1. THE BER TREE

Ber (*Ziziphus mauritiana*) is an economically important tropical fruit tree, which is grown all over the drier parts of the Indian subcontinent, Africa and northern Australia for its fresh fruits. It is a particularly good tree to grow in dry regions, because it can withstand long periods of drought. It has a long taproot and can withstand high temperatures during the summer.

Ber is a multipurpose tree (see Appendix 1). The fruit is the most well-known and used product from the tree, however it is also a source of seeds, timber, fodder, medicines and potential industrial components. Ber trees can compensate local farmers after subsistence crops have been harvested, giving a potential economic return in local markets when food is scarce. The fruits harvested 3-4 times in a season, provide a steady crop for a longer period.

There are many different cultivars of ber, which have been selected for a number of characteristics. Cultivars are known as early, mid or late maturing, depending on whether they produce their fruit early, mid or late in the growing year. This is an important consideration when selecting which cultivar to grow. The environmental requirements also differ, depending on the cultivar. Some of the more common cultivars are given in section below.

Ber can be successfully cultivated even in the most marginal lands of the tropics and subtropics, with few agricultural inputs and little attention. The tree propagates freely and resists stress conditions in regions experiencing recurrent droughts. It is suitable to rehabilitate the vast resource-poor regions of the tropics and subtropics and is thus an important tree for integration into the agroforestry systems in the warm desert ecoregions. The tree can provide economic sustenance to the region and insurance against ecological degradation.

1.1. What to grow

Table 1.1 Conditions for specific cultivars

To spread fruit harvest over a long period:	
Early maturing	Gola, Mundia, Goma Kirti
Mid season	Kaithli, Banarasi
Late maturing	Umran
For different annual rainfall zones:	
Less than 300mm	Gola
Between 300-500mm	Gola, Mundia, Goma Kirti
Over 500mm	Goma Kirti, Umran, Banarsi, Kaithli
Location of growing area:	
Near the market (within 24 hours transport)	Gola
For distant markets	Umran

2. WHY GROW BER

2.1. Nutrition

Ber produces a nutritious fruit, which is rich in the B group of vitamins (thiamin, riboflavin and niacin), vitamin C and β-carotene, a precursor to vitamin A. The B vitamins work together and help the body to convert food into energy. Vitamin C helps to provide healthy gums teeth, bones, skin and muscle, fight infections and heal wounds. The daily requirement of vitamin C for an adult man can be met by including 3 ber fruits in the diet. Vitamin A is necessary for good eyesight; very low levels in the diet can lead to blindness. Vitamin A is also required for healthy skin, cells and tissues, helps to fight infection and aids in bone growth. It is also thought to be effective in the fight against cancer and heart disease. All the above vitamins help to provide a healthy immune system to protect against disease.

Ber is rich in the minerals phosphorus, calcium and iron. Calcium and phosphorus are essential for the production of bones and teeth, and have a role in providing strong muscles and general health. Iron is present in the blood, and is essential for transporting oxygen around the body.

The ber fruit has high sugar content (sucrose, glucose fructose and starch); it is therefore high in carbohydrates, which provide energy. The levels of sugars vary according to cultivar. The fruits also contain protein with many essential amino acids (asparginine, arginine, glutamic acid, aspartic acid, glycine, serine and threonine).

Table 2.1. Nutritional composition of fresh ber fruits.

Fresh fruits:	**Food Value Per 100 g of Edible Portion**
Moisture	81.6-83.0 g
Protein	0.8 g
Fat	0.07 g
Fiber	0.60 g
Carbohydrates	17.0 g
Total Sugars	5.4-10.5 g
Reducing Sugars	1.4-6.2 g
Non-Reducing Sugars	3.2-8.0 g
Calcium	25.6 mg
Phosphorus	26.8 mg
Iron	0.76-1.8 mg
Carotene	0.021 mg
Thiamine	0.02-0.02 mg
Riboflavin	0.02-0.04 mg
Niacin	0.7-0.88 mg
Citric Acid	0.2-1.1 mg
Ascorbic Acid	65.8-76.0 mg

Source: Morton, J. 1987. Fruits of warm climates. Julia F. Morton, Miami, FL. p.272-275.

