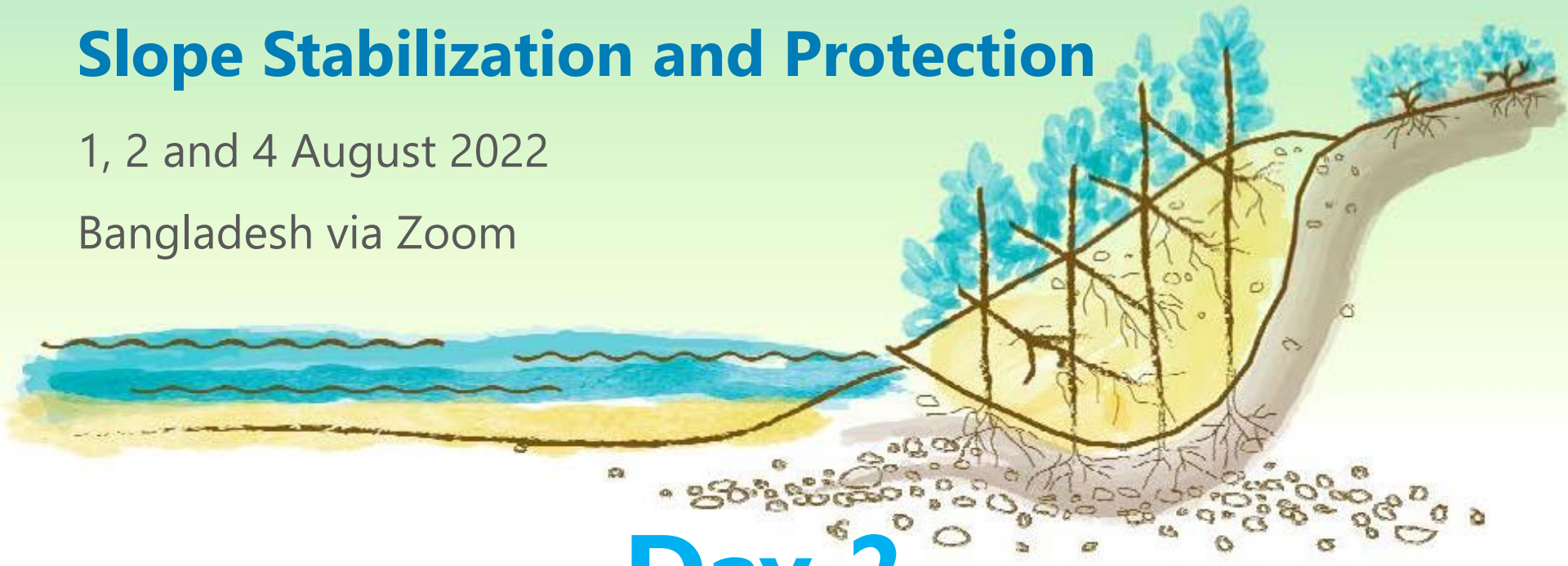
TRAINING ON

Bioengineering Nature-based Solutions for Linear Infrastructure Slope Stabilization and Protection

1, 2 and 4 August 2022

Bangladesh via Zoom



Day-2

Source of Material

This training programme was compiled and delivered by Shankar Rai, working with assistance from Shuva Sharma, Dr. Mohammed Shariful Islam and Syed Abdur Rahim. Quality assurance was provided by John Howell.

This was prepared as part of the Asian Development Bank's TA 9461 REG - Protecting and Investing in Natural Capital in Asia and the Pacific, which was implemented by a team led by Isao Endo and Victor Tumilba

This material may be cited as:

Rai, Shankar. "Bioengineering Nature-based Solutions for Linear Infrastructure Slope Stabilization and Protection." Training Lecture. Asian Development Bank (ADB), August 1-4, 2022. Bioengineering Nature-based Solutions for Linear Infrastructure Slope Stabilization and Protection | ADB Knowledge Event Repository (development.asia).

Recap

- Type of slope instability;
- Component of an unstable slope;
- Cause and mechanism of slope failure;
- Slope protection practice and bio-engineering;
- What is bio-engineering ?
- Design aspects of civil engineering structures and engineering function of civil engineering structures;

- Engineering functions of bio-engineering systems;
- Design aspects of vegetative engineering structures ;
- Interaction /Physical relationship between plants and civil engineering structures;
- Site assessment procedure and selection of bio-engineering techniques;

- Selection of plant species for bio-engineering;
- Bio-engineering works for slope protection and cost comparison of slope protection with conventional engineering and bio-engineering methods;
- Bioengineering maintenance task and seasonal work programming of bioengineering works;
- Rate analysis norms and standard specifications for bioengineering works.

Session-12
Siting of Bio-engineering Nurseries

Siting of bio-engineering nurseries

Why do we need to have a nursery?

Nurseries are required to supply:

- enough plants
  - of the right species,
  - in good, healthy condition,
  - in the form required for planting;
- at the right time;
- at a reasonable cost.

Siting of bio-engineering nurseries

What are the main terrain features which must be considered when siting a nursery?

Terrain features for siting a nursery

- Flat or terrace land with 3-5% slope
- Accessible
- Near or center of the area

Siting of bio-engineering nurseries

What are the main resources required to establish and run a nursery?

Resources for siting a nursery

- Land
- Adequate water supply
- Availability of materials and labour
- Budget for nursery

Siting of bio-engineering nurseries

Spacing of nurseries along the road

- each climatic zone where work is to be carried out should be represented by at least one nursery;
- On some mountain roads crossing much unstable terrain and a wide variety of climatic zones, one nursery per 10 km may be necessary. Elsewhere a distance of 25 km between nurseries may be adequate.

Siting of bio-engineering nurseries

Advantages of small nurseries

- planting programme less likely to be disrupted by landslides
- danger of loss from drought or disease reduced
- less transport costs
- less stress on plants

Siting of bio-engineering nurseries

Advantages of small nurseries

- can have nursery in each climatic zone
- more peoples trained, therefore greater transfer of skills
- nurseries act as focus for extension work in local community

Session-13
Nursery Components and Size

Nursery components

What are the components that should be present in a nursery?

General:

- Compound wall or fence
- Watchman's hut
- Toilet
- Vehicle access and turning area
- Pathways to all parts of the nursery
- Working area

Nursery components

Storage:

- Nursery store
- Soil and sand stores
- Compost bays

Water:

- Water tank and accessories
- Drainage systems

Nursery components

Beds:

- Seed bed
- Grass bed
- Standout bed for polypot seedlings
- Bare root plant bed
- Stool cutting bed
- Bamboo bed
- Shades for bed

Nursery equipments and tools

- Shovel
- Pick-Axe
- Crowbar
- Hammer
- Scissors/secateurs
- Axe
- Knifes
- Watering can with roses

Nursery equipments and tools

- Flit gun sprayer
- Tin trunks with padlocks
- Buckets
- Seed trays
- Soil and sand sieves
- Leather or paper punch
- Plant carrying trays
- Safety equipment
- First aid kit

Materials for nurseries

- Soil
- Sand
- Compost
- Seeds
- Fertiliser
- Fungicide
- Insecticide
- Polypots: 4" x 7"

Materials for nurseries

- Heavy gauge polybags for storage
- Heavy gauge polythene sheet
- Shade material (bamboo, hessian)
- String
- Wire
- Wire mesh
- Nails

Materials for nurseries

- Soap
- Seedbed labels
- Waterproof marker pens
- Pens/pencils
- Registers: nursery, seed

Nursery size

Nursery production plan:

- 500.000 grass slips;
- 18,000 shrub/tree plants in 4" x 7" polypots.

