1.5 Germination Stimulation Methods

(1) Germination Stimulation Treatment

The number of seeds/unit volume and the germination stimulation treatment for the main species are given in Table II-5. It is difficult to stimulate the germination of hard seeds (there are species other than species of the Leguminosae family which produce hard seeds) without scarification or treating them with hot water or condensed sulphuric acid.

The seed hardness varies from species to species and also depends on the provenance and conditions of the mother tree in the case of seeds of the same species. Moreover, the seed maturity may also vary depending on age. The data given in Table II-5 should, therefore, be treated as general information only. In practice, it is necessary to collect a small number of samples from each lot, i.e. a group of uniform quality seeds collected from the same place in the same year), to determine the appropriate treatment method (mainly treatment time).

There are several ways of treating seeds with hot water. Firstly, water containing seeds can be heated to a predetermined temperature. Secondly, seeds can be put into boiling water and then cooled naturally. Thirdly, boiling water can be poured onto seeds which are placed in a basket. The selection of one of these methods depends on the seed hardness.

In the case of sulphuric acid treatment, seeds are immersed in concentrated sulphuric acid for a specific period of time, removed from the liquid using a net or similar and then thoroughly washed with water. As the use of sulphuric acid is hazardous, it is recommended that the hot water method be firstly employed to see if germination is stimulated.

Other treatments to stimulate germination include the lighting method, dipping method, high and low temperature wet treatment, shifting temperature method and scarification method. The appropriate method should be selected based on the seed characteristics and storage method used. Many dry stored seeds are in a state of dormancy and require treatment to end this dormancy and to stimulate germination.

a) Lighting Method

Red or natural light is used to stimulate germination. In contrast, far red light suppresses germination.

b) Dipping Method

In general, the seeds are dipped in cold water for 1-5 days. If a germination suppression agent has been used during the storage period, the water should be changed 2-3 times/day.

c) Low Temperature Wet Treatment Method

The seeds are mixed or stratified with wet bog moss, powdery peat, sand and/or sawdust under a low temperature (1-10°C) with appropriate amounts of water and oxygen to stimulate the after ripening process of the seeds and to reduce the mechanical resistance strength of the seed coat.

d) High and Low Temperature Wet Treatment Method

This method is used for those seeds which require a long germination time. The seeds are firstly placed under a high temperature of 20-30°C for a certain period of time which is followed by low temperature treatment.

e) Shifting Temperature Treatment Method

There are several derivative methods, i.e. ① dipping of the seeds in hot water (40 - 60°C) for 30 - 60 minutes, ② dipping of the seeds in near boiling water for a few seconds, ③ dipping of the seeds in very hot water (80°C) for a few minutes and ④ dipping of the seeds in hot water (50°C) for 1 - 5 days. In Indonesia, the seeds of Acacia spp. and Albizia spp. are dipped in boiling water (100°C) for one minute and are then kept dipped in the same water with the heating cut-off for 24 hours before seeding.

f) Scarification Treatment Method

If the quantity of seeds is small, a knife or a file is used to scratch the skin of the seeds while the mechanical method is used to deal with a large quantity of seeds. Chemicals may also be used to stimulate germination.

(2) Mechanical Germination Stimulation Treatment

Aerial reforestation requires a large quantity of seeds in a short period of time and demands a high germination rate given the generally unfavourable environmental conditions of the subject area. A germination stimulation test using an Iwata type small skin peeler (Photograph III-1) was conducted on seeds of Acacia mangium and Acacia auriculiformis. As explained below, the test results indicate the effectiveness of this method to stimulate germination. There are, however, some still unsolved problems relating to the storage of treated seeds and a declining germination rate with the passing of time, etc.

a) Acacia mangium

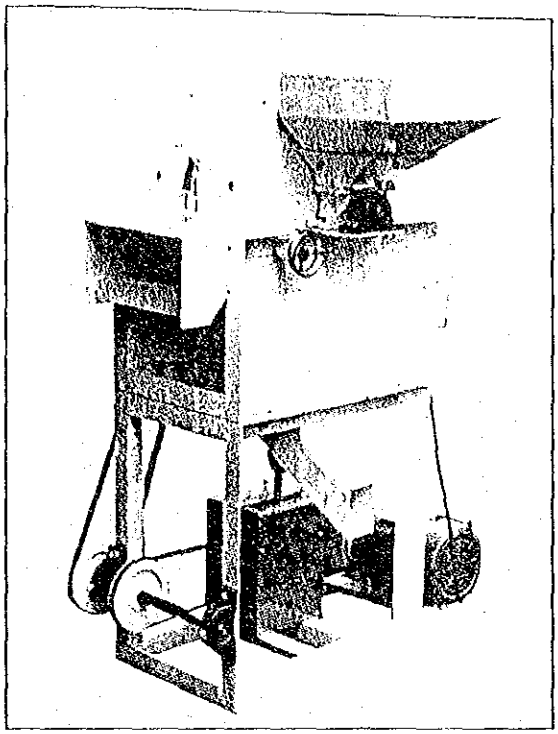
In the germination test using planters and the mechanical treatment and hot water treatment methods, the germination process was almost completed on the 10th day of seeding. The germination rate was approximately 70% for the mechanical treatment and approximately 85% for the hot water treatment.