2.2. Income generation

Ber is an economically important tree. Major production areas are in the semi-arid and arid areas of India, where it is grown on a commercial scale, the area under production was 88,000 ha in 1995, giving a production of about 0.9 million tons of fruit. Ber can provide sustained production irrespective of occurrence of drought and can yield between 50kg and 200kg of fruit depending on the climatic conditions. Ber trees can provide additional income to farmers if incorporated into their agricultural system or grown on marginal or unused land. To ensure a profitable income however, local market price and demand for the fruit (sold in the fresh form) must first be established.

2.3. Fodder

The leaves of the ber tree are popular for fodder, especially in arid regions. They are very nutritious and the tree grows and regenerates very quickly, even under stress conditions.

Table 2.2. Composition of ber leaves.

Leaf composition:	**% dry weight**
crude protein	12.9-16.9
fat	1.5-2.7
fibre	13.5-17.1
N-free extract	55.3-56.7
ash	10.2-11.7
calcium	1.42-3.74
phosphorous	0.17-0.33
magnesium	0.46-0.83
potassium	0.47-1.57
sodium	0.02-0.05
chlorine	0.14-0.38
sulphur	0.13-0.33

Source: Morton, J. 1987. Fruits of warm climates. Julia F. Morton, Miami, FL. p.272-275.

2.4. Fuelwood

The wood of the ber tree is valued as fuelwood and produces a good charcoal. Fuelwood can be collected after pruning, the amount is dependent on severity of pruning, however on average 10-20 kg/tree/year can be produced.

2.5. Timber

The wood of cultivated varieties of ber does not have value as timber. However, the wild type, *Z. mauritiana* var. *rotundifolia*, is moderately durable and is used for a variety of purposes such as house posts, agricultural implements, tent pegs, cartwheels and spokes.

2.6. Medicines

Ber is used in traditional medicine throughout India and other *Ziziphus* species (*Z. nummularia*, *Z.*

rugosa, Z. spina-christi and *Z. jujuba*) are used throughout Asia and Africa. All parts of the plant are used, from the fruit pulp and seed to the leaves, bark and flowers. Ailments such as diarrhoea, dysentery, ulcers, eye infections, coughing, asthma and vomiting can be treated with infusions, pastes and powders. Ber also has antifungal activity and can be used against fungal infections Herbal practices are still used.

Table 2.3. Medicinal uses.

Plant part	Medicinal uses
Fruit	• Applied to cuts and ulcers, used for pulmonary ailments and fevers; and, mixed with salt and chili peppers, can be given for indigestion and biliousness. • Dried ripe fruit is a mild laxative.
Seed	• The seeds are sedative and taken, sometimes with buttermilk, to halt nausea, vomiting, and abdominal pains in pregnancy. Powdered seed is used to treat chronic diarrhoea, jaundice and dysentery. Mixed with oil, they are rubbed on rheumatic areas.
Leaves	• The leaves are applied as poultices to wounds and are helpful in liver troubles, asthma and fever.
Twigs and Bark	• The bark is said to cure boils and is useful in the treatment of dysentery and diarrhoea. The bark paste is applied to sores.
Root	• Used to treat fever, wounds and ulcers. Juice of the root bark is said to alleviate gout and rheumatism. Strong doses of the bark or root may be toxic.
Flowers	• Internally used as a remedy to cure jaundice and externally to cure eye disease and skin ulcers.

2.7. Industrial

A number of products are produced for industry from the ber tree. Most are food products such as preserves, candy and dehydrated ber, which are prepared from the fruits. Pulp made from ripe fruits is used to prepare products such as juice and squash. Other products such as jam, nectar and fruit leather can be prepared from ber pulp.

Ber trees are also one of the best hosts for the lac insect (*Kerria lacca*). The insect sucks the juice from the leaves, producing an orange/red resin. This can be harvested and is most commonly used as shellac in industry for the production of waxes and varnishes. The tree cannot be grown for fruit if it is a host to the lac insect.