Space requirement for a nursery

?

Nursery size

Calculation of grass slip multiplication and space requirements

Nursery altitude	Species	Slips first planted	Number to plant
Coastal to 1200 m	Tiger grass	October	Final site number / 3
	Any other grasses	October	Final site number / 7
		February	Final site number / 3

Nursery size

Space required for a nursery

a) 500,000 grass slips

If you plant in October in nursery the average multiplication rate when planted on site is five.

Grass slips required for nursery: 500,000/5 = 100,000

Bed space is required for (500,000 / 5) = 100,000 slips to grow into clumps which will give a multiplication by five times when the plants are taken to site. They stand at 100 slips per m^2 in bed:

100,000/100 = 1000 m^2

Nursery size

Space required for a nursery

b) 18,000 tree/shrub plants in polypots of 4" × 7" size

+ 25% for losses and culling = 22,500

Space is required for 22,500 to allow for losses and culling. They stand at 128 per m^2 when spaced out:

22,500 / 128 = 176 m^2

But half of these plants require twice as much space because they will be in the nursery for more than 12 months:

176 +88 = 264 m^2

Nursery size

Space required for a nursery

Grand total of beds area = 1000 + 264 = **1264 m²**

You must multiply this area by 1.5 for an unterraced nursery, or by 3 for a terraced nursery, to allow space for the paths between beds and for terrace risers. An unterraced nursery would therefore need **1896 m²** for the main plant growing area, and a terraced nursery **3792 m².**

Nursery size

Space required for a nursery

a) 500,000 grass slips

If you plant in February in nursery the average multiplication rate when planted on site is three.

Grass slips required for nursery: 500,000/3 = 166,667

Bed space is required for (500,000 /3) = 166,667 slips to grow into clumps which will give a multiplication by five times when the plants are taken to site. They stand at 100 slips per m^2 in beds:

100,000/100 = 1,667 m^2

Nursery size

Space required for a nursery

Grand total of beds = 1,667 + 264 = **1,931 m²**

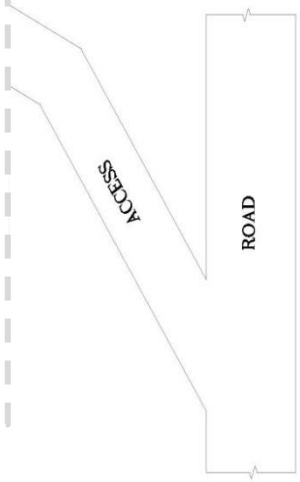
You must multiply this area by 1.5 for an unterraced nursery, or by 3 for a terraced nursery, to allow space for the paths between beds and for terrace risers. An unterraced nursery would therefore need **2896 m²** for the main plant growing area, and a terraced nursery **5793 m².**

Session-14

Nursery Layout Design and Bed Construction

Nursery layout design

Proposed land for nursery

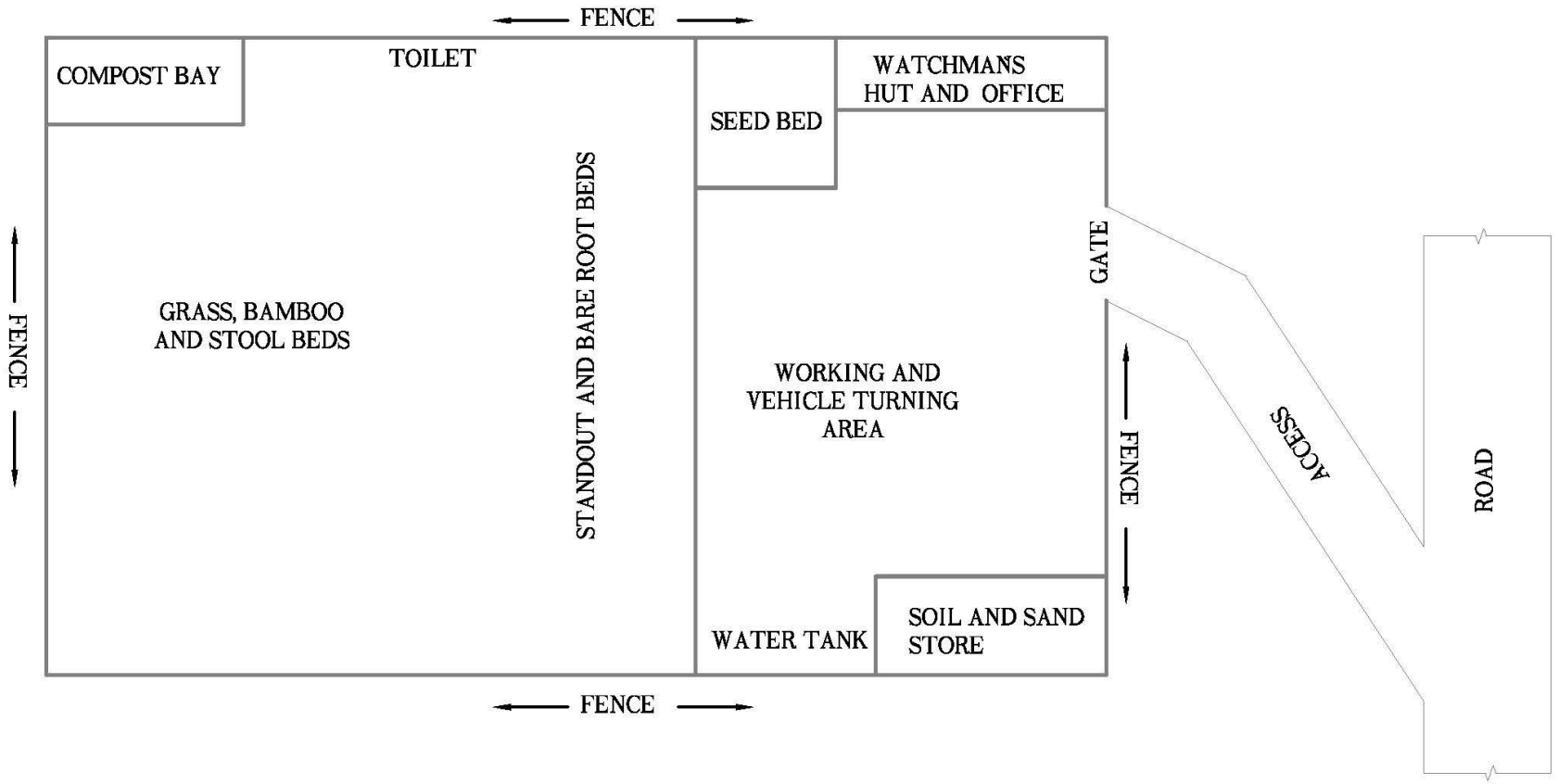


Nursery component

- Compound wall or fence
- Nursery store/ office/ watchman’s hut
- Vehicle access and turning area
- Soil/sand store
- Working area
- Water tank and accessories
- Drainage system
- Pathways to all parts of the nursery
- Compost bays
- Grass slip beds
- Seed beds
- Standout beds for polypot seedlings
- Bamboo culm beds
- Bare root plant beds
- Stool cutting beds

