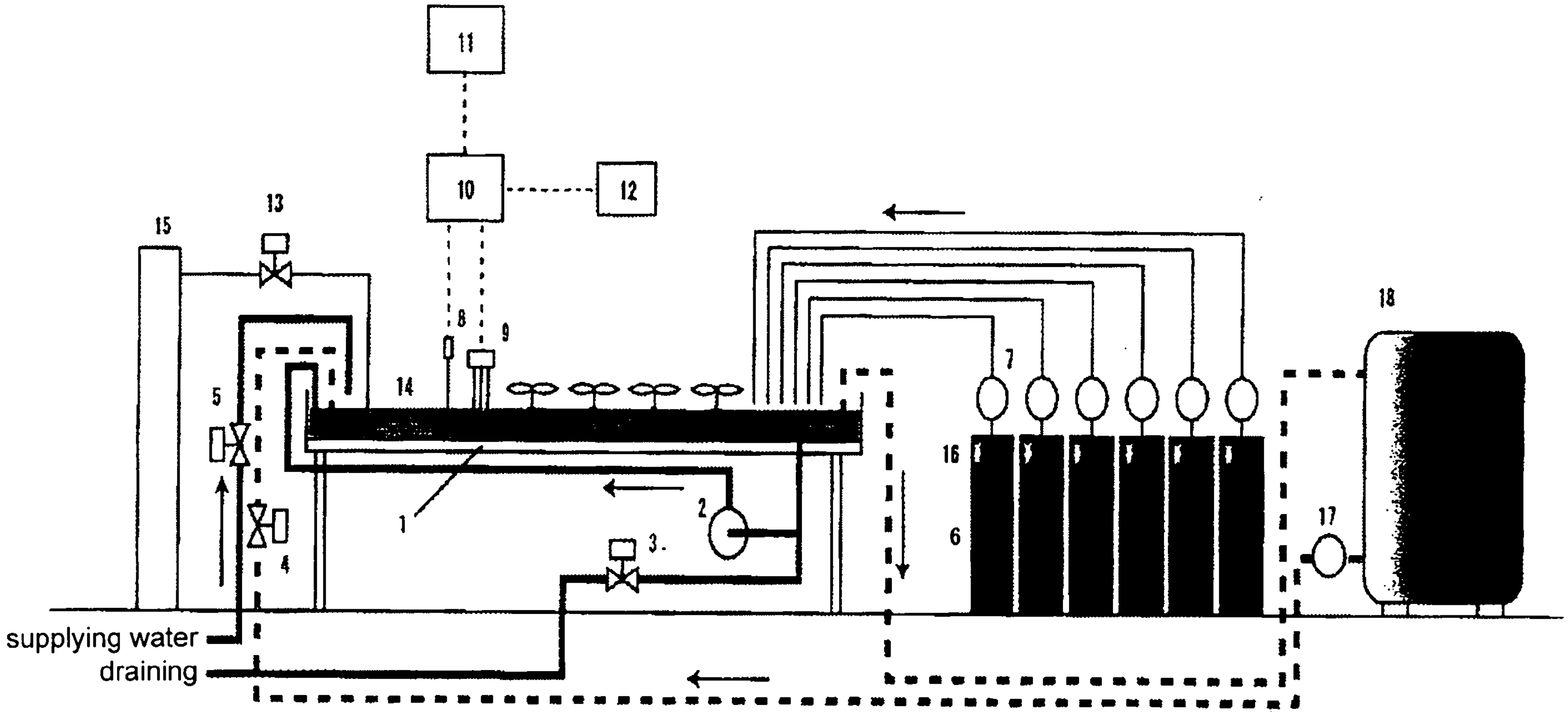

Fig. 2