2.8. Environmental impact

Ber trees have positive environmental benefits as they provide perennial cover protecting the soil. The strong root system also helps to maintain structure and therefore conserve the soil. Ber trees can grow under conditions of extreme stress from drought, salt and waterlogging and can therefore be grown on degraded or marginal lands. Ber has been used in the soil conservation of dune lands, where it stabilises the soil by the storage and recycling of plant nutrients. The tree has also been used as a live fence and windbreak.

3. WHERE TO GROW BER

Ber is a versatile tree and can be grown on a homestead, plantation, grassland or as a forest tree. The tree is suitable for marginal lands where other crops have no or limited production. The tree can be grown in semi-arid or arid regions, and although it can tolerate very high summer temperatures (49-50^{o}C), fruit-set can be affected at temperatures above 35^{o}C. However, trees are often grown successfully at temperatures of 39-42^{o}C. The trees shed their leaves and enter dormancy in extremely hot summers. Growth stops when the leaves are shed and dark scales may develop on the buds. New leaves emerge with the onset of the rains. Summer dormancy may not occur, or be very short in areas where temperatures are not so extreme. Growth, flowering and fruiting development phases may vary depending on the temperature conditions. Ber trees can withstand very short periods of freezing temperatures, however, frost will damage the young twigs and developing fruits, and may kill the tree. For healthy growth, ber trees should not be planted in areas experiencing a minimum temperature lower than 4^{o}C for extended periods. It can tolerate temperatures as low as -2 ^{o}C if occasional and for short periods.

For rainfed production of ber, a minimum average yearly rainfall of 400mm is required. Performance of the ber tree is adversely affected in humid areas having more than 1500mm annual rainfall. Fruit yields are higher in high rainfall years and lower in low rainfall years. The incidence of pests is also lower in low rainfall areas. Ber is highly drought tolerant. Its deep taproot system enables it to survive long periods without water, even when the surface soil completely dries out. Drought tolerance varies in the different cultivars of ber. Cultivar Gola is one of the most drought hardy.

The tree has no specific soil requirements. It is able to flourish in poor soils, e.g. rocky or highly sandy, but all soils need to be free draining. It has the ability to improve soils for crops, where they are overly sandy or saline.

Ber can be grown to 1000 m above sea level.

4. HOW TO GROW BER TREES

There are two basic methods of propagating ber trees, seed propagation and vegetative propagation.

- **Seed propagation** involves the collection, preparation and direct planting of the seed into soil or compost (see section 4.3 of this manual). This method is very simple, however the growth, fruiting and fruit quality of the trees raised cannot be guaranteed and the time taken for the tree to reach bearing age is usually longer than for trees propagated using vegetative methods. However, seed propagation is most often used to raise rootstocks for the purpose of vegetative propagation.

- **Vegetative propagation** may be carried out using a number of different methods, these are described in section 4.4 of this manual. Generally, vegetative propagation involves grafting of the budwood from a scion of a mature good quality tree onto a seedling raised from seed obtained from a selected rootstock tree. This guarantees the growth and fruit quality of the new tree. Selection of planting materials for both seed and vegetative propagation is described below.

The best time to begin propagation depends on local climate, water availability and method of propagation. Seed propagation will be limited to the fruiting time of the mature, healthy trees from which seed is to be collected. Vegetative propagation can be carried out throughout the year, however scion wood collection is dependent on the stage of growth of the mother tree. Regardless of which propagation method is used, it is essential to select a good mother tree from which to collect either seeds or vegetative material.

4.1. Selection of planting materials

When selecting a good rootstock tree the following points should be considered:-

- the tree should have a good crown frame and strong trunk;
- the tree should be disease-free, undamaged and have no signs of pest attack;
- the tree should be older than 15 years and known to produce a good harvest of fruit.

