

1. THE TAMARIND TREE

Tamarind (*Tamarindus indica*) is an economically important tree, found in many countries of Asia, Africa and South America. The tree can grow to a maximum height of 25m and a crown diameter of 12m. It is ideal for drier-arid regions, especially in areas prone to prolonged drought. Tamarind can tolerate 5-6 months of drought conditions, but does not like fire, frost or waterlogging.

There are different varieties of tamarind, e.g. cultivars 'Sithong', 'Piyai' and 'Jaehom'. The varieties can be divided into 'sweet' and 'sour' types. Most countries grow unselected local 'sour' types, when standard 'sweet' varieties are not available. In some 'sour' tamarind trees, isolated branches can be found that bear 'sweet' fruit (bud spots), these branches can be used for vegetative propagation to obtain sweet tamarind plants.

Tamarind is a multi-use tree (see Appendix 1). It is a source of timber, fruit, seeds, fodder, medicinal extracts and potential industrial components, so in terms of the rural farmer the tree can provide seasonal income in periods of potential hardship. Tamarind trees are able to compensate farmers in seasons after subsistence crops have generally been harvested (pods are harvested in the dry season), thereby giving a potential economic return in local markets when food is scarce.

Tamarind is a tree that is easy to cultivate and requires minimum care. It is generally free of serious pests and diseases, has a life span of 80-200 years and can yield 150-500kg of pods per healthy tree/year at 20 years of age. The potential of the tamarind tree within rural farming communities has been well recognised, although unimproved wild trees are continuously being exploited to meet growing domestic and international demand.

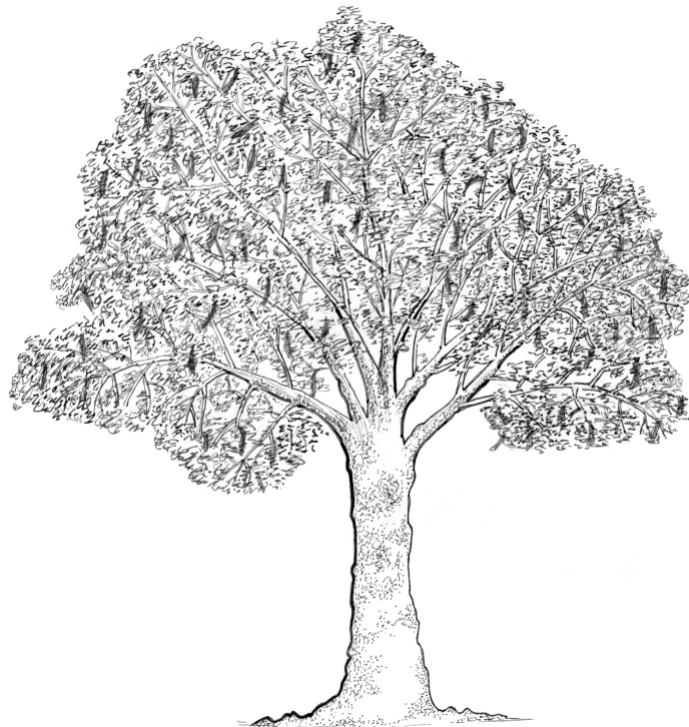


Figure 1.1. Tamarind tree with pods

2. WHY GROW TAMARIND

2.0.1. Nutrition

Tamarind produces a nutritious fruit, high in vitamins B1 (Thiamin), B2 (Riboflavin) and B3 (Niacin). These vitamins work together to help the body convert food into energy. They also help to provide a healthy immune system to fight off disease and help the body to be strong. Tamarind is a fair source of vitamin C, which, like the B vitamins, helps to provide a healthy immune system. Vitamin C also helps to provide strong bones, teeth and skin. Tamarind is rich in the minerals, potassium, phosphorus, calcium and magnesium, which help to keep the body in balance. Calcium, magnesium and potassium help to protect the bones and teeth, and all have a role in providing strong muscles and general health. Tamarind can also provide smaller amounts of iron and vitamin A. Iron is present in the blood, and helps the movement of oxygen through the body, to the organs which require it. Vitamin A is necessary for good eye sight. Some cases of blindness have been attributed to lack of vitamin A in the diet, predominantly in developing countries. Tamarind also contains a high level of protein, with many essential amino acids, which help to build strong and efficient muscles. Tamarind is also high in carbohydrate, which provides energy.

2.0.2. Income generation

Farmers can use the tamarind tree by incorporating it within their agricultural system to enhance household incomes. Tamarind products are popular in many countries, but there is little organised marketing of pods or pulp, so market returns can vary considerably. In full production, a tree yields on average 80-100kg of pulp per year and the tree should remain productive for at least 60 years. If unused land is available, tamarind trees can be considered for additional income. However, the local market and market price for tamarind must first be established to ensure production would be profitable.

2.0.3. Fodder

Both the seeds and leaves of the tamarind tree can be used to feed domestic animals. Leaves are more popular as they require less preparation. The leaves are very high in crude protein and are relished by wild animals. Leaves, however, are rarely used for this purpose on homesteads, as harvesting the leaves can reduce fruit production.

Seeds can also be used as animal feed, however, the seed coat is very hard and must first be removed, which can be eased by boiling. The seeds must then be ground. The seeds are also very high in protein.

2.0.4. Timber

Tamarind wood is made up of heartwood and sapwood. The heartwood is dark reddish in colour and is very hard, durable and resistant. It is often used for making furniture, as it gives a good polish, but it can be difficult to work. The sapwood is yellow in colour and is far less durable than the heartwood; it is also liable to insect attack. Although tamarind wood is used widely, it is of little commercial importance.

2.0.5. Medicines

Tamarind is used in traditional medicine throughout Africa and Asia. Modern medical science has also confirmed the laxative and diuretic properties of the tree. All parts of the plant are used, from the fruit pulp and seed to the leaves, bark and flowers. Ailments such as diarrhoea, jaundice, ulcers, eye

infections and digestive problems can be treated with infusions, pastes and powders. Herbal practices are still widely used.

2.0.6. Industrial

In addition to the industrial processing of tamarind fruit into a range of products such as pulp, juice, paste and candy, tamarind seed can also be processed to produce oil, jellose (a jelling agent) and tamarind kernel powder (TKP).

2.0.7. Environmental Impact

Tamarind trees have positive environmental benefits as they provide perennial cover protecting the soil. Grown especially in arid climates, tamarind can provide, store and recycle plant nutrients, and give stability to the soil. Tamarind trees also act as effective windbreaks.

3. WHERE TO GROW TAMARIND

Tamarind can be grown on a homestead, plantation, wasteland or as a forest tree. The tree is suitable for marginal lands, where rainfall and poor soil may limit other crop production. An average yearly rainfall of 500-1500mm is required for healthy tree growth. Where rainfall exceeds 4000mm, the trees may grow but flowers will not develop and the tree will not yield a crop. Regardless of total annual rainfall, tamarind produces more fruit when subjected to a fairly long annual dry period. The tree can be grown in warm regions, but temperatures should not exceed 33-37°C (maximum) or go below 9.5°C (minimum). The trees cannot withstand frost and should therefore not be planted where frosts occur.

Tamarind is able to flourish in a wide range of soils e.g. rocky, sandy, or rich soils, but all soils need to be free draining. The tree grows well in open areas and does not thrive when shaded. The branches are wind resistant, and the deep tap root and extensive root system aid stability, which means it can withstand violent typhoons and cyclones. Tamarind can grow up to 2000m above sea level.

Once established in the field, tamarind trees do not usually require irrigation and can be inter-cropped with a number of food crops, such as cowpeas and beans, until 4 years old. Homestead trees can provide shade and act as a windbreak in areas of strong prevailing winds.

4. GROWING TAMARIND TREES

There are two methods of propagating tamarind trees:- seed propagation and vegetative propagation.

- **Seed propagation** involves the collection, preparation and direct planting of the seed into soil/compost. This method is very simple, however the quality of the new offspring cannot be guaranteed (not true-to-type) and the time taken for the tree to reach bearing age is usually longer than for trees propagated using vegetative methods.
- **Vegetative propagation** may be carried out using a number of different methods, these are described in section 4.3 of the manual. Vegetative propagation involves the growth of the new tree from a shoot, bud or cutting of a mature, 'good quality' or 'plus' tree. This guarantees the quality of the new tree. Selection of planting material for both seed and vegetative propagation is described below.

The best time to begin propagation depends on the local climate, water availability and method of propagation. Seed propagation is limited by the fruiting time of the mature, healthy trees from which seed is to be collected. Vegetative propagation, on the other hand, does not have the same limitation. Scions (shoot/buds) can be obtained throughout the year, however collection is dependent on the stage of tree growth of the mother plant. Regardless of which propagation method is used, it is essential to select a tree with good qualities, referred to above as 'plus' tree, from which to collect either seeds or vegetative material.

4.0.1 Selection of planting materials

When selecting a good 'plus' tree the following points should be considered:

- the tree should have a good crown and strong trunk;
- the tree should be disease-free, undamaged and have no signs of pest attack;
- pods and scions should be selected from a tree that is older than 15 years and is known to produce a good harvest of fruit;
- for consistent pods and pulp yields, it is essential that the tree produces pods every year. Some trees produce pods every two years.

Once the 'plus' tree has been selected, it is necessary to prepare an area for propagation. A nursery will provide protection to the plants when very small, and a greater chance of full establishment later on. The following pages provide details of nursery establishment.

4.1. NURSERY ESTABLISHMENT

The size of a nursery is dependent on the number of trees required. Seeds may not have 100 % viability (in tamarind most seed lots give 72 - 82 % germination from healthy seed), so 20-30 % extra seed will need to be sown than required in terms of number of trees. Not all grafted or stem propagated trees will root, so it is better to prepare a slightly larger area than for the exact number of trees required.