b) Acacia auriculiformis

In the germination test using planters, the germination process was almost completed on the 10th day after seeding for those seeds having undergone mechanical treatment with a germination rate of approximately 75%. In the case of those seeds having undergone hot water treatment, the germination rate on the 10th day after seeding was approximately 15% and the germination process was almost completed on the 30th day with a germination rate of approximately 75%.

c) The mechanical treatment methods tested were the single treatment method at 2,500 rpm, the double treatment method at 2,200 rpm and the double treatment method at 2,000 rpm. Each treatment lasted one hour. No significant difference was observed in the germination rate.

d) The capacity of mechanical treatment is 200 - 300kg/hr.



External Dimensions: 805mm (L)
575mm (W)
1,055mm (H)
Motor: 750W (200V) with automatic transmission
Capacity: 100-200kg/hr (approx.)

Photograph III-1 Iwata Type Small (MF) Skin Peeler

2. Coating of Seeds

The objectives of the coating of seeds are to make the seeds heavier, to repel animals, to prevent bacteria damage, to stimulate germination, to reshape and to make it easier to identify sprayed seeds, etc. The coating of seeds for forestry work has been conducted on pines and other species in Canada and the US. Coating is not a standard practice and is conducted as and when deemed necessary.

2.1 Coating Materials

One characteristic of coating is that useful agents can be coated in layers, often mixed with a coating base powder or glue, to suit specific purposes. There are 3 coating types depending on how the coating changes at the time of the germination of coated seeds, i.e. ① cracking type, ② collapsing type and ③ swelling type. Selection of the coating type depends on the germination characteristics of particular seeds and the natural conditions of the subject reforestation area. The main ingredients of coating layers by the purpose of use are as follows.

a) Enhancement of initial growth: fertilizer, minor elements, plant growth promoter, symbiotic bacilli

b) Prevention of damping off of seedling: fungicide against Rhizoctonia spp. and Pythium spp. etc.

c) Prevention of insect damage: such insecticide as organic phosphorous agent, carbamate agent and Pyrethroid agent, etc.

d) Prevention of animal damage (eating of seeds): Thiram agent and colouring agent

e) Improved germination rate: plant growth promoter and water retaining agent

2.2 Coating

Technically speaking, attention must be paid to the following points in the coating of seeds.

① If the coating multiplication rate (weight ratio of coated seed vis-a-vis uncoated seed) is small, the coating layer is thin. A thin coat may crack during transportation or seeding work.

② A sufficiently thick coating layer does not necessarily guarantee a good compressive strength and abrasion resistance if the coating technology is poor.

③ The germination rate tends to decrease in accordance with a thicker and/or harder coating layer.

④ It is important for all coated seeds to be individually coated in the optimal way so as not to reduce the seeding work efficiency. The desirable coating techniques are to give the coated seeds a smooth surface and a roundish or rugby ball shape. It is also important for all coated seeds to be of the same size or within a certain size range.

Table III-9 shows the basic standards for coating.

Table III-9 Basic Standards for S-Type Coated Seeds

Item	Unit/Size	SS	S	L	LL	LLL
Diameter	mm	1.5-2.0	2.0-3.0	2.5-3.5	3.5-4.5	4.5-6.0
Compressive Strength	g/seed	200-300	200-300	300-500	400-600	400-600
Approximate Number of Seeds/Litre	1,000 seeds/litre	210	55	28	18	9

2.3 Storage of Coated Seeds

According to the storage test on coated seeds for agricultural use, the germination rate of coated seeds is almost equivalent to that of uncoated seeds. The results of the coated seed storage test on 5 species (Acacia mangium, Acacia auriculiformis, Pinus radiata, Eucalyptus globulus and Leucaena leucocephala) indicate that the germination rate is significantly reduced by high humidity as described below.

a) Under high temperature and high humidity storage conditions, the germination rate of both coated and uncoated seeds declined.

b) Under a sealed storage condition of 2°C, the germination rate of both types of seeds after one year was identical to the rate recorded immediately after coating. Use of a fungicide should be considered for a long storage period, however, as all the seeds were slightly mouldy.

3. Land Preparation

The basic principles, types and actual methods of land preparation have already been discussed in II-3. The necessary preparatory work and precautions for burning and mechanical land preparation are described here.

3.1 Burning

While it is difficult to precisely determine the process of burning in the tropics, the following precautions must at least be taken.

a) Burning must be supervised by a specialist in view of the risk of forest fire. In this context, the weather conditions and other relevant matters must be checked in advance.

b) To prevent the undesirable spread of fire, firebreaks must be introduced taking the expected extent of burning, the vegetation conditions and topography of neighbouring areas and the wind, etc. into consideration. When the subject area is Alang-alang (Imperata cylindrica) grassland, the firebreak width is usually 5 - 8m.

c) Other precautions, such as the provision of fire extinguishers, must be taken to prevent the undesirable spread of fire.