Seeds should be collected from fruits that have fully ripened on the tree. Seed stones collected from fallen fruits of ber often have poor viability. 50-70% of the seed stones will have non-viable seeds. Such seed stones float in salt water (15% salt) and can be thrown away;

When selecting a good scion tree, the following points should be considered:-

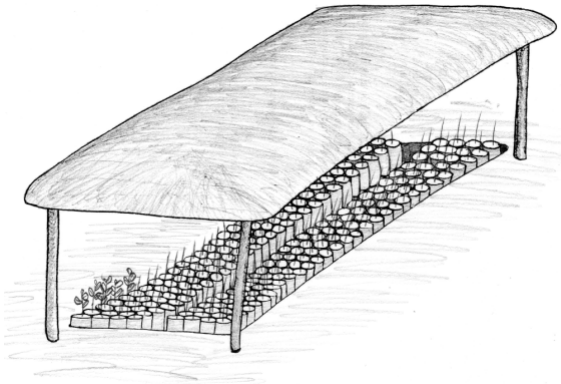
- wherever possible, the cultivar of the mother tree should be known, having the typical flowering and fruiting pattern and characters;
- the tree should have a record of consistent fruit yield and quality characters for at least five years;
- the tree should be free from disease and pest incidences.

Once the mother 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.

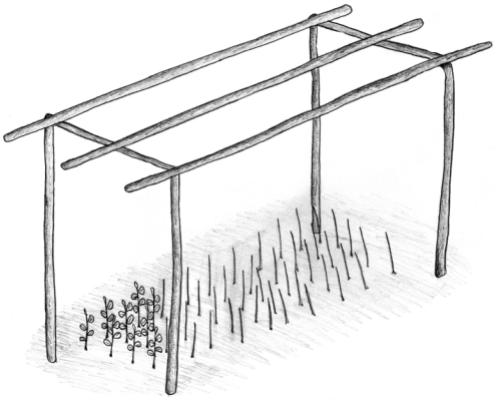
4.2. Nursery Establishment

A small nursery can be established on a homestead, or other available land. Young plants are more prone to damage by animals such as goats than older trees, so an enclosure around the chosen nursery area will be required. Young trees also require more water, so, it might be useful to be near a water source.

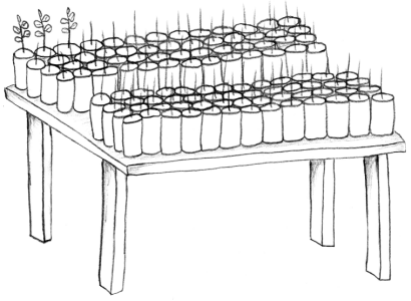
The size of a nursery is dependent on the number of trees required. Seeds may not have 100% viability, so it is better to sow more seed than is required in terms of number of trees. Viability of ber seed is variable depending on source, storage time, seed preparation and growth conditions. In general, about 20-30% extra seed should cover losses. It is also better to prepare a slightly larger area than for the exact number of trees required.



a. Pots or bags on the ground.



b. Seed bed on the ground.



c. Pots or bags on benches.

Figure 4.1. Ber tree nurseries

The design of the nursery can be very simple or more complex depending on materials and time. Examples of different nurseries are shown in the diagrams above. Seeds can be sown in pots on benches (Fig. 4.1c), in pots on the ground (Fig. 4.1a), or directly into seed beds (Fig. 4.1b).

The nursery can be built from local materials such as bamboo or wood for the uprights and palm fronds or grasses for the roof. It is better to use fresh materials for the construction, especially palm fronds and grasses for the roof, as older materials can harbour fungi, such as mildew, which can cause serious damage if transmitted to the young plants. A gate or guard can be built to prevent foraging animals, or a fence to surround the entire nursery area. The nursery shade should 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. The ground must be cleared of weeds. A plastic ground cover can be used to prevent weed regrowth, or the ground can be dug over or ploughed.

4.2.1. Nursery containers and Potting Mixture

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

NOTE: Natural pots may not last long and be more sensitive to uplift or storm damage.