Land suitable for a small tree nursery could be on a homestead, in a fenced enclosure, and if possible, situated close to a water source. Young trees do require more water than mature trees and they are more prone to damage by animals, such as goats and cattle, so an enclosure around the chosen nursery area may be required.

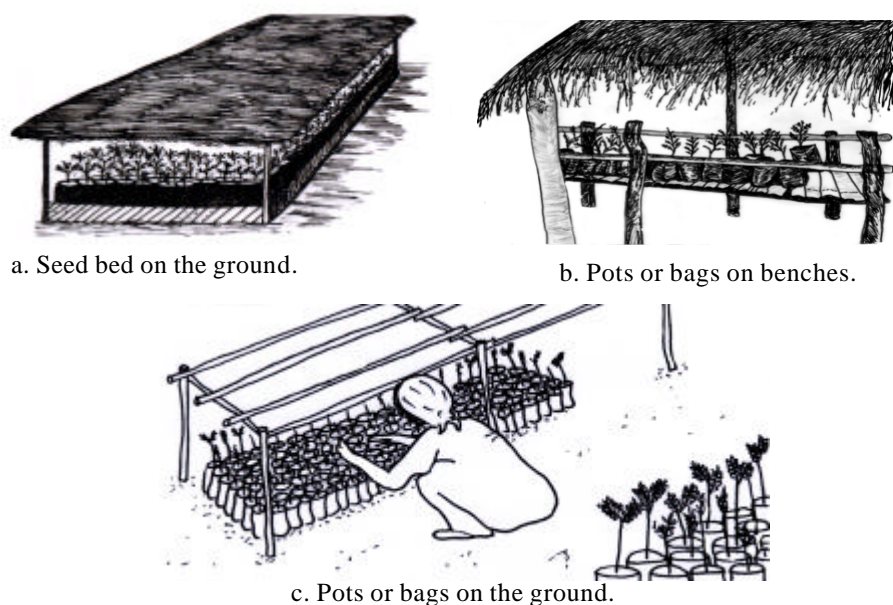


Figure 4.1. Tamarind tree nurseries

The above diagrams show three types of tree nurseries with overhead shade. The benches (Fig. 4.1b) can be made from locally available materials such as bamboo canes, and palm fronds or grass can be used for the roof. A tree nursery does not always require benches, as pots can be placed directly on the ground (Fig. 4.1c), or a seedbed/rooting bed can be used for bare-rooted transplants (Fig. 4.1a).

All seedlings or cuttings require a roof structure to shade the plants and prevent leaf scorch. Care must be taken in the design of the nursery in terms of the height of the shade attachment and also the quality of the palm leaves or grasses used. Older palm leaves should be avoided for such structures as they can harbour fungi, such as mildew, which can be transmitted to the young plants below. Therefore, only new fronds or grasses should be used and, if possible, a fence to prevent foraging animals should be built. The nursery shade should allow some sunlight through the roof and sides; the aim is to allow about 30 % sunlight to reach the top of the young plants and 60 % to reach the sides.

The nursery should not be situated on waterlogged land or land prone to waterlogging. It should be sufficiently far from paths to prevent human and animal damage, and far enough from shade trees if a roof is being used. Prior to building the nursery structure, the ground must be cleared of all weeds and pests. A plastic ground cover can be used to prevent weed re-growth. Otherwise, the ground should be lightly hoed and top dressed with clean sand and gravel or small stones.

4.1.1. Pots and potting mixture

Pots can be made from any available material, such as plastic bags, clay, tin cans (punctured) or natural vegetation, e.g. banana leaves or woven baskets (Fig. 4.2).

NOTE: Natural pots may last for less time and be more sensitive to uplift or storm damage.

Tamarind usually produces a long tap root, which, in the case of plastic bags and natural pots, may grow into the soil. Moving the pots with the plants is therefore a delicate operation. Placing the pots on a raised bench (perforated or latticed) reduces this problem, as the roots will be air pruned with no damage to their growing points.

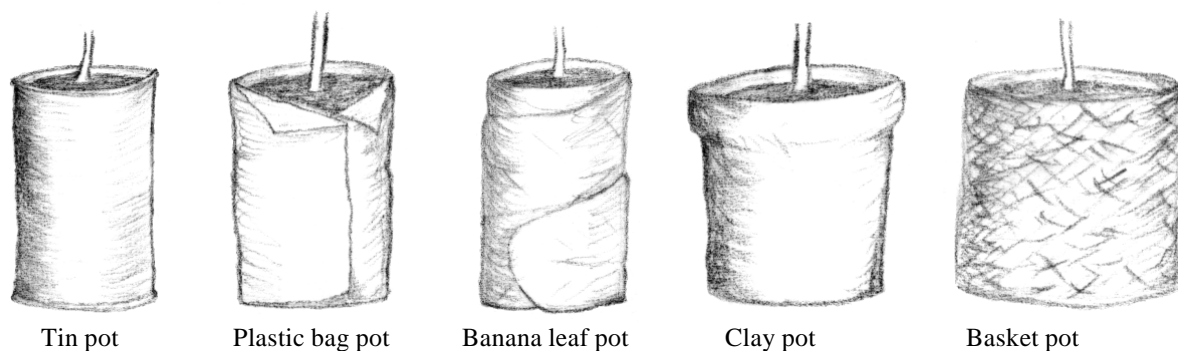


Figure 4.2. Pot sources

The best media for seed germination is soil, mixed with sand and cow or chicken dung. Normal potting mixtures usually contain 3 parts topsoil, 1 part sand and 1 part compost.

NOTE: Sand should not be used directly from beach sources, as it may contain too much salt for the young trees. Sand from high up the beach or inland is better for potting mixtures.

4.2. SEED PROPAGATION

4.2.1. Seed extraction from the pulp

Fully formed, ripe pods, showing no damage or disease, should be selected. The ripe pods are dried in the sun for 5 to 7 days, turning occasionally. When the fruit is dry, the pods should be cracked to separate the pulp from the pod shell and the seed extracted by hand kneading or washing in water. The seeds should be washed to remove any pulp and dried in the shade for 2 days. The seed can be stored in a cool, shady place in sealed, clay jars, away from rats, mice or insects. Storage time can depend on the condition of the seed, and how well it was cleaned and dried.

IMPORTANT: Fresh pods bought in the market can be used as a source of tamarind seed, though seed may originate from poor or diseased trees. Such seeds may have a delayed germination time, lack of viability or produce inferior trees.

4.2.2. Seed pre-treatments

Healthy seeds of tamarind have approximately 72 % germination. The percentage of germination can be increased by treating the seed before planting, which also reduces the germination time.

Tamarind seed can be treated as follows:

- Soaking in clean water for 24 hours (can improve germination to 80 %) (Fig. 4.3a)
- Cutting (scarifying) the seed coat (can improve germination to 85 %) (Fig. 4.3b)
- Both scarifying and soaking in water for 24 hours (can improve germination to 92 %)

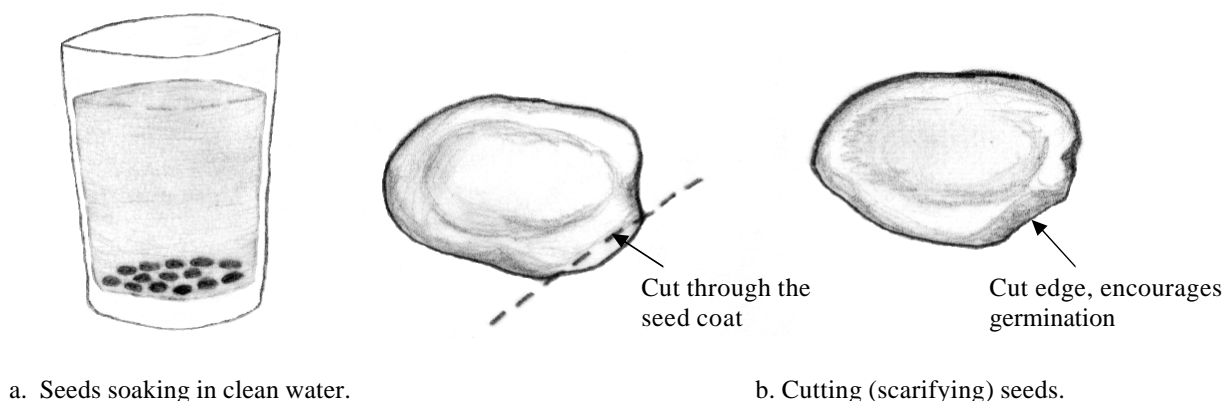


Figure 4.3. Seed preparation

4.2.3. Planting and germination

Tamarind seeds should be sown in well-prepared seed beds, boxes or pots, at 2-3cm distances apart. One seed should be placed in each hole at a depth of 1-2cm, covered with compost (sandy loam) and watered. If the seed is planted too deep in the soil, germination might not occur and the seeds will rot (Fig. 4.4).

The compost should be kept moist. Seed germination should begin after approximately 5-10 days with viable seed, but may take up to one month before shoots can be seen above the soil. Tamarind has a hard seed coat, so delayed or poor germination may occur.

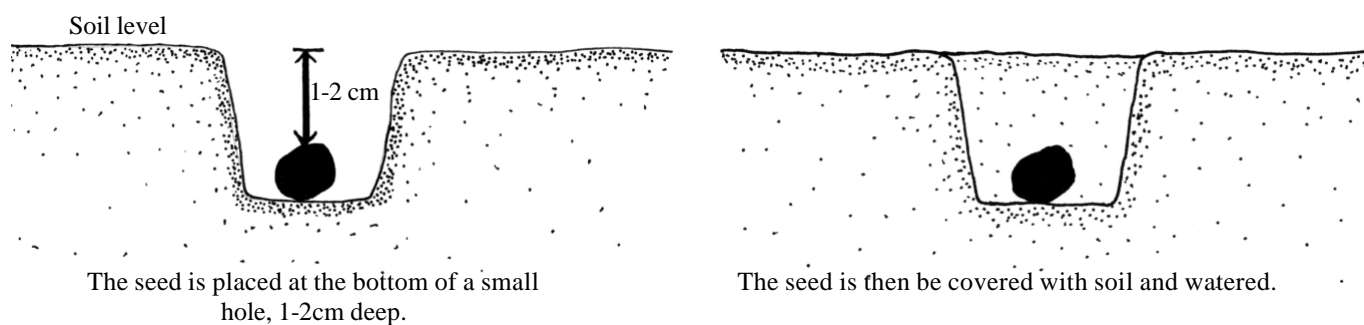


Figure 4.4. Planting of Tamarind seeds

Once the seedling tree has emerged, it should remain in the nursery and be watered regularly until it is at least 30-40cm tall. After this time, the seedling can be established in the field.