3.2 Mechanical Work

The preparatory work and precautions necessary for mechanical ground surface preparation are as follows.

a) A mechanical ground surface preparation plan should be prepared in the following manner.

   ① Decisions on the subject sites, firebreaks, work roads and heliport should be based on the findings of a preliminary investigation.

   ② Selection of the equipment and materials to be used should be based on the findings of a preliminary survey on the availability and quality of after-services and the availability and easy procurement of spare parts, etc. The quantities of the selected equipment and materials must be appropriate for the expected scale of work.

   ③ Preparation of an input plan for equipment and materials.

   ④ Preparation of a plan for the required fuel and parts, etc. for each piece of equipment.

   ⑤ Recruitment of equipment operators and workers.

b) As the land preparation work at sloping land may become a cause of soil erosion or hillside landslide in later years, the work should be conducted along the contour lines and not in the slope direction.

4. Flight Preparation

4.1 Necessary Flight Procedure

1. Unlike general machinery, the use and flying of aircraft involves a legal procedure which consists of the following processes in the case of Japan.

a) Application for temporary permission to land outside an airport.
b) Application for permission to fly below the minimum safe flying altitude.
c) Application for permission to drop goods.
d) Submission of a flight plan.

This procedure is usually conducted by the aviation company lending or leasing the aircraft.

4.2 Preparation of Spraying Operation Map

The spraying map is prepared based on the spraying plan and indicates the subject areas, excluded areas and dangerous sites, etc. A base map with a scale of 1/10,000 - 1/15,000 appears appropriate.

The pilot must prepare the flight plan prior to the flight based on the spraying operation map and also uses the latter to calculate the required fuel. The early preparation of the spraying operation map and its delivery to the aviation company is, therefore, important for the smooth implementation of the operation.

4.3 Flight Routes

Flight routes should avoid houses, hospitals, schools, railway lines and trunk roads, etc. as much as possible. Reasonably economical routes should be decided taking the above requirements, topographical conditions and existing obstacles to flying into consideration. The following measures should be adopted if the flying over or near buildings or important facilities is unavoidable.

a) Local communities should be informed on the selected flight routes to facilitate their understanding and cooperation.

b) The relevant permits should be obtained from the competent agencies.

c) Crossing points should be designated by the placing of white or yellow guiding flags at 50m intervals for a distance of 200m on both sides of the crossing points.

d) Crossing points of more than 50m wide should be marked by white or yellow crossing point flags at all corners.

e) Security men should be appointed at road crossing points to control ground traffic.

f) Markers should be placed at crossing points over power transmission lines.

g) Streamers should be erected at places where turbulent air currents are likely to occur.

4.4 Markers and Signals

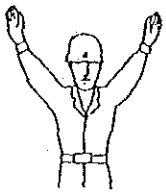
① 2 types of markers of an easily recognisable colour from the air: flight prohibition marker and flight guidance marker.

② Markers are either triangular flags, square flags or aerial marking boards.

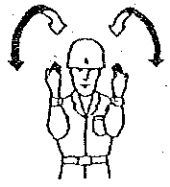
③ The signals used by the ground signalman should be common international signals (Fig. III-1). The following points must be noted when guiding an aircraft using hand signals.

   a) The signals must be clear enough to be recognized by the helicopter pilot.
   b) Early signals must be given using both hands. Hand movements can be gradually made smaller to indicate minor adjustments.
   c) As helicopter movement involves coasting, all hand signals must be given slowly, taking the coasting element into account.

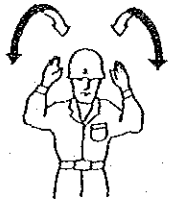
① Come to This Position
Stretch and raise both arms in a Y shape



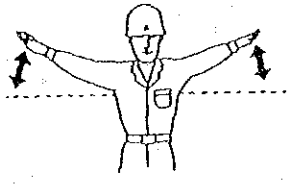
② Move Forward
Stretch both arms right in front and repeatedly move hands to shoulders and back with the palms facing you



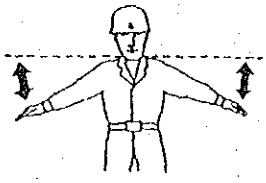
③ Move Backward
Repeatedly move hands forward from shoulder position with palms facing outward as if pushing something back



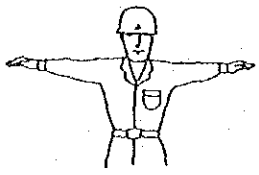
④ Ascend
Stretch both arms horizontally with palms facing upward and move them up and down above the level position



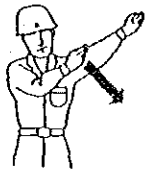
⑤ Descend
Stretch both arms horizontally with palms facing downwards and move them up and down below the level position



⑥ Hovering
Stretch both arms horizontally and keep them still



⑦ Cut the Cargo
Stretch and raise the left arm in a slanting position and move the right arm as if cutting the left arm



⑧ Abort and Try Again
Raise both arms and repeatedly cross them above the head when moving them left and right

Fig. III-1 Signaling by Ground Signalman

4.5 Decision on Flight Operation

The decision on flight operation is taken by the pilot and must take the preparatory conditions of the goods to be transported, aircraft conditions and weather conditions, etc. into account. The main criteria for flight operation are as follows.