Nursery layout design

Considerations in general nursery layout



Design requirements of the physical components of nurseries

Component	Design features	Reasons for design
Compound wall or fence	• Secure against all animals • Strong and long lasting • Built using local materials • Simple but effective gate	• To protect the nursery adequately • As cheap as possible • Effective • Show people it is private
Nursery store/ office/ watchman's hut	• Secure against all unwelcome people • Strong and long lasting • Big enough for all its functions • Built using local materials • Good quality so the watchman will be happy to stay there • Efficient layout	• To look after tools, seeds, etc. safely • To give the watchman a reasonable place to stay • As cheap as possible to be effective

Design requirements of the physical components of nurseries

Component	Design features	Reasons for design
Vehicle access and turning area	• Beside safest and easiest road access point • Adequate space for turning and unloading (if space is limited, vehicles may reverse in)	• Easy transport of goods in and out of the nursery
Soil/sand store	• Adequate size for storing all soil and sand • Space for working in during wet weather (optional)	• As cheap as possible to be effective

Design requirements of the physical components of nurseries

Component	Design features	Reasons for design
Working area	• Big enough for all operations • Big enough for more labourers to work in at peak times • Hard, well drained surface • If possible, shaded by a large tree	• To enable efficient performance of all operations
Water tank and accessories	• At highest part of nursery • Permanent good water source • Well built tank • Tank of large capacity • Good taps • Hose pipes reaching every bed in the nursery	• Water is most essential for plants • It must be guaranteed at all times of the year • Water must be easily available in all parts of nursery

Design requirements of the physical components of nurseries

Component	Design features	Reasons for design
Drainage system	• Must prevent water logging of all beds • Must prevent erosion in the nursery • Keep paths and working areas hard and dry	• To keep the nursery in good condition all year round • As cheap as possible to be effective
Pathways to all parts of the nursery	• Well made so they last a long time • Drained so they are good during rains	• To allow easy access • As cheap as possible to be effective
Compost bays	• Strong and long lasting • Big enough for all the nursery's needs • Built using local materials	• To provide compost for the nursery on an annual basis • As cheap as possible to be effective

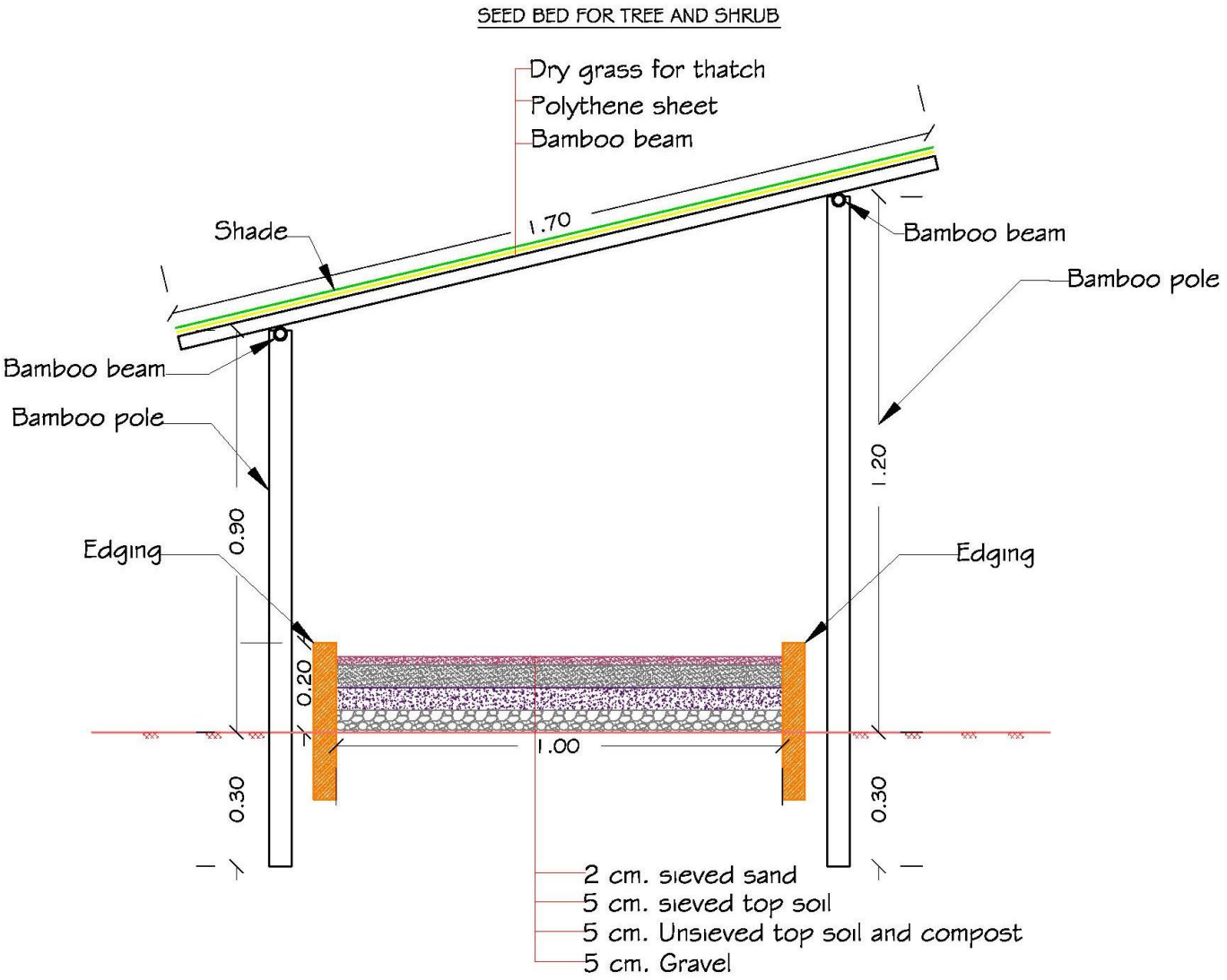
Design requirements of the physical components of nurseries

Component	Design features	Reasons for design
Grass slip beds	• Well drained • Good quality soil • Sufficient depth • Enough space	• To give good growing conditions for maximum productivity • To produce enough slips, including reserves
Seed beds	• Best available soil • Finely prepared soil/sand bed • Well shaded • Very well drained	• To give young seedlings the best possible chance of survival
Standout beds for polypot seedlings	• Well drained base • Strong frame to support pots • Removable shades	• To support polypots and prevent damage