4.3. VEGETATIVE PROPAGATION

Vegetative propagation can be practiced throughout the year, but it is less successful in the hot season. This method requires shade and water resources, and higher losses may be experienced than with seed planting. Chemical rooting hormones will improve the efficiency of this method.

Tamarind can be propagated vegetatively by stem cuttings (softwood, semi-hardwood and hardwood), grafting and ground or air layering. With all methods, it is important to choose shoots and branches that are free from disease, pests and damage. Stems or branches displaying leaf colours other than green should also be avoided.

4.3.1. Stem cuttings

The easiest and cheapest method of propagating tamarind vegetatively is by stem cutting. There are three types of stem cuttings: softwood (new shoots, flexible and green), semi-hardwood (young shoots under a year old with wood evident) and hardwood (older shoots, all wood). Hardwood cuttings, however, will not root for tamarind and should not be attempted.

All cuttings should be collected early in the morning. Softwood cuttings should be approximately 15cm in length, whereas semi-hardwood cuttings should be 18-20cm in length with 3 nodes (leaf attachments). Leaves are removed from the bottom nodes in all cuttings and a clean cut should be applied to the base of this node, at a 45 degree-angle (Fig. 4.5).

Softwood cuttings have better rooting success than semi-hardwood cuttings, especially when they are from terminal shoots with new flushes of leaves. Terminal cuttings have an advantage over mid stem cuttings because there is only one cut end, which reduces the possibility of infection.

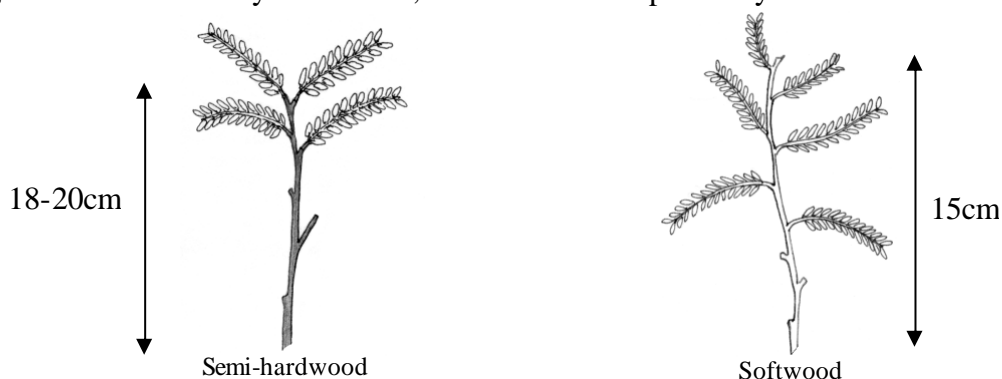


Figure 4.5. Tamarind cuttings

Soft or semi-soft mid stem cuttings must be wrapped in moist cloth after removal from the tree to prevent loss of moisture. Rooting hormone is essential when using this method. The cuttings should be dipped in rooting hormone (IBA at 1000ppm) and then placed on a sand bed in a mist propagator (75-80 % humidity).

NOTE: If the cuttings have to be transported for a long time they should be wrapped in moist cloth or paper to prevent loss of moisture.

4.3.2. Propagation areas and shoot treatments

Before the cuttings are collected, it is necessary to have a soil bed prepared within which rooting will take place. The soil bed provides shade and protection to the young cuttings. Wooden poles can be used for the uprights and grasses or palm fronds can be used for the roof (see nursery construction, section 4.1). A soil bed can be constructed on or near the homestead, but care must be taken to keep animals away from the rooting area.

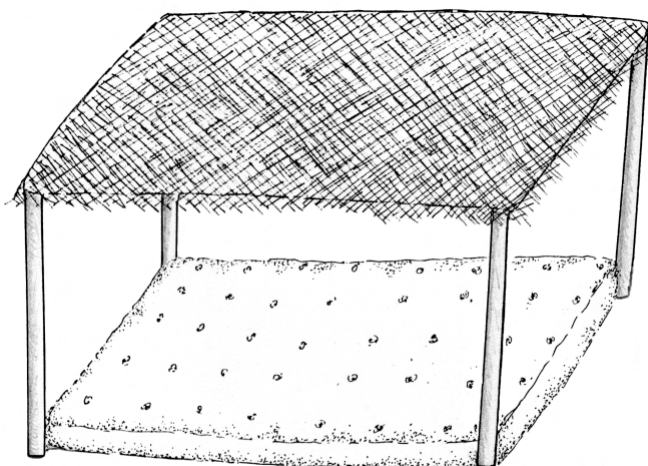


Figure 4.6. Rooting bed and shade for propagation

Softwood cuttings should be pushed straight into the soil to a depth of 2.5cm, the top of the shoot should be no more than 20cm from the soil surface. The shoot top can be removed, this may encourage root growth rather than further shoot growth, however, this method is not recommended for semi-hardwood cuttings.

If available, rooting hormone should be applied to the cuttings, this can improve rooting success and reduce the time taken for root development (10-15 days instead of 40-50 days). The cut end of the cutting should be moistened and dipped for 10 seconds in the powder, before inserting into normal nursery soil mixture. The cuttings should be watered regularly but not excessively and once well established can be transplanted into the field.

NOTE: The local extension officer should have information about the availability, cost and use of rooting hormone.

4.3.3. Grafting

Grafting involves removal of a shoot or bud from a tree and joining it to a rootstock. Once the union has healed and fresh growth occurs on the newly attached portion, it is said to be successfully grafted. It is mostly done by removing a shoot or bud from a 'superior' or 'plus' tree to a compatible seedling rootstock. Grafting of tamarind trees can enhance pod production, reduce length of time to bearing and may increase resistance to disease.

Equipment required for grafting includes a clean and sharp budding knife, polyethylene tape, 1.5-2cm wide, approx. 30-40cm long, which can be cut from ordinary clear plastic bags if budding tape is not available.

There are two main types of grafting, bud grafting (also known as patch budding) and shoot grafting.

4.3.3.1. Bud grafting

A small piece of budded bark (scion) is taken from a good quality 'plus' tree and fixed onto a rootstock in place of an equal sized piece of bark that has been removed. The bud is tied firmly with polyethylene or specially prepared budding tape to keep it in position. Budding should be carried out when the seedling rootstocks are 6-9 months old. A good indicator that the budding is likely to take, is when the budwood is in active growth and the bark is easy to peel off.

Bud grafting results in a stronger bud union than shoot grafting and can be used for large-scale multiplication of tamarind.

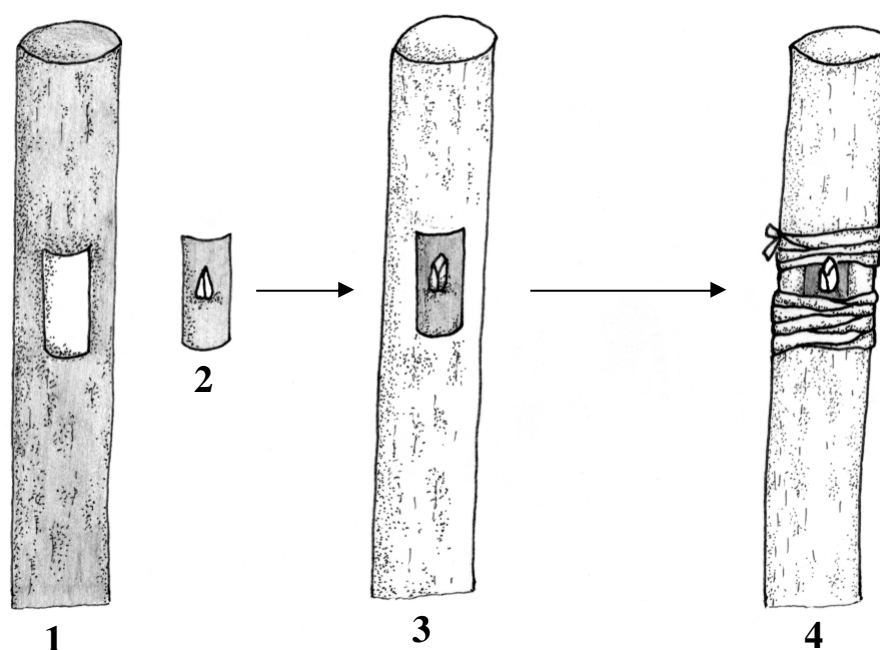


Figure 4.7. Patch budding in Tamarind

1. Patch of bark removed from 'plus' tree, 2. Patch of bark with a bud from a desirable scion, 3. Bud inserted into the rootstock plant, 4. Bud is wrapped firmly with tape.

4.3.3.2. Shoot grafting

There are two methods of shoot grafting, 'approach' grafting and 'cleft' grafting. The most reliable method (95 % success) for tamarind is the approach method.