Positive Criteria

a) Between 30 - 60 minutes after sunrise and 30 - 60 minutes before sunset
b) No cloud interference for flying
c) Visibility of at least 1,500m

Negative Criteria

a) Strong rain, wind or snow
b) Noticeable occurrence of turbulent air currents
c) Expected drastic weather change
d) Expected icing during operation
e) Pilot's decision not to fly

4.6 Working Hours

① The standard daily hours of helicopter operation are set at 4 hours in view of refueling, maintenance before and after the flight and the tiredness of the pilot, etc.

② Refueling generally requires some 20 minutes each time.

③ The maintenance work before and after a flight generally requires 30 - 60 minutes each time.

④ The number of personnel required to maintain flight operation depends on the types, quality and packaging of the goods to be transported. A sufficient number of personnel must be allocated.

4.7 Work Uniform and Related Issues

The following points must be noted in regard to work clothes and other issues.

a) Workers must wear a safety hat.

b) Work clothes must be capable of withstanding the wind pressure caused by a helicopter.

c) Workers must wear protective goggles and a mask.

d) Workers must wear rubber gloves or similar to prevent the negative effective of static electricity accumulated in the helicopter body.

e) Signalmen and hook operators at the loading/unloading yard must wear safety hats and jackets, etc. of an easily identifiable colour.

f) Those with particularly sensitive skin must not be allowed to conduct loading, mixing or any other work involving chemical agents.

5. On-Site Management System and Related Issues

An on-site management system and command system must be clearly established for project implementation to ensure the safety and efficiency of the work. The basic requirements of and points to note in relation to on-site management are described below.

5.1 On-Site Management

① The on-site management system and command system must be decided through discussions between the project implementation body, contractor and aviation company involved in the project.

② Given the fact that helicopter operation requires professional expertise, instructions given by the site representative of the aviation company must be obeyed at the heliport and loading/unloading yard.

③ Prior to actual operation, a test flight must be conducted to check the flight routes, to confirm the loading/unloading yard location and to obtain all information which is vital for helicopter operation.

5.2 Safety Control

① Safety Education

Workers engaged in helicopter transportation work must be properly educated on the characteristics of the work to prevent accidents.

② Safety Control at Heliport and Loading/Unloading Yard

a) Unauthorized personnel should not be allowed access to the heliport which should be enclosed by fencing or a rope. A sign prohibiting the entry of unauthorized personnel should be erected at the heliport entrance.

b) Appropriate measures should be taken to prevent damage to the helicopter while parked.

c) Only those workers authorized by the site supervisor should be allowed to conduct the work at the heliport and all unauthorized workers should be prohibited from going within 5m of the heliport and loading/unloading yard perimeters.

d) All necessary precautions should be taken when using heavy machinery, including the designation of an operating area and the provision of shelters.

e) The storage of goods and entry of works into the helicopter's take-off or landing path should be prohibited.

f) Approach near the tail rotor should be prohibited.

g) All the premises should be kept clean and tidy. Those items which could be blown away by the wind pressure should be removed from the premises or tied down.

h) During refueling, the engines of nearby vehicles must be turned off and a smoking area properly designated.

i) If the loading/unloading yard is located on sloping land, shelters must be provided outside the helicopter's take-off or landing path.

j) Hovering should be monitored from both inside the helicopter and outside.

k) Such long items as transceiver antennas, poles and long tools, etc. should be placed in a horizontal position.

l) After use, the wire rope should be bundled and firmly tied to the helicopter body as loose wire on the hook could start to drift due to the wind pressure, thus damaging the body of the helicopter or resulting in an accident through its tangling with the tail sector or tail rotor.

IV AERIAL SEEDING OPERATION

1. Indication of Target Area

The target seeding area must be easily identifiable from the air through, for example, the use of white flags to indicate the target area, red flags to indicate dangerous areas (obstacles) and streamers to indicate the key points of flight routes.

2. Requirements of Aerial Seeding

a) Aerial Seeding on Flat Land

An Aerial seeding flight in the case of flat land should be made at a right angle against the wind direction as shown in Fig. IV-1. Spraying should commence at the leeward side and the turning should, in principle, be made towards the wind. Turning while spraying should be prohibited as this can result in excessive spraying and the drifting of seeds.