Design requirements of the physical components of nurseries

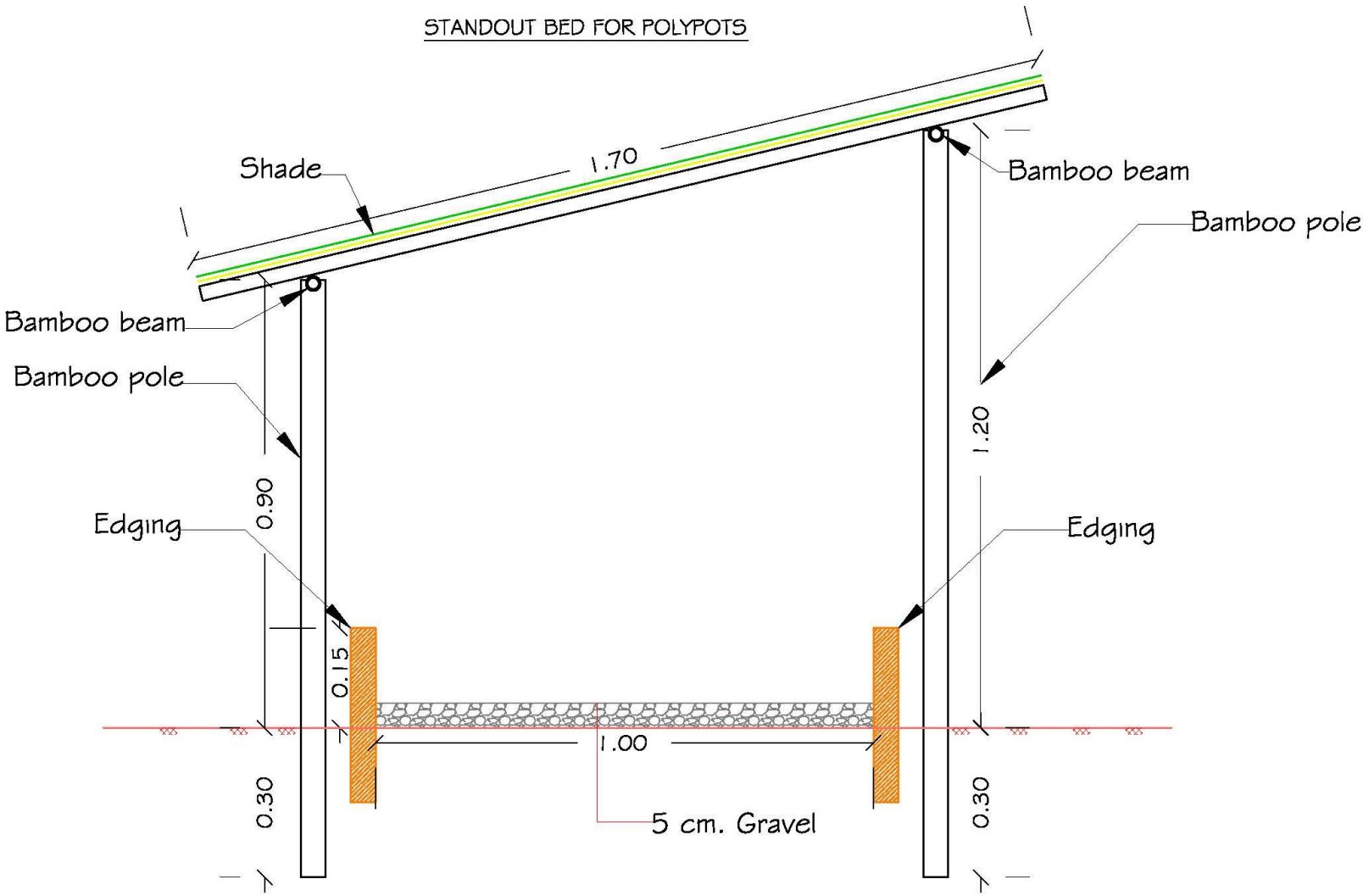
Component	Design features	Reasons for design
Bamboo culm beds	• Good quality soil • Dug to at least 50 cm depth • Well shaded • Plenty of water available	• Bamboo culms need very damp, shady conditions in which to sprout
Bare root plant beds	• Well drained • Good quality soil • Carefully constructed	• To give good growing conditions for delicate plant parts
Stool cutting beds	• Well drained • Good quality soil • Carefully constructed	• To give good growing conditions for delicate plant parts