Approach grafting

This method requires two self sustaining plants, one is the rootstock plant, which must be vigorous and sturdy to provide excellent anchorage for the new plant and the other is the 'superior' or 'plus' plant, which has the desirable characteristics required by the grower. A small section of bark (approx. 5-6cm in length and 1-2cm in width, depending on the size of the stem) should be removed from both the rootstock plant and the superior tree, at the same level, using the budding knife. The area of bark removed should be just deep enough to expose the inner tissue of the stem and allow close contact of this tissue between the two plants. The union of the two plants should then be bound firmly using grafting tape and waxed. The wax will prevent water entering the wound, as this may cause rotting. The wax will also increase the temperature and humidity around the union which will help in the healing process of the graft. The healing process in shoot grafting is usually longer than in bud grafting, and may take up to one month. Once the union is complete, the rootstock plant should be severed above the graft and the base of the 'superior' plant is removed below the graft. The grafted tree will now obtain nutrients from the soil using the root system of the rootstock plant.

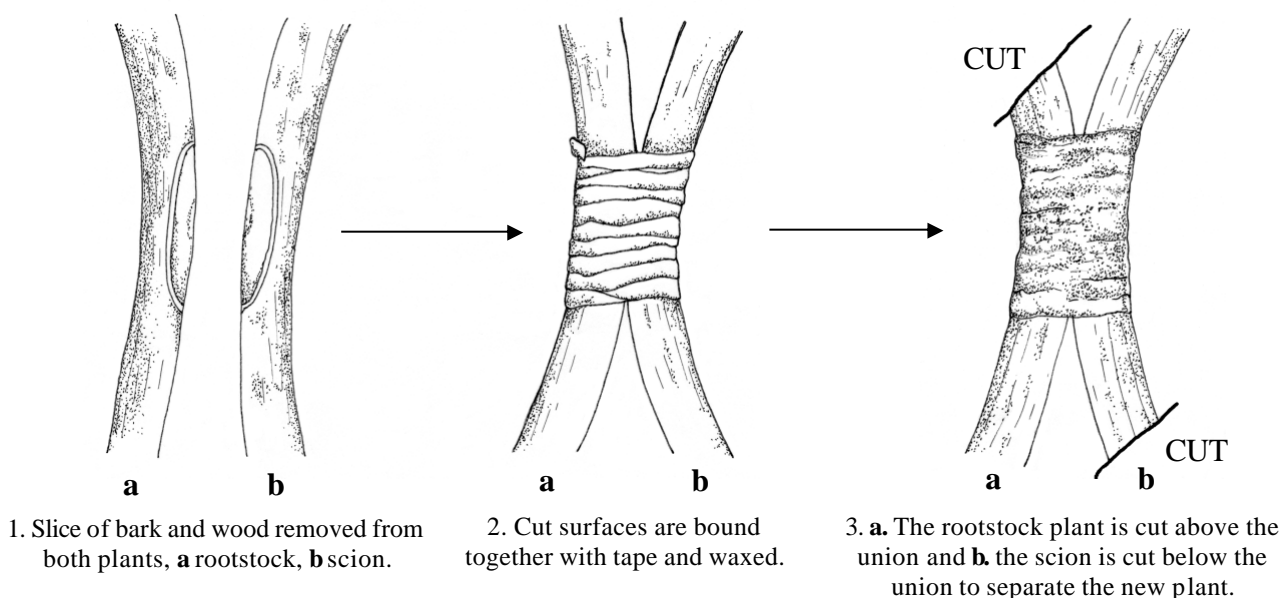


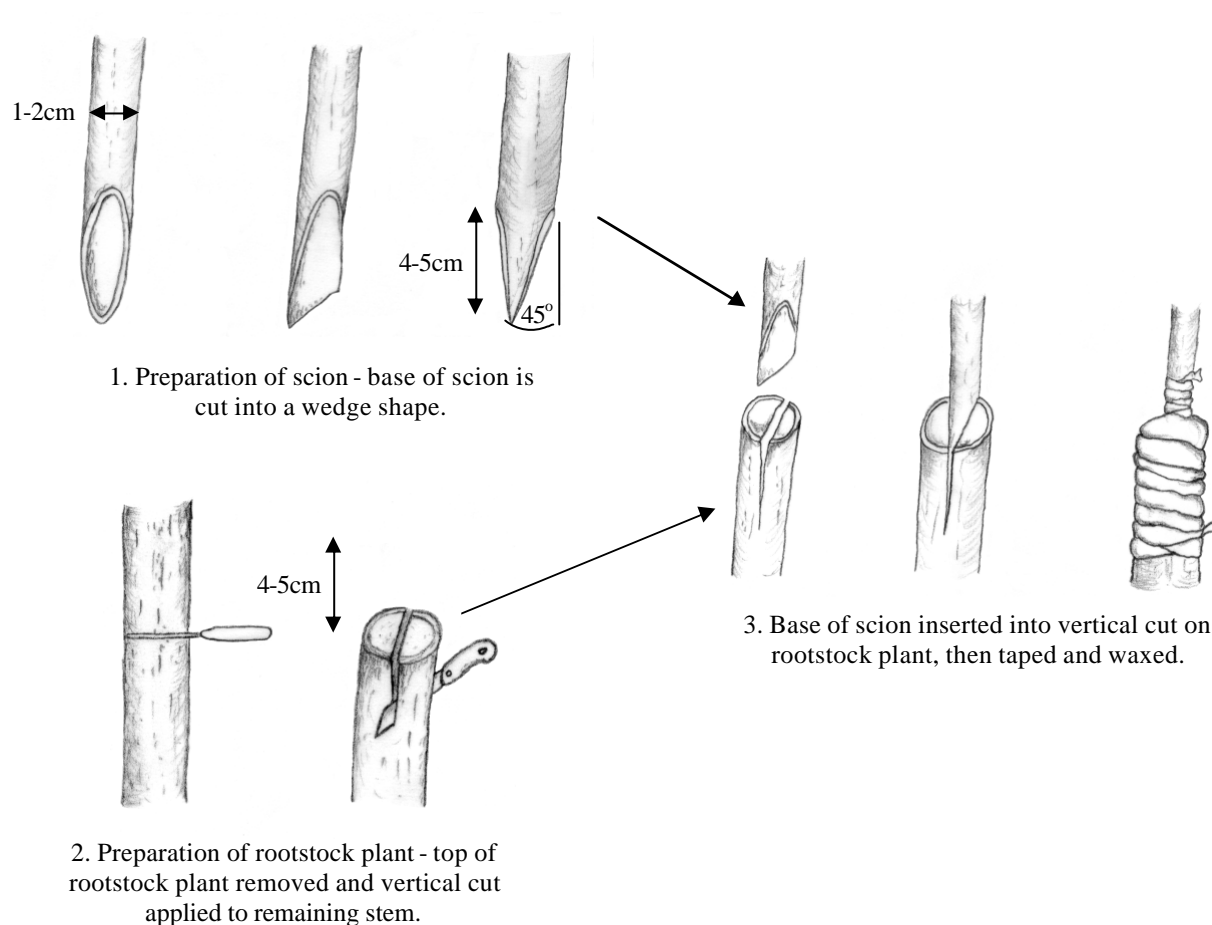
Figure 4.8. Approach grafting of Tamarind

Cleft Grafting

Tamarind can be propagated using cleft grafting. This method also requires two self-sustaining plants, the rootstock and the 'superior' plant. The vegetative (top) section of the rootstock plant should be removed with the budding knife, using a horizontal cut at 20-30cm above the level of the soil. A 4-5cm vertical cut should then be made into the cross section of the stem. A scion should be removed from a 'superior' plant. A young branch should be used, with a similar diameter to that of the rootstock plant (approx. 1-2cm). The base of the scion should be cut into a wedge-shaped point at approx. 45 degrees, to a depth of 4-5cm, similar to the vertical cut in the rootstock plant. The wedge-shaped scion should be inserted into the vertical cut of the stem of the rootstock plant. The aim is to provide a good point of contact for the rootstock plant and 'superior' scion to encourage grafting. The graft

should be firmly bound with grafting tape and waxed as with the approach grafting method. If the grafting process is successful, the scion will form new shoots in about 3-4 weeks.

Figure 4.9. Cleft grafting of Tamarind



Softwood grafting is most successful in tamarind

4.3.4. Layering

Layering involves the growth of roots on a stem, while the stem is still attached to the mother plant. There are 2 methods of layering used for tamarind, air (marcotting) and ground layering.

4.3.4.1. Air layering

Air layering is the most commonly used method of layering for tamarind propagation. A young branch should be selected and the bark removed from an area of about 2-3cm or a small cut can be made, this reduces sap circulation and encourages rooting. The area or cut should be covered with soil mixture or root promoting material, such as coir fibre dust, watered and kept in position by wrapping with clear polythene film (plastic bag). The plastic should be tied firmly at both ends to retain moisture and encourage rooting. The rooting area must be kept moist. After about 2-3 months the growing roots should be observed through the polythene film. At this stage the branch can be severed about 5cm below the rooting area and potted for later field establishment. It is best to leave the new plant in a pot for 6-12 months to allow the roots to become well established before replanting in the field.

Rooting hormone (IBA at 1000ppm) can be applied to the initial cut to encourage shoot rooting, this

can reduce the time required for rooting from 12 to 6-8 weeks.