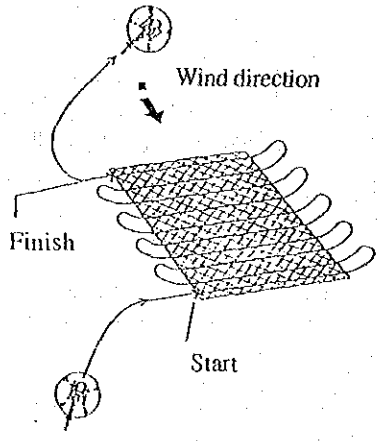


Fig. IV-1 Aerial seeding Flight on Flat Land

b) Seeding on Sloping Land

A seeding flight in the case of sloping land should, in principle, be made along the contour lines. Seeding while flying downwards in the slope direction makes it difficult for the seeds to descend properly due to the air current created by the helicopter. Such downward seeding is, however, accepted upto a slope gradient of 15°. For sloping land with a gradient of more than 15°, upward seeding or diagonal upward seeding should be repeated.

c) Seeding Around Parallel Running Obstacles

A seeding flight near such parallel running obstacles as power transmission lines and roads, etc. should be conducted parallel to them rather than across them.

d) Seeding on Sites Restricting Free Flight

A seeding flight on small sites, bending sites and/or topographically complicated sites which restrict free flight must be conduct at the early stage of the operation to ensure a fresh memory of the survey flight. In the case of this type of flight, the load should be limited to permit flexible manoeuvering.

e) All sites earmarked for frequent or possible turbulent air currents should be avoided on flight routes. Alternatively, a sufficient flight altitude should be maintained to avoid such adverse air currents.

f) Taking the time lag of 1 - 2 seconds between switching on and switching off and between the commencement and stoppage of seeding into consideration, the seeding switch should be switched on approximately 20m before the seeding starting point and switched off approximately 30m before the sseeding finishing point.

3. Post-Seeding Requirements

Upon completion of seeding, several requirements must be met as described below. The adoption of these requirements depends on the project objectives and the degree of necessity to meet such requirements.

a) It is necessary to study the state of dispersion and landing conditions of the sprayed materials to obtain a true picture of the seeding operation and to provide reference data for future operations. A number of white papers or cloths (1m x 1m or 2m x 2m) should be placed in the target area for this purpose.

b) The guiding personnel on the ground should promptly report the seeding results found with these white papers or cloths to the operation base. The reported information should then be conveyed to the pilot by the operation supervisor.

c) The amount of seeds found on the white papers or cloths in the range of 80 - 120% of the planned seeding amount should be judged successful.

d) Productivity data, flying time and other records relating to the seeding operation should be submitted to the operation supervisor.

e) Because of the unique features of aerial seeding, uniform seeding is difficult to achieve. This difficulty is particularly felt near perimeter areas and the edges of forests. In addition, successfully sprayed seeds may be washed away or the subject area may be eroded. Should a loss of the sprayed seeds occur, appropriate means should be employed to conduct supplementary spraying.

f) Subject sites of aerial seeding generally have poor soil and resulting reforestation efforts tend to become extensive compared to reforestation by ground work. A single seeding operation followed by additional fertilizer application may not sufficiently assist the germination and growth of the seeded species. Consequently, a further plan to provide fertilizer and seeds depending on the subsequent germination performance may be required.

4. Supervision and Inspection

4.1 Supervision

The main items to be supervised in association with aerial reforestation are described here.

(1) Confirmation of Quantity and Quality of Spraying Materials

① Seeds

- To confirm that the seeds satisfy the required germination rate and purity criteria.

- To confirm that the seeds are accompanied by an inspection certificate issued by a reliable organization.
- To conduct a germination test if necessary.
- To confirm the quantity of the seeds.

② Fertilizer (when used)

- To visually verify that the fertilizer supplies are what are required, especially in terms of grain shape.
- To confirm the quality of the fertilizer.

③ Other Materials

- To verify them in accordance with the processes described in ② above.

(2) Confirmation of Spraying Volume

① At the time of loading, the quantity of the materials should be checked to confirm that the spraying volume is within an acceptable range of between 80% and 120% of the planned volume. It is useful to use a field notebook to record the spraying volume by flying hour.

② A field notebook to record the spraying performance at the spraying verification sites should be used to assist supplementary spraying operation and the issue of the necessary instructions.

4.2 Inspection

(1) Every plant has its own specific temperature and water quantity requirement for germination and germination method. The germination period also differs from one plant to another. Moreover, simultaneous seeding does not guarantee the uniform germination of all seeds. After germination, the number of plants is generally reduced due to the natural selection process.

Although it is possible to argue that an aerial reforestation operation ends when aerial seeding has been completed, it is also possible to argue that the end of such operation is when most of the seeds have germinated.

In general, construction contracts have a warranty clause. In the case of aerial reforestation, however, as the performance is largely affected by the weather conditions and site conditions, etc., it is difficult to determine whether or not a poor result should be blamed on the contractor or force majeure. Consequently, the warranty in the case of aerial reforestation ceases to exist once the completion of the work has been agreed after inspection.

(2) As no records exist on the inspection of aerial reforestation performance in the tropics, a brief inspection format used in the case of aerial revegetation work for national forests in Japan is given below for reference purposes.

1. The inspection of the work shall be conducted in accordance with the "Supervision and Inspection Guidelines" or similar rules.

2. The inspection of aerial revegetation work shall judge the successful performance of the work based on the number of successfully grown new plants and the rate of remaining bare land, taking the passage of time after seeding, seeding method and species seeded, etc. into consideration. Concrete judgement criteria are given in the table below.