Nursery bed



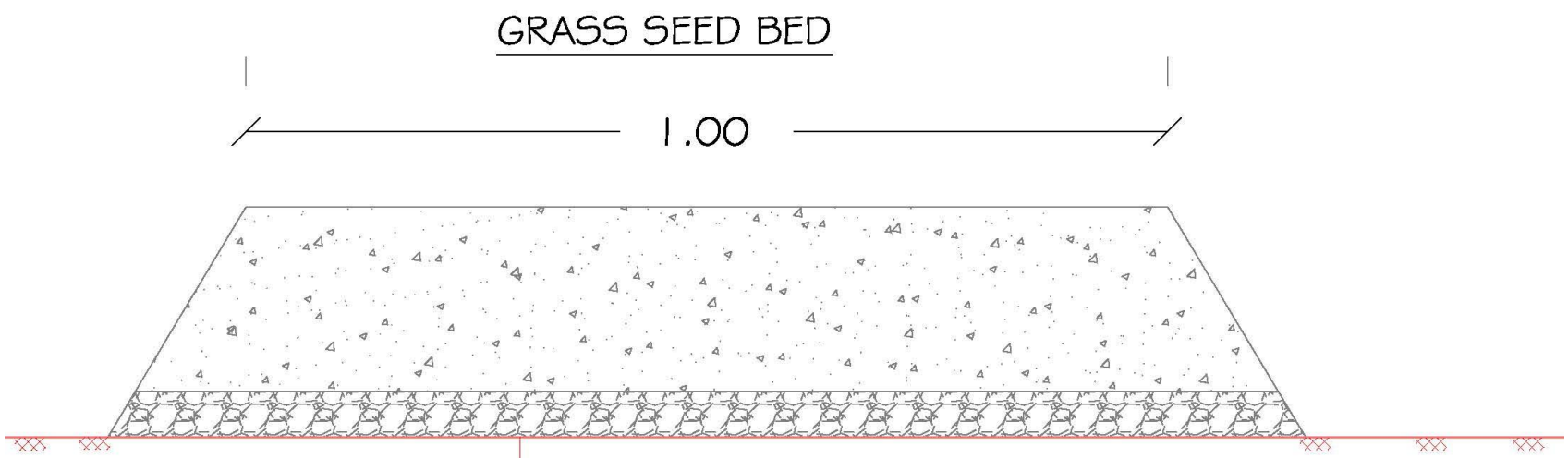
Seed bed for trees and shrubs

Nursery bed

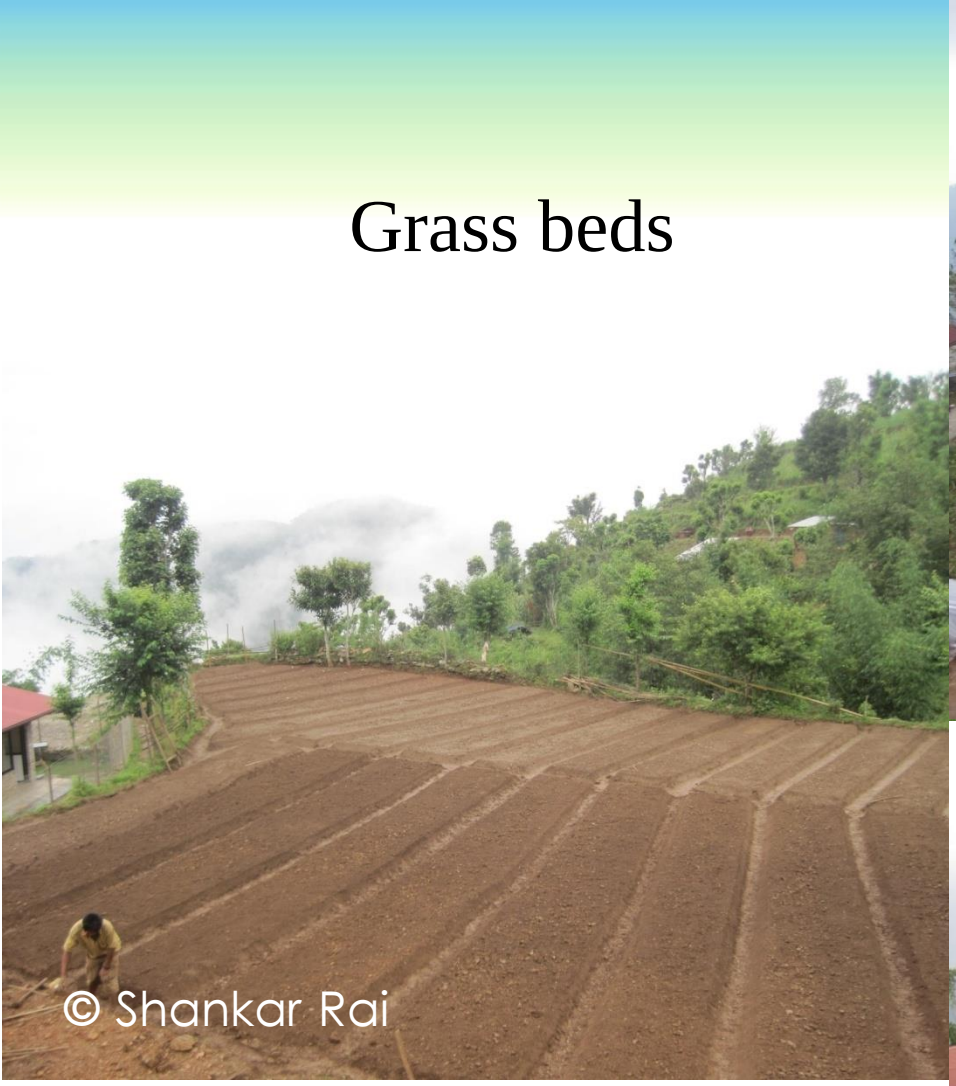


Standout bed for polypot seedlings

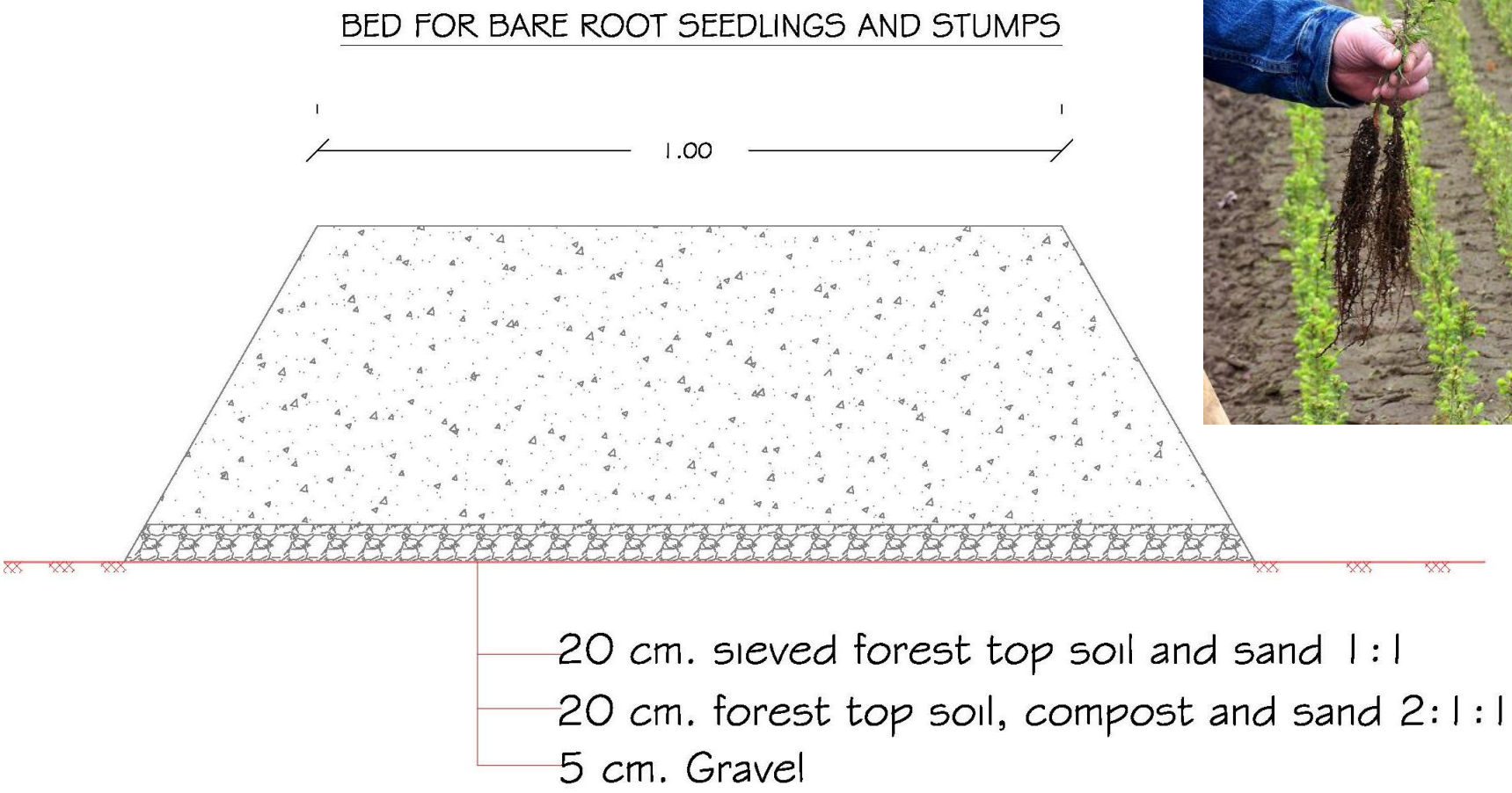
Nursery bed



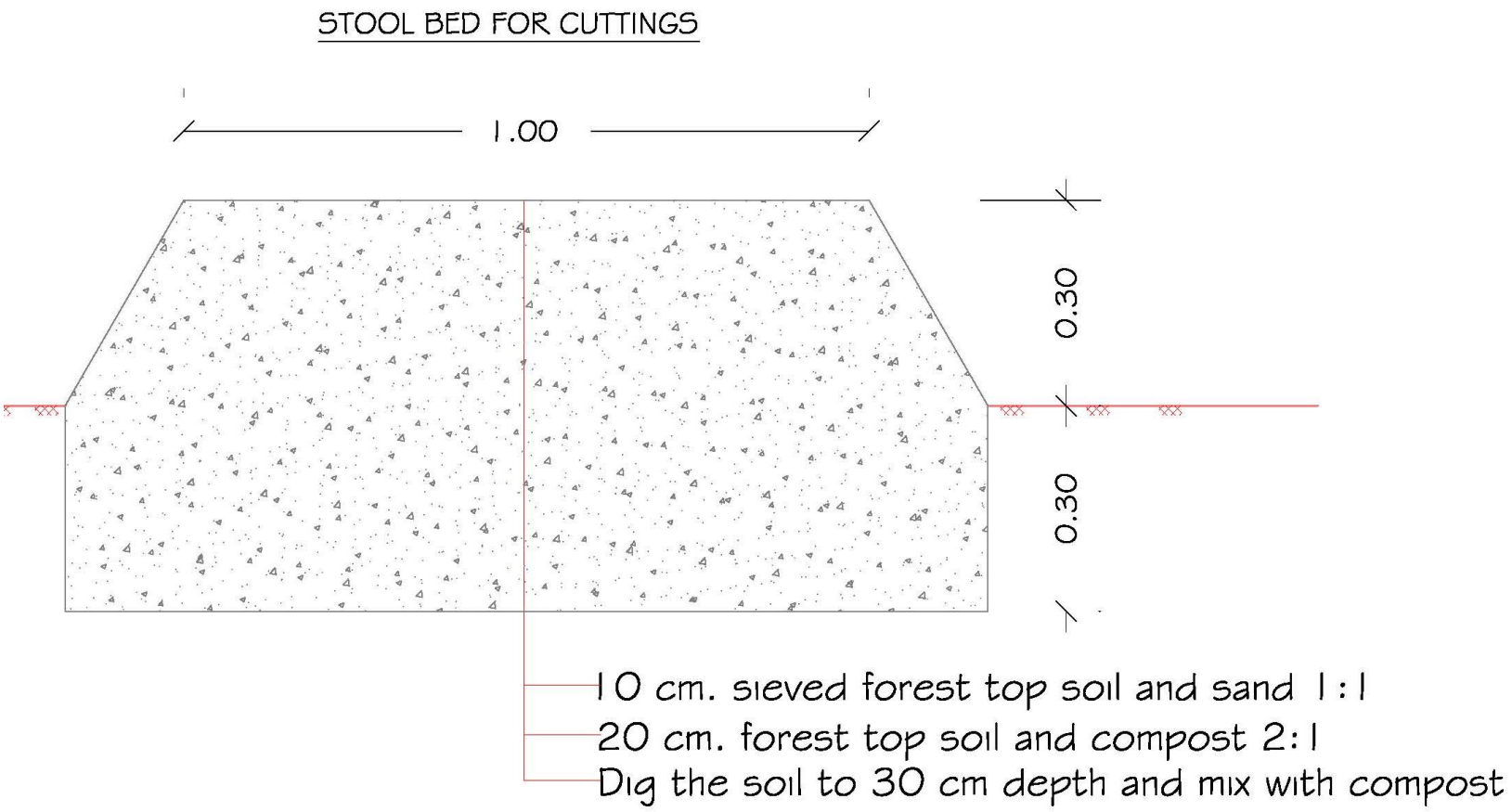
Grass beds



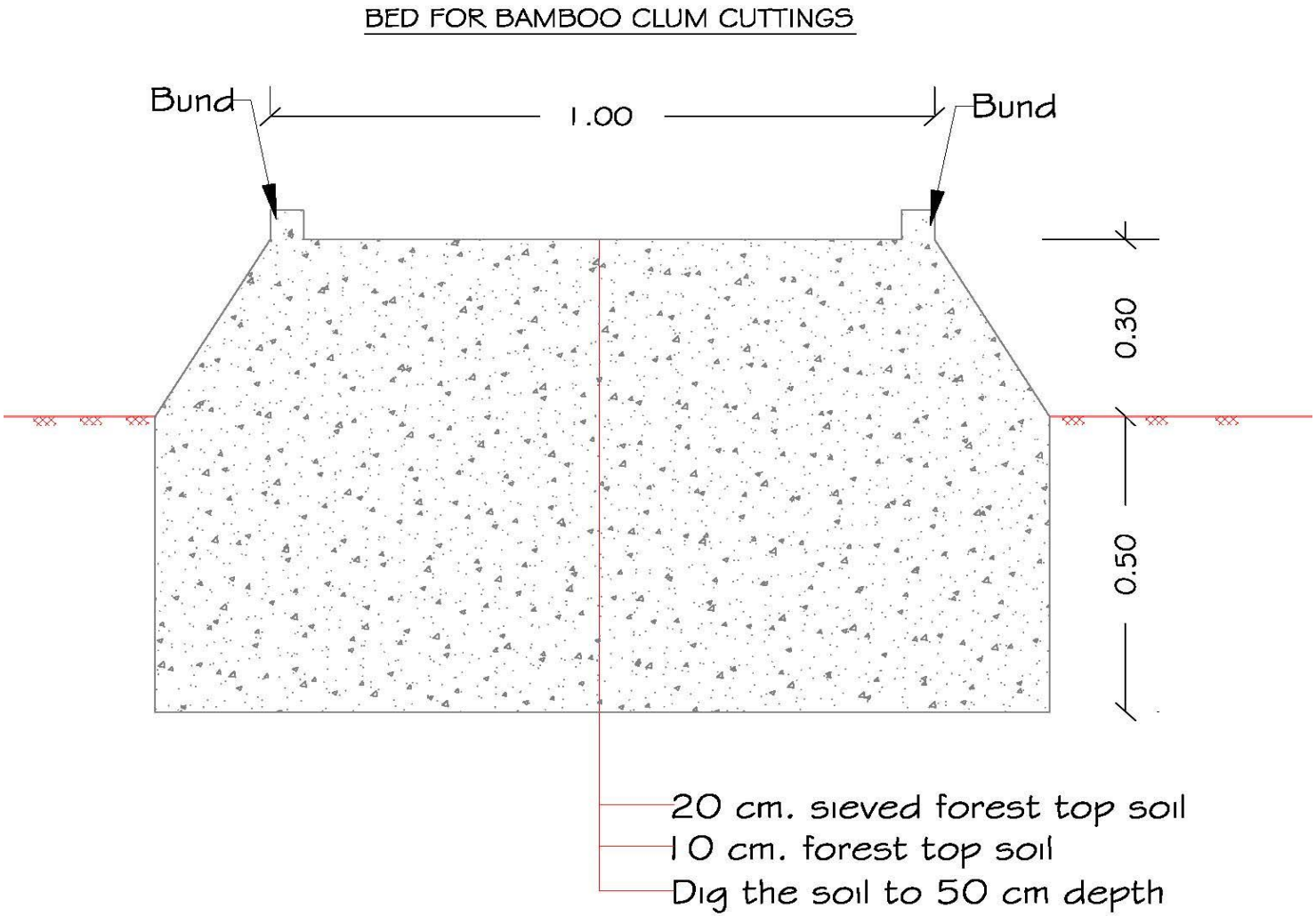
Nursery bed



Nursery bed



Nursery bed



Bamboo bed

Session-15
Seed Collection and Storage

Seed collection

What is the purpose of collecting seeds?

The purpose of seed collection is;

- to raise plants in the nursery for later planting on site
- for direct seeding on site
- to raise plants in nurseries or reserve areas as sources of material for later use.

Seed collection

Selection of propagation method

- In bio-engineering works we use the propagation method which gives us the best combination of the following:
  - the cheapest means of mass reproduction
  - the best chance of success in producing new plants
  - the most vigorous new plants

Seed collection

Sometimes plants grow better from cuttings than they do from seed. But some plants do not grow from cuttings.

Examples:

- *Acacia catechu (Bangla: Khayer) grows very well from seeds but it does not grow by cuttings*.

Seed collection

Examples:

- *Saccharum spontaneum* (*Bangla kans*) grows very well from slip cuttings with almost 100 % success but, although it will grow from seed, it has a lower survival rate from seed;

- *Vitex negundo (Bangla: Nishinda)* grows very well from cuttings but its seeds are very small and are difficult to germinate in nurseries.

Seed collection

Locations and plants for seed collection

- Ideally seeds should collect locally, from natural stands near the proposed planting site, with similar altitude, rainfall, soil and aspect.
- If we are obtaining seed from another supplier we should aim to provide information on the nature of the planting site and ask our supplier to provide seed to match this site as closely as possible

Seed collection

How to collect seeds

- only employ seed collectors if they like climbing trees and can do so safely;
- seed collectors should work in twos, then if one needs help, the other can go and get it;
- only healthy trees with strong branches should be climbed and the climber should use safety gear;
- proper fruit cutting tools with long handles should be used, so that there is no need to cut off large branches.