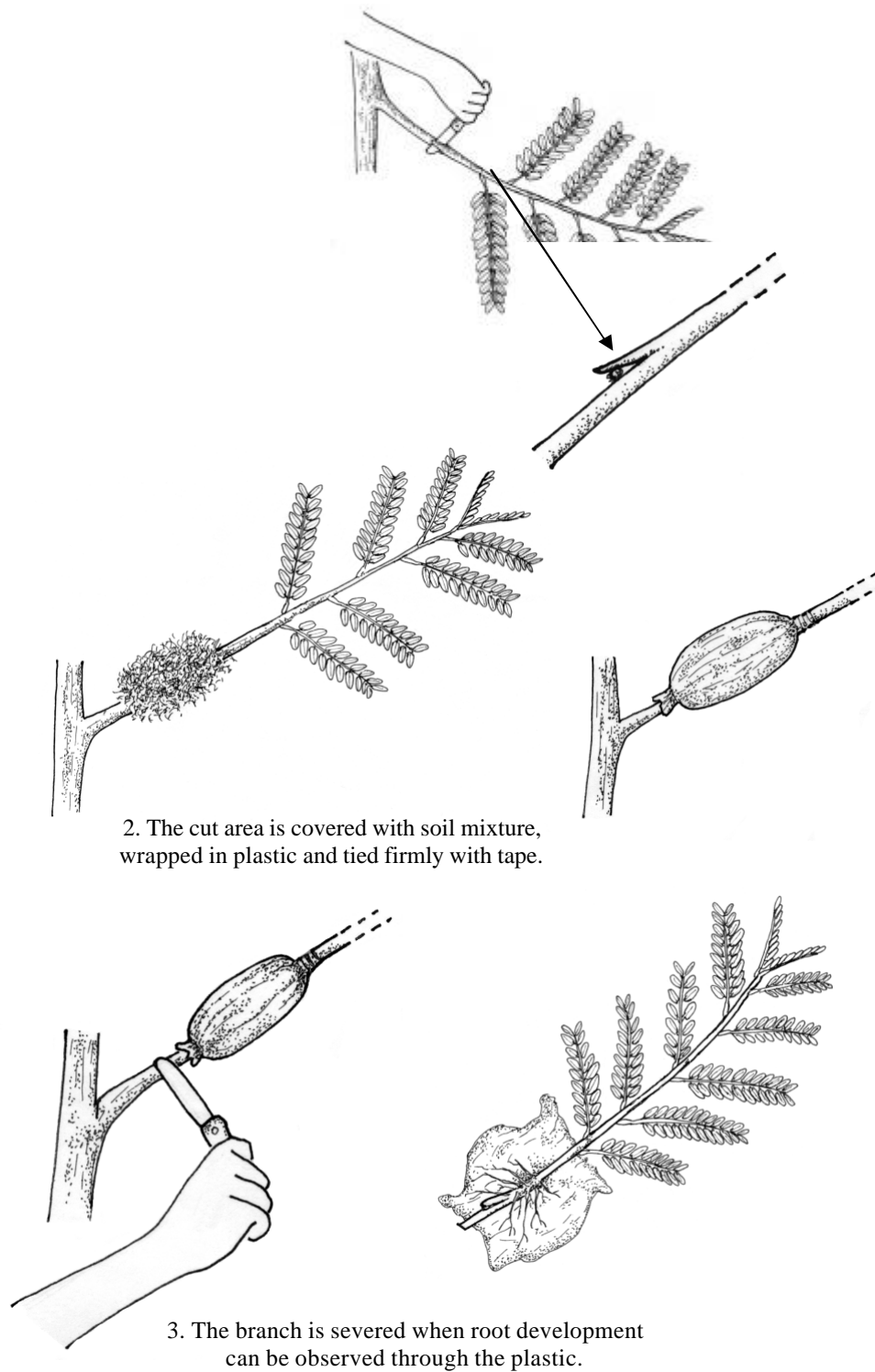
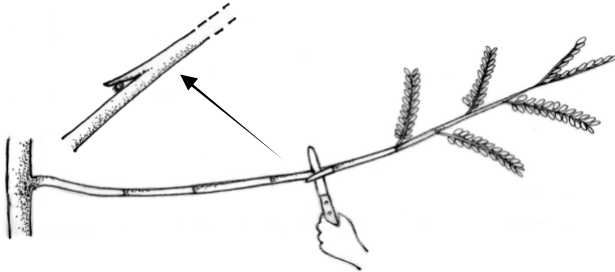


Figure 4.10. Air layering of Tamarind

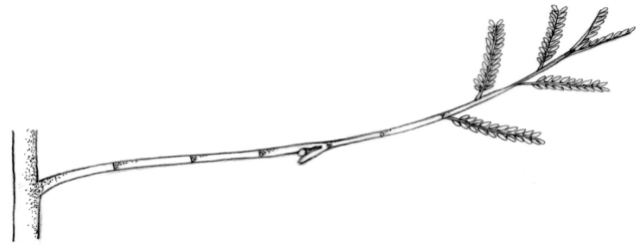
4.3.4.2. Ground layering

This method is very similar to air layering, the only difference is that rooting is encouraged below ground and not in the air. A flexible branch from a 'superior' tree should be bent to the ground and

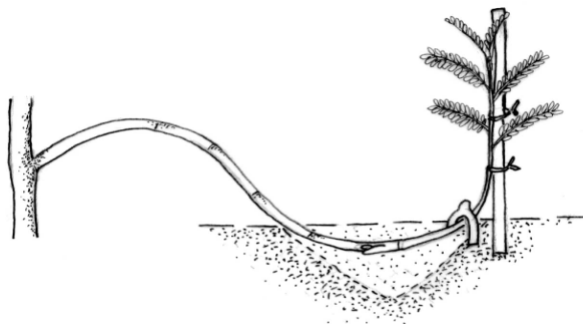
pegged. A small cut is made onto the lower side of the stem where it touches the ground. This section of branch is then covered with soil. The top of the stem can be supported by a stick to encourage upright growth. After 10-12 weeks, roots begin to develop at the point of the cut. Once the roots are established the new plant can be obtained by severing the branch from the mother tree, above ground level. This method is less common than air layering as it can be difficult to select a flexible enough branch unless the tree is very young.



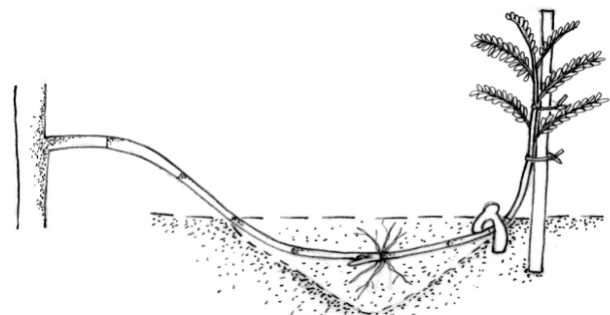
1. The branch is cut to encourage rooting.



2. The cut can be held open using a small piece of wood.



3. The branch is bent to the ground and the cut portion covered with soil.



4. The cutting is pegged at ground level and staked to keep it erect.

Figure 4.11. Ground layering of Tamarind

4.4. FIELD ESTABLISHMENT

Tamarind trees prefer full sun and open areas are most suitable for planting out. They should not be planted under heavy shade, in boggy patches, within the leaf litter of other trees, near refuse areas, animal enclosures or in areas where the trees are likely to be damaged. The tree should not be planted in highly saline soil or in areas of contamination with heavy metals, e.g. petrol spills. The land should be free draining and not subject to flooding.

Tamarind can be planted on roadside corridors, homesteads, agricultural land or as a tree in open grasslands. Tree protection may be required, in the form of a stick/cane as a tree support and a thorn or wire enclosure, to prevent damage by children or animals.

4.4.1. Land preparation

Weeding is required on all tamarind planting sites, up to 1m in diameter around the planting hole. A larger area of 3-4m squared must be cleared when local vegetation such as 'creeper' weeds and vines are invasive, as these can choke the young trees. If planted on grassland, the grass also needs to be removed to 1 m in diameter around the planting site.

If a site is over-run with woody growth and shrubs, some clearance will be necessary. The cutting of a small area for each tree is not sufficient, as cutting stimulates growth and the cleared shrubs will continue to grow through their root stumps, unless removed.

When preparing the soil for seed planting, it should be lightly turned to allow aeration.

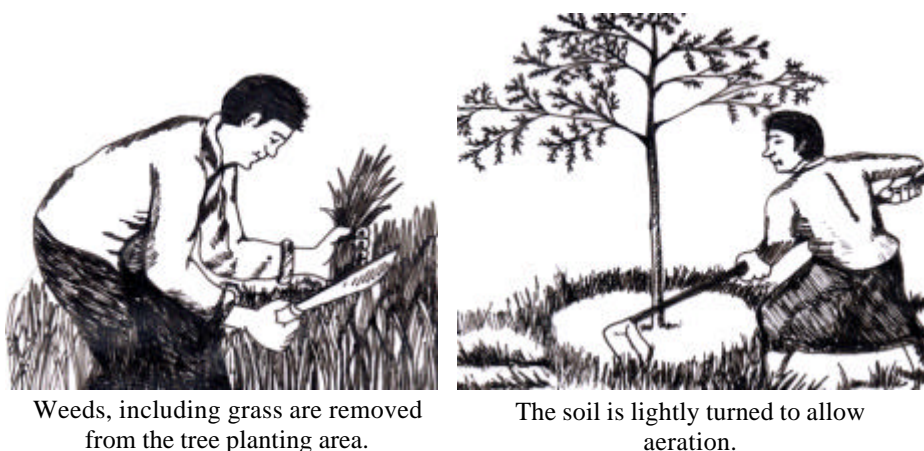


Figure 4.12. Land preparation

If a number of trees are to be planted in an area of grassland grazed by animals, it might be necessary to consider fencing structures. Alternatively, tree guards can be made and placed around the base of each tree to a height of 120cm. These guards can be made from local branches or thorny scrub to prevent animal damage.