3. The judgement shall be based on the growth performance within quadrats (in principle, $1m^2$ each) established in the spraying performance verification site.

4. The judgement of terrace foundation work and supplementary revegetation work shall be based on the Erosion Control Work Inspection Criteria or similar criteria.

5. In the case of aerial revegetation work, the warranty shall, in principle, cease to exist after the completion of inspection

Aerial Revegetation Work Inspection Criteria

Time of Inspection	Within One Month After Seeding		Within 2 Months After Seeding
	Non-Germination of Most Seeds	Germination of Most Seeds	
Number of Plants	-	approximately 3,000 or more	approximately 2,000 or more
Rate of Bare Land	-	10% or less	15% or less
Remarks	Judged a failure if the spraying result is found to be extremely uneven or further germination cannot be expected to take place.	The number can be reduced to 2,000 if there is a delay in the germination of the main species but the germination of the remaining seeds is highly likely.	May be judged a failure if the number of the germination seeds of the main species is extremely low or if their growth is extremely poor.

Notes

1. The number of plants means the number of individual plants/$1m^2$.

2. Bare land means land not covered by vegetation (by the oblique projection method), excluding land covered by civil engineering structures, outcrops and boulders, etc. where plant growth is impossible (this type of land is called barren land), and is called feasible plant growth land. A piece of land with an oblique projection area of less than $25m^2$ shall not be considered bare land.

3. The rate of bare land is calculated as follows.

$$\text{Rate of Bare Land} = \frac{\text{Total Bare Land Area}}{\text{Total Quadrat Area - Total Barren Land Area}}$$

4. The average number of verification sites is 1/ha or 3 operation area. The total number shall be a minimum of 5 and a maximum of 20.

5. The number of plants and the rate of bare land shall be average values for the entire quadrats. If it is difficult to judge the performance in the manner described above, operation records and photographs should be used.

V MAINTENANCE AND MANAGEMENT OF SEEDED AREAS

1. Maintenance and Management

1.1 Tending

In principle, tending should be avoided as much as possible in view of the objectives of environmental reforestation. During the process of natural growth, the sprayed seeds may encounter such problems as inadequate germination, poor growth and over-stocked or thin stands. The implementation of the following measures should be considered if it appears unlikely that the reforestation targets will be met because of these problems.

a) Additional Seeding
Additional seeding is necessary to secure the number of target trees and target coverage if seed germination or the number of grown trees is insufficient.

b) Additional Fertilizer
The use of a chemical fertilizer should be considered if tree growth is continuously poor over a few years.

c) Weeding
The use of a herbicide, considered safe from the environmental point of view, should be considered if tree growth is poor due to competition with or suppression by weeds.

d) Cleaning or Thinning
Cleaning or thinning should be conducted in the case of over-stocked stands. The offer of cleaned or thinned trees to local communities as firewood should be considered.

1.2 Monitoring

Monitoring of the growth conditions of the sprayed species and the state of original vegetation, etc. should be conducted for a specific period of time to confirm the spraying results and to provide useful information for future aerial reforestation.

① Appropriate monitoring can be conducted by establishing sample zones in accordance with either the quadrat method or the belt transect method.

② The survey items include the growth conditions of the sprayed species, conditions of invading vegetation, occurrence of landslides, etc., relationship between plant growth and the factors listed in Table IV-1 and possible remedial measures.

Table V-1 Factors Affecting Plant Growth

Factors	
Natural Environment	Climate (Temperature, Rainfall)
	Geology, Soil
	Topography, Slope Direction, Gradient
	Fauna, Flora
Artificial Environment	Burning
	Type of Construction, Construction Method
	Tending, Control
	Artificial Selection of Plant Species

2. Protection

The number of reports has finally been increasing in recent years on nurseries, damage to short rotation species and possible remedial measures in the tropics.

2.1 Damaging Weather Conditions

The main climatic factors affecting the germination and growth of sprayed seeds in the tropics are rainfall, high temperatures, wind and drought. The following weather damage is generally observed.

① In general, the tropics has dry and rainy seasons. A prolonged period of drought can result in the drying of seeds and/or roots of young trees and their death.

② According to reports on nurseries in Indonesia, poor growth or decay of the root system occur because of poor drainage during the rainy season. It is necessary to take the site conditions into consideration when selecting the species to be planted.

③ Wind damage is mainly caused by cyclones or typhoons. Most damage occurs to trees which have already been damaged by insects or diseases or to over-stocked stands. There have been reports in Indonesia of the stems of Eucalyptus spp. and Acacia spp. being snapped in half.

2.2 Harmful Insects and Diseases

Appropriate measures should be taken at each specific stage of growth to prevent damage due to harmful insects and diseases. Such damage can be avoided by the chemical and/or biological methods and also by silviculture control. The chemical method should, however, only be adopted after a careful examination of the environmental impacts. Tables V-2, V-3 and V-4 give the types of insect damage and diseases and preventive measures.