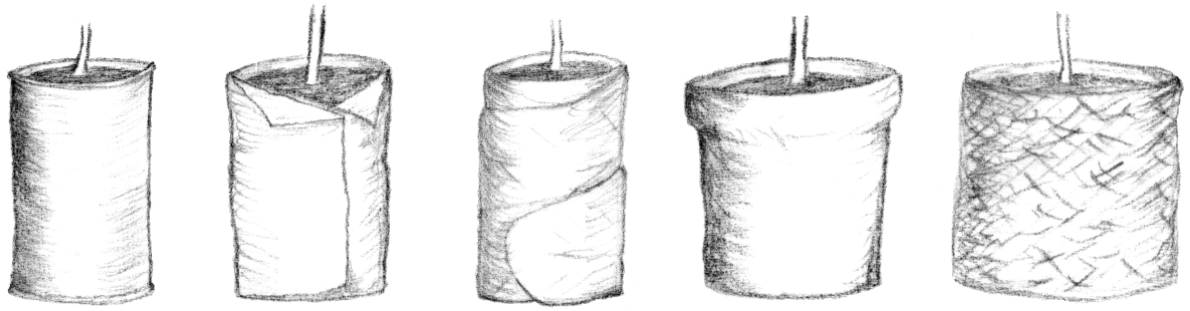


Figure 4.2. Nursery container sources

The seedlings grow better if the pots have no base as ber usually produces a long taproot which may begin to coil. If this happens, the seedling will have shallow root development and reduced growth vigour when transplanted in the field. Seedlings raised in pots without a base (tubes or root trainers) develop straight and uncoiled roots and have more vigorous growth. The tubes should be about 25cm deep and 10cm in diameter. The best media for seed germination and seedling growth is sand, clay and organic manure mixed in equal parts. Salinity in the growing medium may delay or prevent germination.

NOTE: Sand should not be used directly from beach sources as it may contain high levels of salt which would affect the growth of the young trees. Sand for potting mixtures, can be used from higher beach or inland sources.

4.3. Seed Propagation

Ber seeds can be found within the stone of the fruit. The stone is hard, varies in size and has ridges on the outer surface, it is found in the centre of the fruit. Each stone contains up to 3 seeds.

4.3.1. Seed extraction from the stone

Ber seedlings can be raised by planting the stone, however the percentage germination is lower, can take up to 4 weeks longer and the seedlings are less vigorous; it is better to remove the seeds from the stone before planting. The stone should be removed from the fruit and the seeds extracted by carefully breaking with a large stone or heavy object (care should be taken not to damage the seeds). Extracted seeds germinate within a week after sowing. The seeds can remain viable for two and half years when kept in a cool, dry environment, but storage time is dependent on the condition of the seeds and how well they have been dried prior to storage.

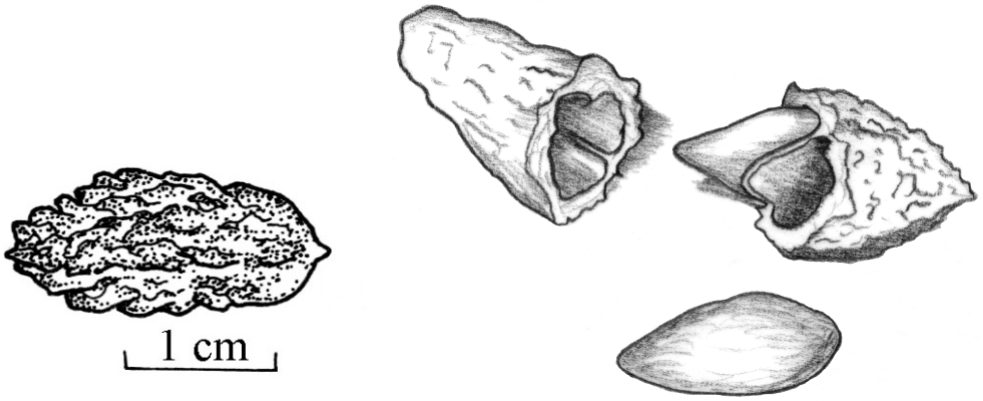


Figure 4.3. Seed extraction

A CONSIDERATION: Fresh fruits bought in the market, can be used as a source of ber seed, though this seed may have originated from poor quality or disease prone stock. Such seeds may have a delayed germination time, lack of viability or produce mixed yields once matured.

4.3.2. Seed pre-treatments

Ber seeds can only germinate after a period of 'after-ripening'. 1-2 months after extraction from the stone, germination increases. Seeds up to 1 year old germinate better than those freshly extracted. Seedling vigour is greatest when sown after 8 months storage. Germination may be reduced when the seeds are over a year old. Soaking the seeds in water for 24 hours also increases germination.