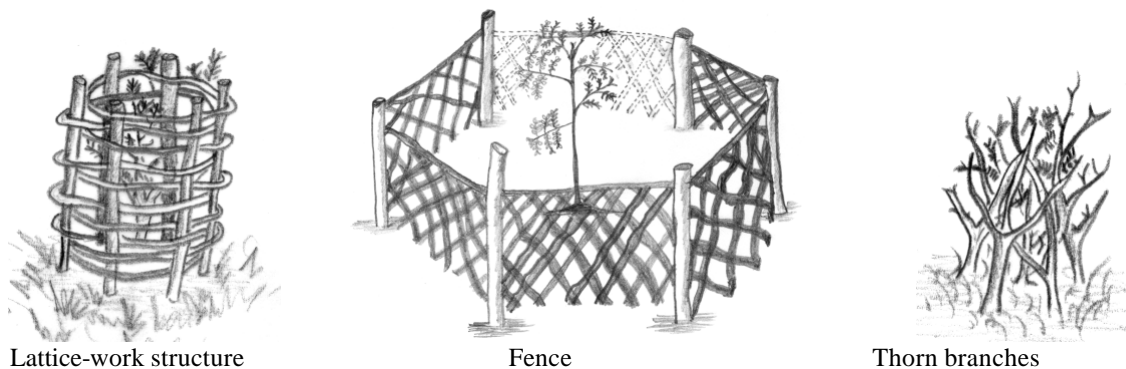


Figure 4.13. Tree guards

4.4.2. Direct seeding

Seeds can be sown directly in the field. This method can be used on homestead farms and in areas where all surface vegetation has been removed. Small holes should be dibbed in the soil and seeds 2-3 placed at a depth of about 1-2cm (the strongest can be selected later on). The seeds should be planted at a spacing of 5x5m and thinned to a spacing of about 13x13m, or line sown, with seeds dibbed 5cm apart in lines and 4-5m apart, and then thinned later to the recommended spacing of 13x13m (seed requirement is in general 20kg per hectare).

In home gardens, tamarind seeds should be sown in cleared patches, spaced at 4-5m apart.

When creating a tamarind firebreak, the spacing adopted should be 2.5x2.5m or 3x3m.

4.4.3. Transplanting

Tamarind seedlings (from seed and vegetative propagation) should be field planted at 12-14 months of age or when they are greater than 30cm in height. All field planted seedlings need to be planted with sticks for support, but within a year they can support themselves.

If the growth is poor, the seedlings should be retained in the nursery for another year. The taproot of these seedlings may grow into the soil and root pruning should be practiced, when required. Over-grown seedlings can be more effectively transplanted when the stem and tap root are pruned to lengths of about 5cm and 20-25cm, respectively.

4.4.4. Planting techniques for transplants

4.4.4.1. Pit planting

Pit planting is one of the commonest methods for planting tamarind trees and is essential for trees over 90cm tall. It is a time consuming method, especially in rocky soils, and may require a lot of effort to make a decent sized pit, but tree establishment has a greater rate of success with this method. The pit should be about 30cm deep and 20cm wide. The soil should be loosened on the sides of the pit walls and base as this will help the roots to grow and develop later. The tree should be held in the centre of the hole, checking that the soil mark at the root collar of the transplanted tree is at ground level and that the tree is straight. The pit and roots should be covered to ground level with the soil that was removed (all stones should be removed before replacing around the tree); if there is insufficient soil after digging

the pit, topsoil should be used to fill the pit. It is important to flatten the soil around the base of the tree up to ground level. The tree should be watered daily if the rains have not occurred.

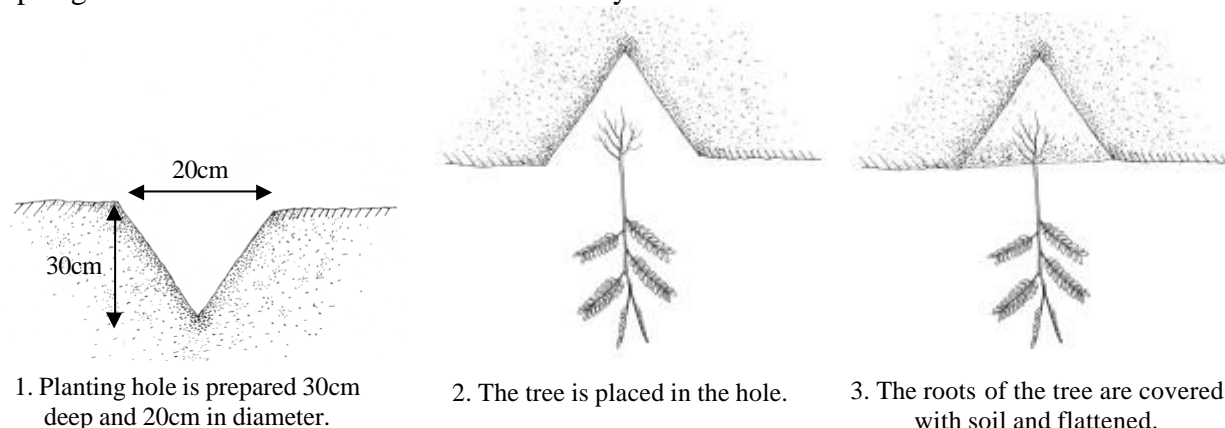


Figure 4.14. Pit planting of Tamarind

4.4.4.2. Notch planting

Notch planting is practised with bare rooted tamarind trees. This method is not possible in rocky soils and should not be used in heavy clay soils as the soil notch may reopen in dry weather.

An 'L' or 'T' shaped notch should be cut into the ground to a depth of at least 20cm (depending on the size of the roots) using a spade or similar tool. The soil should be lifted to create a hole. The tree should be inserted bringing the root collar level with the soil surface. The spade should then be removed to allow the surface of the soil to fall back in place. The soil should be flattened around the stem to firm the roots.

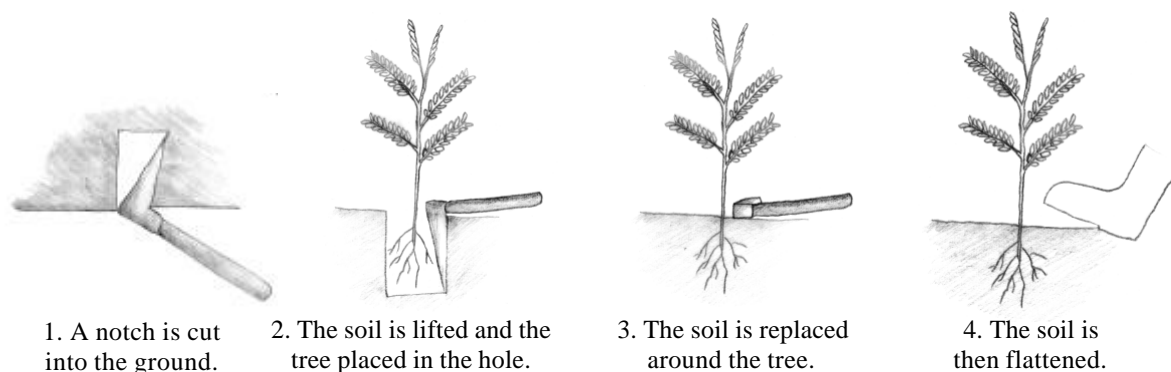


Figure 4.15. Notch planting of Tamarind

4.4.5. Time of planting

The best time for field planting is at the beginning of the rainy season, particularly in seasonally dry regions. If water is constantly available planting may be done throughout the year. The best time of day is late afternoon to early evening.

5. MANAGING TAMARIND TREES

5.0.1 Training and pruning

Tamarind requires minimal care except in the early stages of growth. Initial growth is slow and after the main stem and some branches have developed, young trees should be pruned to allow 3 to 5 well spaced branches to develop into the main structure of the tree.

The lower branches should be pruned to allow easier access for management, such as fertiliser application and inter-cropping. Pruning dwarfs the tree, which facilitates harvesting. Bearing trees require very little pruning, except for removal of weak, dead and diseased branches, this can prevent the spread of disease and infection.

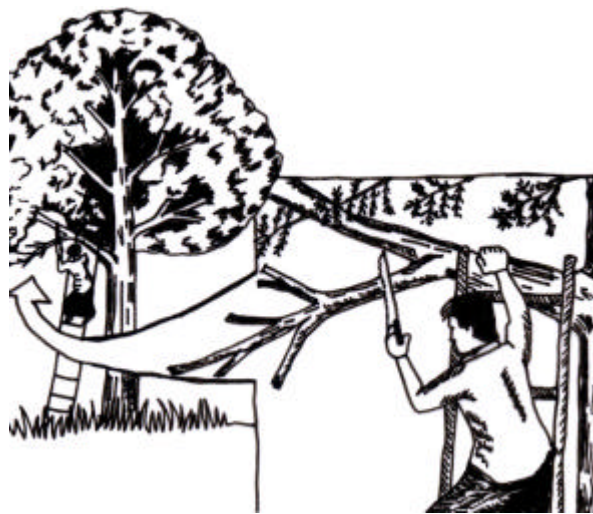


Figure 5.1. Pruning to remove dead branches

5.0.2. Fertilisers

Tamarind trees grow and produce good crops with or without fertiliser, due to their deep and extensive root system. Farmyard manure can be applied at the time of planting or yearly as a top dressing and will improve yield.

Inorganic fertilisers are often applied in sweet tamarind orchards to increase the yield. Ammonium sulphate can be applied at the rate of 100-200g per tree, a month after planting and twice a year at the end of the rains. When the tree begins to bear fruit, 500g of complete fertiliser (NPK) can be applied twice a year, at the end of the rains. A mature, bearing tree can be given 2-3kg of complete fertiliser a year.

5.0.3. Water supply

Mature tamarind trees require no irrigation. Young trees do require water in the nursery and during establishment. The amount of water required varies (depending on local climate), but in general, about 1-2 litres of water every 2 weeks should be applied to each young tree, preferably in late afternoon or early evening.

5.0.4. Weeding

Removal of weeds from around the plant is necessary during the early stages (first 4 years) of growth. In commercial orchards, weeding may not be required if cover crops (inter-crops) are grown in-between the trees to control weeds and conserve moisture.

5.0.5. Intercropping

Inter-cropping can be practised during the first 4 years of growth. It is a good practice and can provide an income in the early stages of tree establishment, before the trees bear fruit. The best inter-crops for tamarind are groundnuts, vegetables, field beans, mung beans, cowpeas and short season cereals.

NOTE: Climbing varieties of inter-crops are not recommended in tamarind orchards because they creep up the trees and reduce available light.