Table V-2 Diseases of Acacia mangium

Disease	Pathogen
Damping Off	Phytophthora sp.
	Pythium sp.
	Fusarium sp.
	Rhizoctonia sp.
Charcoal Root Rot	Macrophomina sp.
Leaf Spots	Glomerella cingulata
	Colletotrichum coffeanum
	Phyllostictina sp.
	Pestalotiopsis sp.
Powder Mildew	Oidium sp.
Seed Rot	Penicillium sp.
Pink Disease	Corticium salmonicolor
Tip Die-Back	Schizophyllum commune
Mottled Sap Rot	S. commune
Brown Root Disease	Phellinus noxius
Red Root Disease	Ganoderma pseudoferreum
Heart Rot	Unidentified sterile basidiomycete

Table V-3 Insect and Diseases Damage in Indonesia

o Insect Damage

Tree Species	Seedling	Young Tree	Middle-Aged Tree	Old Tree
Eucalyptus spp.	eaten by grasshopper or snail	damage by wood borer	damage (die-back) by termite or wood borer (damage to cmabium)	
Paraserianthes falcataria			leaves damaged by yellow butterfly	
Acacia mangium	eaten by grasshopper	pinholes in bark		yellowed leaves due to butterfly
Swietenia macrophylla		damage by moth		
Eucaylptus urophylla	eaten by grasshopper			

o Diseases

Tree Species	Seed	Seedling	Middle-Aged Tree
Eucalyptus spp.		die-back by pathogens	die-back by pathogens
Acacia mangium	damping off after germination by and RIDMIL 26 used to combat it	damage by pathogens	
Paraserianthes falcataria	as above		
Eucalyptus urophylla	as above	yellowed leaves due to Jamur Easat and Belate Tzowp being sprayed	

Table V-4 Insect and Animal Damage to Acacia mangium in Malaysia

Site	Harmful Insect/Animal	Damage/Remedial Measures
Nursery	Slug	Observed at apex. Remove during night if damage is light. Spray insecticide, such as Metalodehyde, for 3 days
	Caterpillar of Yellow Butterfly	Leaves eaten. Remove caterpillar and chrysalis. Apply BHC (0.025%) or Trichlorphon or Endosulfan
	Locust, Grasshopper	Observed in Alang-alang grassland. No particular action taken if damage is light. Apply Dieldrin (0.03%)
	Mites	Observed in dry season. Damaged leaves yellowed and curled up. No control necessary in general. Apply Endrin (0.025%) or Dieldrin (0.05%)
Reforestation Site	Rat	Observed in Alang-alang grassland, secondary forests and dry rice fields. Damage to seedlings and young trees. Use Warfarin
	Squirrel	Observed near seedlings, young trees and secondary forests. Use traps or inject zinc phosphide to tapioca or pumpkins
	Termite	Possible damage to roots as well as stems. Apply Dieldrin
	Carpenter Ant	Collected leaves used to make nests. Apply Malathion (0.1%). Seal nests with wax
	Ambrossia Beetle	Boreholes, little damage to healthy trees. Apply Dieldrin. Conduct thinning
	Yellow Beetle	Leaves eaten. No adverse impact on tree growth. Apply Dieldrin or BHC
	Plant Bug	Sap sucked from young leaves and branches. Apply BHC
	Gelatine Grub (Larva)	Leaves damaged. Apply Trichlorphon
	Beetle (Larva)	New leaves damaged. Apply Trichlorphon, Gamma or BHC
	Bagworm (Larva)	Distinguishable from other larva because of tower-like larva bag. Leaves holed. No chemical application usually as damage is light. Apply Trichlorphon for sudden multiplication on a large-scale

2.3 Forest Fires

It is very common to witness burning for shifting cultivation and/or stock raising purposes in and around reforestation sites. It is, therefore, necessary to enlist the cooperation of local inhabitants in the protection of reforestation sites by making them fully aware of the objectives and practical importance of reforestation and forests in general. Moreover, the employment of local inhabitants in reforestation work may be necessary to secure their cooperation.

While firebreaks are a very effective means of preventing the spread of forest fires, they do not have a 100% guarantee. Measures to prevent forest fires, including the construction of watch towers and the provision of fire-fighting equipment, should be seriously considered.

VI VISION OF ENVIRONMENTAL REFORESTATION

The immediate target of a large-scale reforestation project, particularly an environmental reforestation project using an aircraft, is environmental conservation which includes the swift, large-scale and low cost reforestation of waste land, the restoration of the water conservation function of forests, the prevention of desertification and the control of global warming, etc. through the utilisation of the advantageous elements of aerial operation.

Plant growth is supported by many factors, such as light, temperature, moisture and nutrients, etc. The required levels of these factors vary from one species to another and each species has a specific range of adaptability. As the subject sites for aerial reforestation are generally considered to be poor in nutrients, the selection of the right species is essential. The following points must be taken into consideration when selecting species for aerial seeding.

① Extensive range of adaptability to climatic changes
② Extensive range of adaptability to soil characteristics
③ Vigorous germination and growth strength with particularly fast initial growth
④ Potential for wide coverage of land surface and tight binding of soil through a well developed root system
⑤ Good potential for soil improvement (fertility improvement)
⑥ Strong resistance to harmful insects and diseases

By definition, aerial reforestation has the following weak points.