Seed collection

How to collect seeds

- pick only fresh, ripe and healthy fruits do not collect fruits that are unhealthy or attacked by insects;
- harvest fruits without damaging the tree;
- collected seed should only be stored and transported in cloth or hessian sacks. Do not put them in polythene bags, as they will get warm and mouldy very quickly and spoiling the seeds inside.

Seed collection

Calculation of seed requirement for nursery production

- Because of natural uncertainties, you need to obtain and sow many more seeds than the actual number of seedlings required. It is normal to grow 25% extra seedlings and discard the poorer plants when they leave the nursery. Also allow four times the amount of seed for the total number of seedlings to be grown. Therefore, for every 10 seedlings to be used on site, 50 seeds should be obtained and sown. The calculation below shows the amount of seeds required for 5,000 of Khayer trees.

Seed collection

Calculation of seed requirement for nursery production

Species: *Acacia catechu (*Khayer)

Requirement of seedlings	5,000
25% extra for culling	1,250

	6,250

Total no. of seedlings to be grown in nursery **6,250**

Seed collection

Calculation of seed requirement for nursery production

Number of seeds in kg. 30,000 seeds of Khayer

Seed requirement and to be collect

Total no. of seedling 6,250 x 4 = 25,000 no. seeds

Seeds requirement 25,000/30,000 = 0.83 kg.

Say 0.9 kg.

Seed storage

Seed processing and storage

Type of seed

- Recalcitrant seeds
- Orthodox seeds

- "recalcitrant" seeds:

these are seeds that must be kept moist if they are going to germinate (*Artocarpus heterophyllus*: Bangla: Kanthal - jackfruit)

Seed storage

Seed processing and storage

"orthodox" seeds:

these are seeds require drying and storage in dry condition (*Acacia catechu:* Bangla: Khayer)

Storage:

- Seeds should be properly separated from the fruit
- Recalcitrant" seeds must be kept in moist and cool,

Seed storage

Storage

- Orthodox seeds should be dried in the sun,
- Once the seeds are thoroughly dry, place them in a hessian jute bag for storage.
- Labelling of seed
- Keep the seed containers in a cool, dry room with well-ventilated room.

Session-16

Collection Vegetative Plant Materials

Collection vegetative plant materials

Why do we prefer to use cuttings for bio-engineering plant reproduction?

- plants grow more rapidly from cuttings than from seed;
- seed of some plants is very difficult to obtain.

An additional benefit of hardwood cuttings in bio-engineering is:

- hardwood cuttings immediately perform a physical function

Collection of vegetative plant materials

Examples:

- *Saccharum spontaneum* (*Bangla kans*) grows very well from slip cuttings with almost 100 % success but, although it will grow from seed, it has a lower survival rate from seed;
- *Vitex negundo (Bangla: Nishinda)* grows very well from cuttings but its seeds are very small and are difficult to germinate in nurseries.

Collection vegetative plant materials

Types of cuttings used in vegetative propagation

- Stem cuttings
- Rhizome cuttings
- Slip cuttings
- Stolon cuttings
- Stump cuttings

Collection vegetative plant materials

Types of cuttings used in vegetative propagation

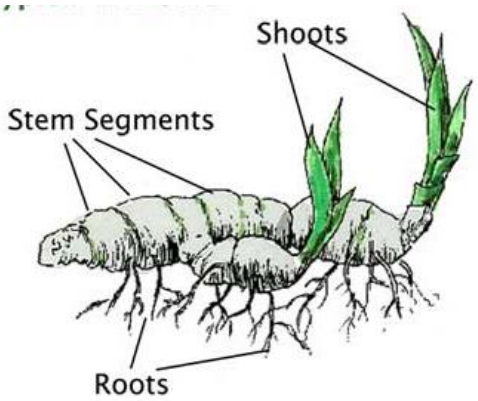
- Grass
  - Stem cuttings
  - Rhizome cuttings
  - Slip cuttings
  - Stolon cuttings

Types of cuttings used in vegetative propagation

Grass:

Stem Cuttings

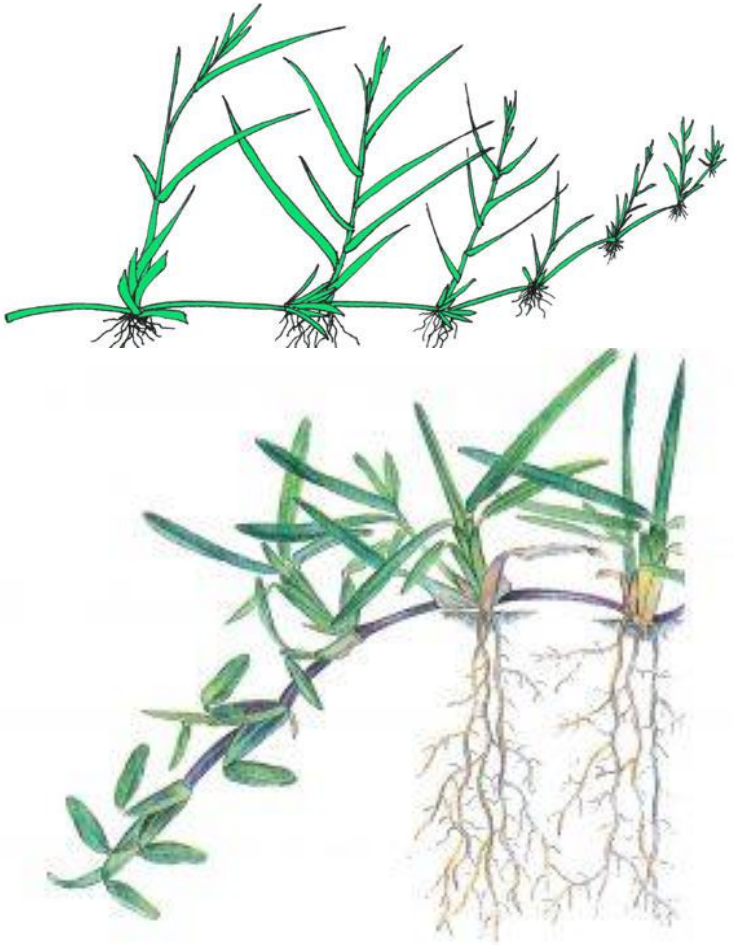
Rhizome cuttings



Types of cuttings used in vegetative propagation

Grass:

Slips cuttings



Stolon cuttings

Types of cuttings used in vegetative propagation

- Tree and shrub
  - Stem cuttings
  - Stump cutting

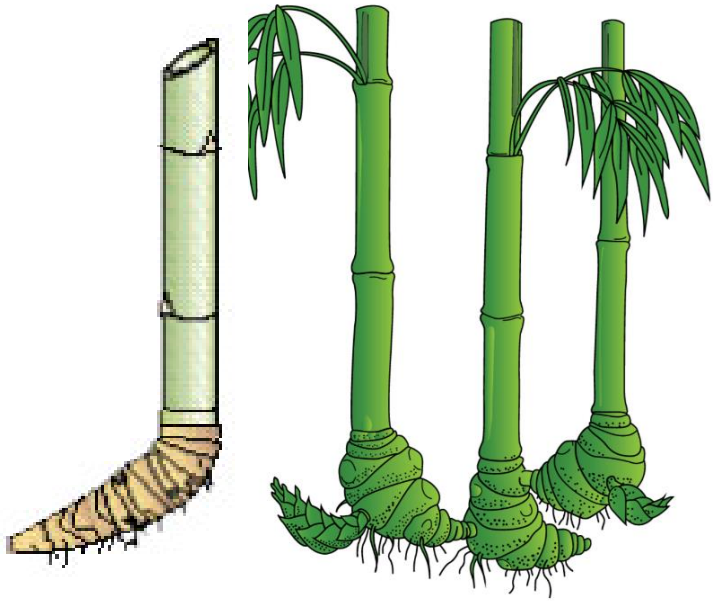
Stem cuttings

Stump cuttings

Types of cuttings used in vegetative propagation

- Bamboo
  - Rhizome cutting
  - Stem cuttings

Stem cuttings



Rhizome cuttings

Collection of vegetative plant materials

Sources of material and age of parent part

Type of plant	Cuttings	Example	Source of material	Age of parent part
Grass	Stem (culm) cuttings	Napiar grass	Upright stem	6 to 18 months
	Rhizome cuttings	Tigar grass	Clump	3 to 18 months
	Slip cuttings	Vetiver grass	Clump	3 to 18 months
	Stolon cuttings	Bermuda grass	Horizontal stem	6 to 18 months
Bamboos	Rhizome cuttings	All types	Clump	1 to 2 years
	Stem (culm) cuttings		Upright stem	2 to 3 years
Trees and shrubs	Stem cuttings	Bangla: Nishinda (Vitex negundo)	Single plant stem	1 to 3 years
	Stump cuttings	Bangla: Sissoo	Single plant stem	1½ to 3 years

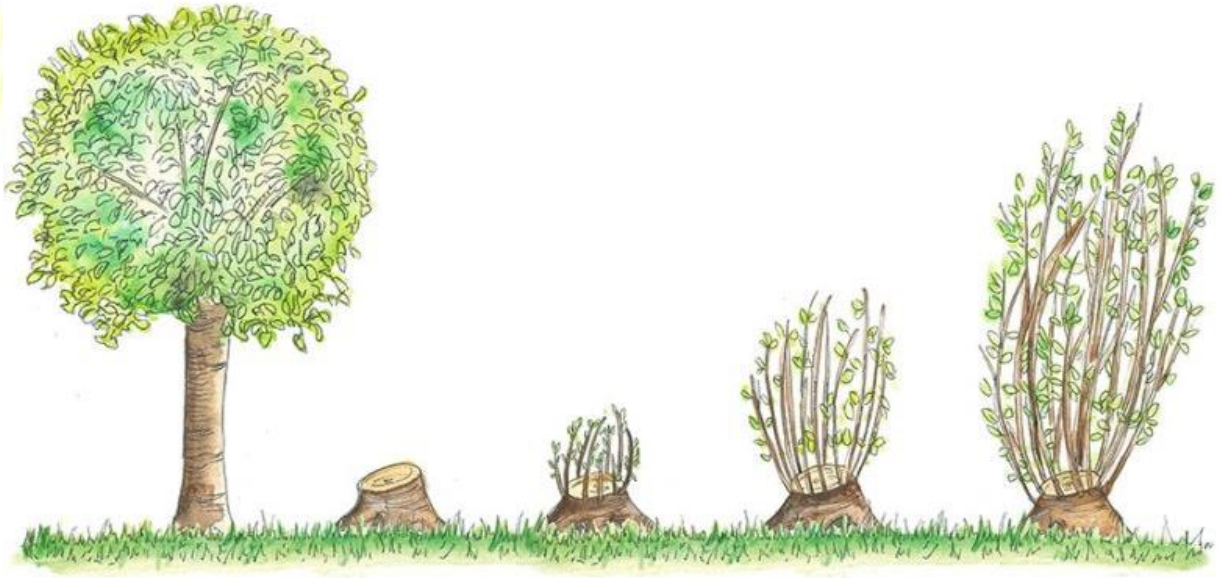
Collection of vegetative plant materials

Selection of plants for cuttings

- plants that are already being propagated by farmers or foresters
- signs of coppicing
- signs of pollarding;
- signs of aerial roots or natural layering;
- heavy branching;
- many new shoots coming from where the plant has been cut or damaged.

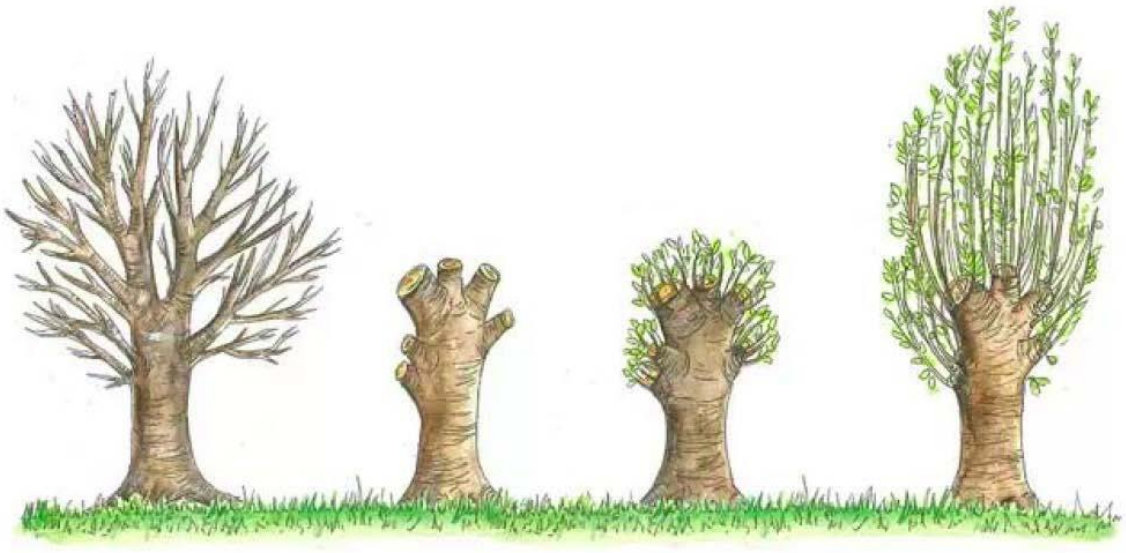
Collection of vegetative plant materials

- Coppicing
  - the process of cutting trees and shrubs, allowing the stumps to regenerate



Collection of vegetative plant materials

- Pollarding
  - a pruning system in which the upper branches of trees and shrubs are removed, which causes the plant to produce a dense but lightweight head of foliage and branches.



Collection of vegetative plant materials

Selection of plants for cuttings

Aerial roots

Layering

Collection of vegetative plant materials

Criteria for selecting individual plants as material sources

- plants must have reached maturity, and therefore be productive and capable of continuing to yield material;
- plants must be healthy and therefore be productive and give healthy material for propagation;
- they must be of reasonable size so they can yield a significant amount of material. Size also indicates age and maturity;

Collection of vegetative plant materials

Criteria for selecting individual plants as material sources

- plants must be in good condition and not damaged by insects or in other ways.
- plants should take only a reasonable quantity of cuttings from each plant so they do not eradicate the entire source of material


BREAK
TIME

Open Discussion

Thank you for your kind attention

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