5.0.6. Pests and diseases

Tamarind trees do not suffer badly from insect pests or diseases. There are however a number of pests (categorised as major and minor), along with possible methods of control (natural and chemical), which are mentioned in Appendices 2 and 3.

In serious outbreaks, chemical methods may be the only feasible means of control. Chemical sprays should not be used if the tree is bearing fruits (it is better to spray after harvesting), if the tree is near a water source or if there is a strong prevailing wind.

Serious pest or disease problems should be reported to the local Extension or Agricultural Officer, who will give advice for control methods and / or chemical application rates and availability. Appendices 2 and 3 can be used as a guide.

Pests - The most common pests are the leaf feeding caterpillars, bag worms, mealy bugs and scale insects. Sap suckers, such as white flies, thrips and coccid aphids, affect tender shoots and fresh foliage, and defoliators, such as caterpillars and chafer beetles, can also cause considerable damage. They can all be controlled with chemical sprays or physical removal of the infected parts. Some pests are also known to attack flower buds, developing fruit and also fruits during storage (See Appendix 2 for pest classification lists and control methods).

Diseases - There are no major diseases of tamarind. The most common minor disease affects nursery seedlings and is a downy mildew caused by the fungus *Oidium* spp. Other diseases, such as powdery mildew, collar rot, stem rot, stem canker, trunk rot and root rot, are also caused by fungi. Spraying fungicides at the recommended rates can effectively control the occurrence of fungal diseases (See Appendix 3 for a disease classification list and recommended chemical application rates).

5.1. HARVESTING

5.1.1. Time to first harvest

The time for a tamarind tree to reach its first harvest will vary, depending on the method of propagation. A tree propagated by bud-grafting will come into bearing in 3 to 4 years, whereas trees propagated by seed may take up to 12 years. Practical management and local conditions will also affect the time for trees to bear. A well tended tree, grown from seed, in an open area will come into bearing in about 7 years. Regardless of the method of propagation, pod yield should stabilise after 15 years. The tree has a pod bearing capacity of 50-60 years, but may yield fruit for over 200 years.

5.1.2. Fruit ripeness and yield

Pod skin colour does not change rapidly with maturity and individual fruits mature at different times, so harvesting should be carried out selectively. Mature fruits should have a brown shell, while immature pods have a green skin. At maturity, the fruits are filled with a sticky brown to reddish-brown pulp and the seeds become hard and glossy. The pod skin becomes brittle as the pulp shrinks and the shell can be broken easily by hand. The ripe pod produces a hollow sound when tapped with the finger.

The yield of a tamarind tree varies considerably from country to country, and is dependent on genetic and environmental factors. Pod yield can also be cyclic, with bumper yields in every third year. A young tree may yield 20-30kg of fruit per tree in a year and a full-grown adult tree can yield about 150-200kg of fruit per tree in a year. An average tamarind tree may yield 100kg of fruit per tree in a year. Pod yield can decline after 50 years. Once the pod yield is no longer profitable, the tree may be harvested for charcoal or fuelwood.

5.1.3. Harvesting techniques

Tamarind fruit can be harvested by hand picking, clipping with a hook mounted on a stick or by shaking the branches. Hand picking is used for sweet tamarind to avoid pod damage, as the fruit is sold whole, this however, requires climbing the trees and can be very time consuming. When the trees are shaken or clipped using a stick, a sheet is usually placed beneath the tree to collect the fallen fruits, this provides some protection against the hard earth and may prevent damage of the shell. The sheet also allows easy collection of the fruits. Fruit left on the tree will eventually fall off naturally.

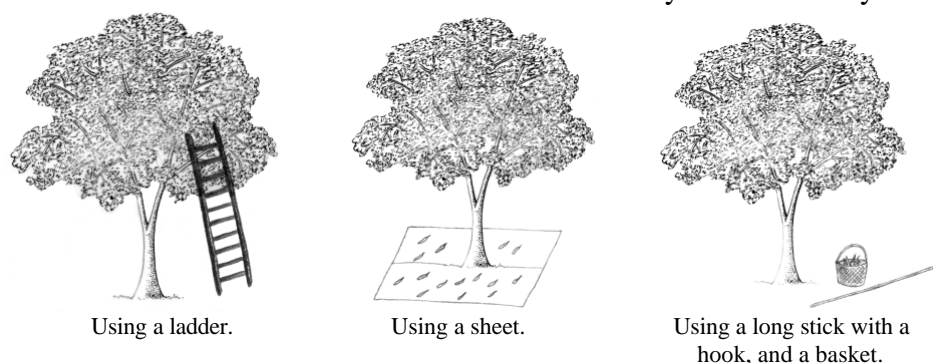


Figure 5.2. Harvesting of Tamarind pods

6. PROCESSING AND STORAGE

6.0.1. Processing

In most rural households the pods are dried in the sun for 5-7 days. Small-scale dehydrators can also be used to dry the fresh fruit, if available. Once dried, the shells are hand-cracked and separated from the pulp. The fibres, seeds and shell pieces are removed from the pulp by hand. The pulp is then dried for 3-4 days before being compressed, ready for storage. The pulp can be mixed with salt or sugar according to preference, prior to storage. Seeds can be used in industrial processing and should be dried for about 2 days.

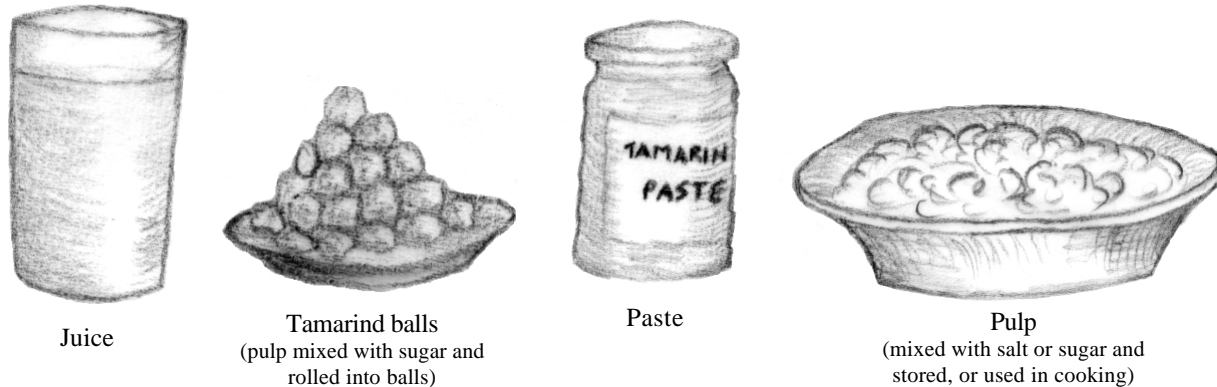


Figure 6.1. Processed products of Tamarind

6.0.2. Storage

In rural areas the compressed pulp can be stored in plastic bags, jute bags or closed clay pots. The pulp is usually stored with the seeds, however, when produced commercially, the seeds are removed. The freshly prepared, dried pulp is light brown in colour, but darkens with time in storage. Under cool, dry conditions the pulp remains good for about one year when stored with salt in a clay jar or in polythene, after which it becomes almost black, soft and sticky in texture.

Various methods can be used to prolong the storage life of the whole fruit and the pulp:

- Drying is the best and easiest way to store small amounts of tamarind pulp.
- Freshly harvested fruits can be stored for 2-5 days in a cool, dark area, or a refrigerator.
- Freshly harvested pulp can be stored for 4-6 months by packing in high density polyethylene and storing below 10 degrees in a dry place.

6.0.3. Marketing

Tamarind is marketed locally, regionally and internationally. Market value varies depending on location, variety, quality, processing and demand. Products sold in local markets are usually in the form of fresh fruits, pulp, juice, sauce and paste. Products in international markets include pulp, juice, paste and TKP (Tamarind Kernel Powder). India is the world's largest exporter of Tamarind and in 1993, exported 11,145 tonnes. Thailand exported 7,006 tonnes in 1999 and Sri Lanka exported 6903 tonnes in 1997. Other countries also export tamarind, including Indonesia, the Philippines, Nicaragua, Venezuela and other Asian and South/Central American countries.

APPENDIX 1. MULTI-PURPOSE USES OF TAMARIND

Wood	<ul style="list-style-type: none"> • Purplish brown hardwood used for furniture, well construction, tent pegs, canoes, side planks, boats, cart shafts and axles, naves for wheels, toys, hubs, oil, sugar presses and tool handles. • Fuel with high calorific value (4850 k cal/kg) used for brick making; excellent charcoal.
Fruit and pulp	<ul style="list-style-type: none"> • Product of economic value, sold in local markets in fresh or processed form with high export value. • Fruits of sweet varieties are eaten fresh and sour fruits are used to prepare juice, jams, jellies and candy. • The juice is sold commercially in polypacks and can also be used as a vinegar to preserve food. • Acidic pulp used in curries, chutneys, sauces, ice cream, sherbets and toffees. • The pulp can also be mixed with common salt to clean brass, copper and silver. • Fruit pulp improves appetite and is a gentle laxative (medicinal).
Seed	<ul style="list-style-type: none"> • Eaten roasted or boiled and used in jams, jellies, confectionery and condiments. In some countries seeds are eaten alone or mixed with cereal powders, made into flour for bread and cake making. • Seeds are a good substitute for fruit proteins. • Used to manufacture tamarind kernel powder (TKP), an adhesive used in textile and paper sizing, and in the food industry to thicken and stabilise. • TKP is also used as a filler for adhesives in the plywood industry, where seeds, when ground, boiled and mixed with gum, produce a strong wood cement. • Oil extracted from the seed can be used for making varnishes, paints and lighting oil. • Seed is also a source of pectin which can be used in the food industry. • Seed meal is a good livestock feed. • Powdered seed is used to treat chronic diarrhoea, jaundice and dysentery (medicinal).
Leaf	<ul style="list-style-type: none"> • Edible, used to make curries, soups, salads and stews. Young leaves are used as a seasoning vegetable. Fodder relished by cattle and goats, also preferred by wild animals. • Leaves contain tannin and can be used as an ink and in fixing dyes. • Used in cardiac and blood sugar reducing medicines (medicinal). • Ground with salt to prevent throat infections, coughs, fever, intestinal worms and liver ailments (medicinal). • Applied to boils/abscesses to reduce inflammation (medicinal).
Flowers and immature pods	<ul style="list-style-type: none"> • Edible and can be used in salads and stews. • Used internally as a remedy to cure jaundice and externally to cure eye diseases and skin ulcers (medicinal).
Twigs and bark	<ul style="list-style-type: none"> • Used in the tanning industry for tanning hides. • The bark can be burnt to make ink. • Twigs and bark can be used to make dyes. • Twigs are used as chewsticks. • Bark is used as an astringent for the treatment of diarrhoea, as a cure for asthma and acts as a digestive aid (medicinal).
Root	<ul style="list-style-type: none"> • Component in medicines for leprosy and dysentery (medicinal).