① The reforestation performance is unstable.
② The aerial spraying of seeds makes it difficult to achieve uniform seeding depending on the topography of the subject site. This difficulty is particularly manifest at the upper end of a subject area and at forest edge.
③ The sprayed seeds may be washed away by rain or eaten by small animals.

Under these conditions, the natural forest expansion method through natural regeneration may be useful to create a closed stand by selecting species which have the following characteristics.

① Production of mature seeds in 2 - 3 years for quick natural regeneration
② Multiplication by means of the root system or rhizomes
③ Regeneration by sprouting

At the growth stage, aerially sprayed seeds are believed to encounter such problems as a low germination rate, poor growth and the formation of over-stocked or thin stands, etc. These problems can be solved by the supplementary spraying of seeds, additional fertilizer, weeding, cleaning cutting and/or thinning. Given the objectives of environmental reforestation, however, it is desirable not to adopt these measures if possible. Similarly, the use of machinery and the construction of facilities for land preparation should also be kept to a minimum through the careful examination of the various conditions of the subject site and the degree of necessity to use such machinery, etc.

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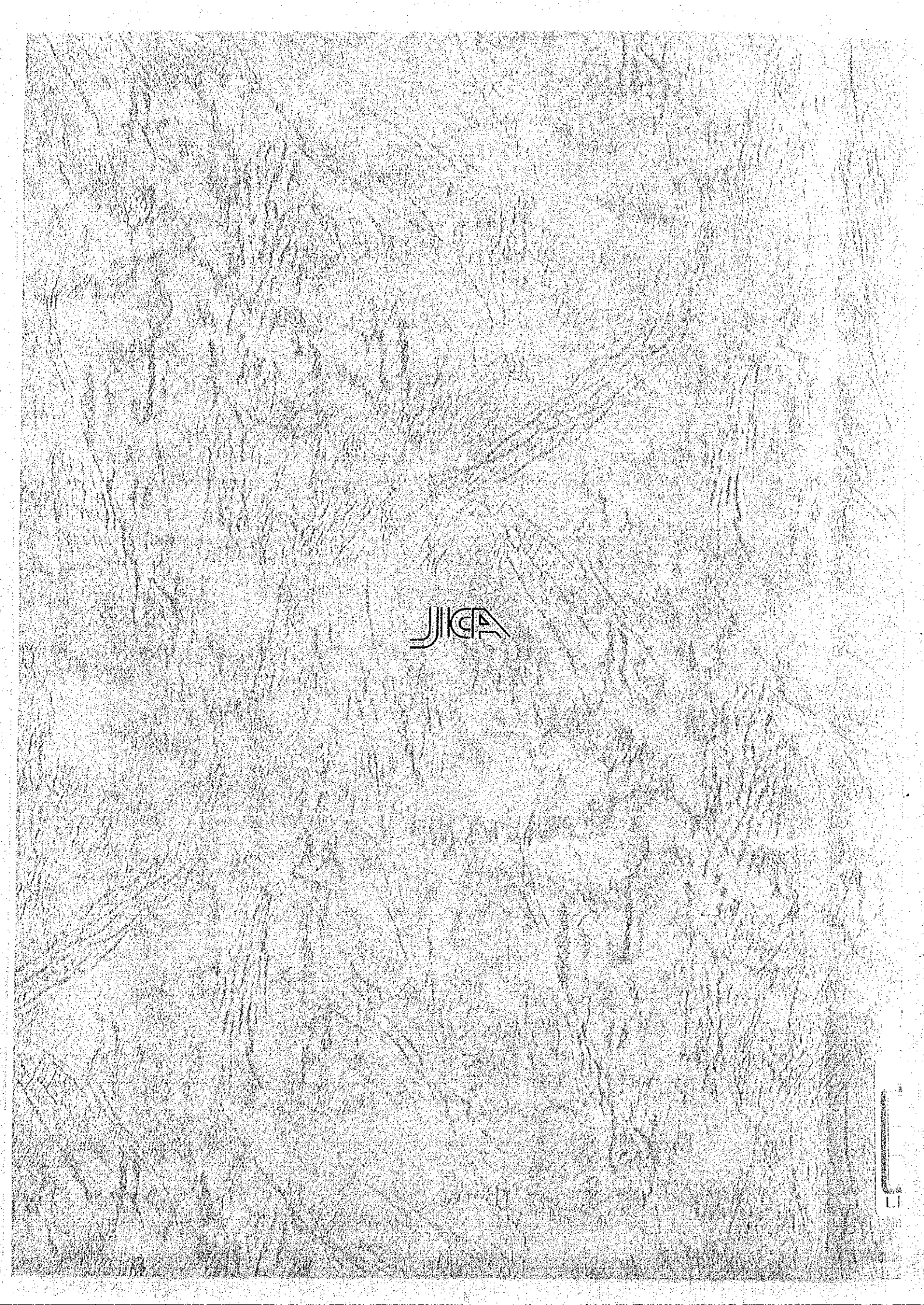
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