APPENDIX 2a. MAJOR PESTS OF TAMARIND

COMMON NAME	SCIENTIFIC NAME	NATURE OF ATTACK	BIO-CONTROL	*CHEMICAL CONTROL
Scale insect	<i>Aonidiella orientalis</i> , <i>Aspidiotus destructor</i> , <i>Saissetia oleae</i>	Sucks the sap of tender shoots.	Remove affected parts in initial stages.	For serious infestations, spray with diazinon or carbosulfan at 0.1% solution.
Mealy bugs	<i>Planococcus lilacinus</i> , <i>Nipaecoccus viridis</i>	Sucks the sap of leaflets, mature and tender shoots and leaf petiole bases. Leaves become chlorotic and defoliate. Immature fruit fall.	Remove affected parts.	Spray with diazinon or carbosulfan at 0.1% solution.
Thrips	<i>Scirtothrips dorsalis</i> , <i>Halothrips ceylonicus</i> , <i>Eublemma unguifera</i>	Attacks flowers, bores into flower buds causing bud death and can web flowers together.	No known bio-control.	Spray with dimethioate at 20-40 ml/10 litres of water or Fenthion at 10-15 ml/10 litres of water.
Coccids Soft scale insects	<i>Aspidiotus tamarindi</i> , <i>Cardiococcus castilleae</i> , <i>Hemiberlesia lataniae</i> , <i>Howasdia biclavis</i> , <i>Pinnaspia temporaria</i> , <i>Unaspis articolor</i> , <i>Saissetia oleae</i>	Sucks the sap of semi-hard and tender shoots.	Remove affected twigs.	Spray carbonsulphan at 0.1% solution or dimethioate at 3% solution (20-40 ml/ 10 liters of water).
Aphids	<i>Toxoptera aurantii</i> , <i>Acaudaleyrodes rachipora</i>	Sucks cell sap of tender leaves and stems. Leaflets are distorted and covered with moulds.	Remove affected twigs and leaves.	Spray endosulphan at 10 ml/10 litres of water or spray dimethioate at 20-40 ml per 10 litres of water. Repeat every 2 weeks until pest disappears.
Semilooper caterpillar	<i>Achaea janata</i>	Infests flowers and causes a lot of damage.	Remove caterpillars by hand and crush.	Spray permethrin at 0.5% solution (5 ml per 10 liters of water).

* Chemical control regulations may change after publication of this manual. Please check with local Extension or Agricultural Office before application.

APPENDIX 2b. MINOR PESTS OF TAMARIND

COMMON NAME	SCIENTIFIC NAME	NATURE OF ATTACK	BIO-CONTROL	*CHEMICAL CONTROL
-	<i>Thalassodes quadraria</i>	Feeds on plant foliage.	No known bio-controls.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Bag worms	<i>Chaloides vitrea</i> , <i>Perteroma plagiophles</i>	Feeds on plant foliage.	No known bio-controls.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Lobster crab caterpillar	<i>Stauropus alternus</i>	Feeds on plant foliage.	Remove pest by hand and crush.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
-	<i>Cryptocrameri</i> spp., <i>Euproctis scintillans</i>	Defoliates plant.	No known bio-controls.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Beetles	<i>Myloccerus blandus</i> , <i>Myloccerus</i> spp.	Feeds on plant foliage.	No known bio-controls.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Butterfly larvae	<i>Charaxes fabius</i> , <i>Taragama siva</i>	Feeds on plant foliage.	Remove by hand and crush.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Beetle larvae	<i>Lockmaecles</i> spp.,	Damages branches. Attacks ripe pods.	No known bio-controls.	Spray permethrin at 0.5% solution (5 ml / 10 litres of water).
Caterpillar	<i>Aphomia gularis</i> , <i>Paralipsa gularis</i> , <i>Corcyra caphalonia</i> , <i>Assara albicostalis</i>	Attacks ripe pods and stored fruits. Bores inside the fruits and eats the pulp and sometimes bores into seeds.	Remove by hand and crush.	Pirimiphos-methyl dust at 2%. Fumigation with ethylene bromide, carbon tetrachloride, acrylonitrile or phosphine. Mix with neem oil at 5-10 ml per 1 kg seed in seed infestations in storage.
Grubs	<i>Alphitobius laevigatus</i> , <i>Echocerus maxillosus</i> , <i>Uloma</i> spp.	Attacks the fruit.	No known bio-controls.	Pirimiphos-methyl at 2% dust. Fumigation with ethylene bromide, carbon tetrachloride, acrylonitrile or phosphine. Mix with neem oil at 5-10 ml per 1 kg seed in seed infestations in storage.
Beetles	<i>Lasioderma serricorne</i> , <i>Calandra linearis</i> , <i>Tribolium castaneum</i> , <i>Dichocrosis punctiferalis</i> , <i>Phycita orthoclina</i> , <i>Cryptophalebia illepidia</i>	Bores into the fruit.	No known bio-controls.	Pirimiphos-methyl at 2% dust. Fumigation with ethylene bromide carbon tetrachloride, acrylonitrile or phosphine. Mix with neem oil at 5-10 ml per 1 kg seed in seed infestations in storage.

* Chemical control regulations may change after publication of this manual. Please check with local Extension or Agricultural Office before application.

APPENDIX 3. DISEASES OF TAMARIND

COMMON NAME	CAUSAL AGENT	BIO-CONTROL	*CHEMICAL CONTROL
Leaf spot	<i>Bartalinia robillardoides</i> , <i>Exosporium tamarindi</i> , <i>Hendersonia tamarindi</i> , <i>Pestalotia poonensis</i> , <i>Phyllosticta tamarindicola</i> , <i>Prathigada tamarindi</i> , <i>Sphaceloma</i> spp., <i>Stigmina tamarindi</i>	No known bio-controls.	Spray maneb 80 wp at 200/100 litres of water.
Powdery mildew	<i>Erysiphe polygoni</i> , <i>Oidium</i> spp.	No known bio-controls.	Spray benomyl 50 wp at 10 g/20 litres of water.
Collar rot	<i>Phytophthora</i> spp.	No known bio-controls.	Spray benomyl 50 wp at 10 g/20 litres of water
Stem rot Stem canker	<i>Pholiota gollani</i> , <i>Hypoxylon necatriodes</i>	No known bio-controls.	Spray captan 80% wp at 200 g/100 litres of water.
Trunk and root Rot	<i>Stereum nitidulum</i>	No known bio-controls.	Spray captan 80% wp at 200 g/ 100 litres of water.
Root and wood Rot	<i>Ganoderma lucidum</i>	No known bio-controls.	Spray captan 80% wp at 200 g/100 litres of water.
Stony fruit	<i>Pestalotia macrotricha</i>	No known bio-controls.	Spray captan 80%wp at 200 g/100 litres of water.

* Chemical control regulations may change after publication of this manual. Please check with local Extension or Agricultural Office before application.

GLOSSARY

Abscise -	when a leaf, flower or fruit falls off the plant naturally.
Air layering -	a method of propagation where a cut is made in a woody stem and surrounded by damp soil or peat moss and held in place with a wrap (plastic). When roots from the plant can be seen the stem can be cut and the plant transplanted.
Bole -	the trunk of a tree below the first major branch.
Frond -	leaf of a plant with many divisions, in this case referring to a palm leaf.
Grafting -	method of propagation, by inserting a section of one plant, usually a shoot into another so that they grow together into a single plant.
Ground layering -	similar to air layering except a flexible branch is bent to the ground and buried in the moist soil and pegged. When roots form, the stem can be cut from the mother plant.
Hormone -	a biochemical product of a cell or tissue that can cause a change of activity in a cell or tissue elsewhere in the plant (organism). Rooting hormone is an artificial chemical which causes rooting in the tissue it is applied to.
Loam -	a generally fertile and well-drained soil, containing clay, sand and a significant amount of decomposed organic matter.
Node -	point on a stem where one or more leaves are attached.
Nursery -	an area or structure set aside for growth and protection of young plants.
Pinched -	the terminal leaves may be removed using a finger nail or sharp knife, this may encourage growth in the roots.
Plus tree -	Superior or high quality tree from which cuttings and seeds can be collected.
Propagation -	to produce a new plant, either by vegetative means involving the rooting or grafting of pieces of plant or by sowing seeds.
Rootstock -	the root system and lower portion of a woody plant to which a graft of a more desirable plant is attached.
Scarify -	to scar, nick or cut the seed coat, to enhance germination.
Scion -	a cutting from the upper portion of a plant, which is then grafted onto the rootstock of another plant.
Seed propagation -	to produce a new plant from sowing seeds.
Soil bed -	an area where soil is laid down for seeding.
Unpinched -	opposite to pinched, terminal leaves are not removed.
Vegetative propagation -	to produce a new plant by vegetative means involving the rooting or grafting of pieces of plant.

FIELD NOTES

FIELD NOTES