4.3.3. Seed sowing and germination

Seedlings can be raised directly in the field or in the nursery.

In the field, sowing should be carried out during the rainy season. The seeds (2-3 as thinning can be carried out later) should be placed at about 2cm deep, directly into the soil, at 6x6m spacing. The seeds should germinate in about 7 days. The seedlings become ready for *in situ* budding during the following the spring or summer, i.e. 7-12 months after sowing. Since no transplanting is required, the plants retain their deep taproot and are thus more drought hardy and vigorous.

In the nursery, pots or tubes should be arranged with 4 tubes (depending on the space available and number of seeds to be sown) in an upright position on either side (width-wise) leaving a 20cm space in the centre to avoid crowding and to help with irrigation later on. The seeds of suitable rootstocks should be sown, 2 seeds per tube at about 2cm deep. The seeds will need to be watered regularly until they germinate. The seeds can also be sown directly into a soil bed at 30x30cm spacing, also at about 2cm depth. Maximum germination takes place when the temperature is about 30°C and germination is reduced at about 25°C or less. The best time for sowing seed is in the summer in tropical and subtropical climates.

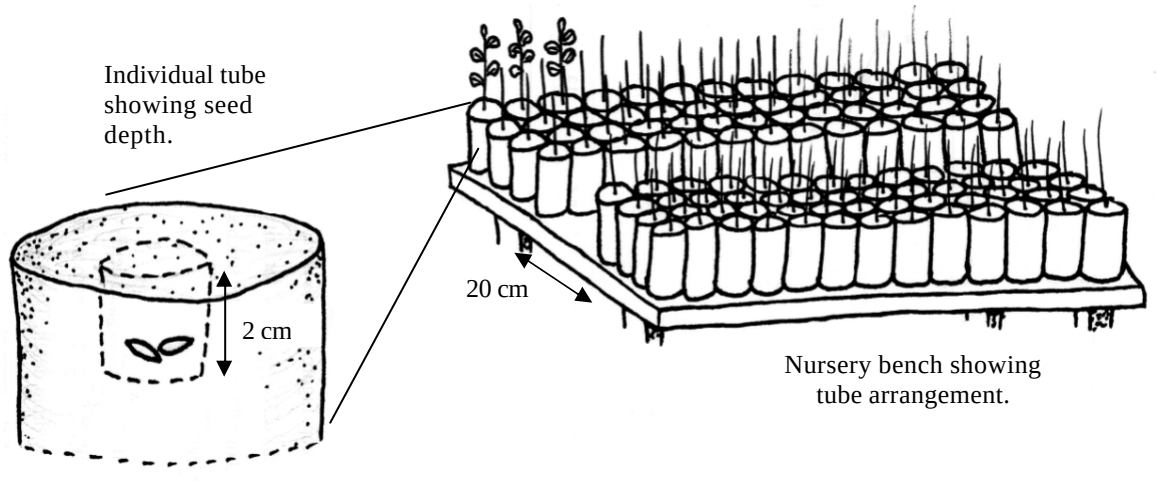


Figure 4.4. Sowing of ber seeds in the nursery.

4.3.4. Direct seeding

Seeds can be sown directly in the field. This method is used mainly on homestead farms. The seeds are sown at spacing of 6x6m under rainfed conditions or at 7x7m or 8x8m under irrigation.

4.4. Vegetative Propagation

4.4.1. Grafting

Grafting involves removal of a shoot or bud from a scion 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' tree and joined to a compatible rootstock.

The equipment required for grafting includes a clean, sharp budding knife and polyethylene tape, 1.5-2cm wide, approx. 30-40cm long. The tape 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 budding) and shoot grafting. Bud grafting is the most common, economical and easiest method used for ber and is detailed below.

Bud grafting

Budwood becomes available during the active growth period in the summer. Buds from juvenile shoots should be collected. Juvenile shoots can be induced to grow by severe pruning of the mother trees. The bud sticks, with well swollen and recently matured buds (but still not open) should be collected. Immature and undeveloped buds from the upper part of the new shoots are unsuitable, similarly, over mature and inactive buds should not be used. Buds collected from a flowering shoot also give very poor success.

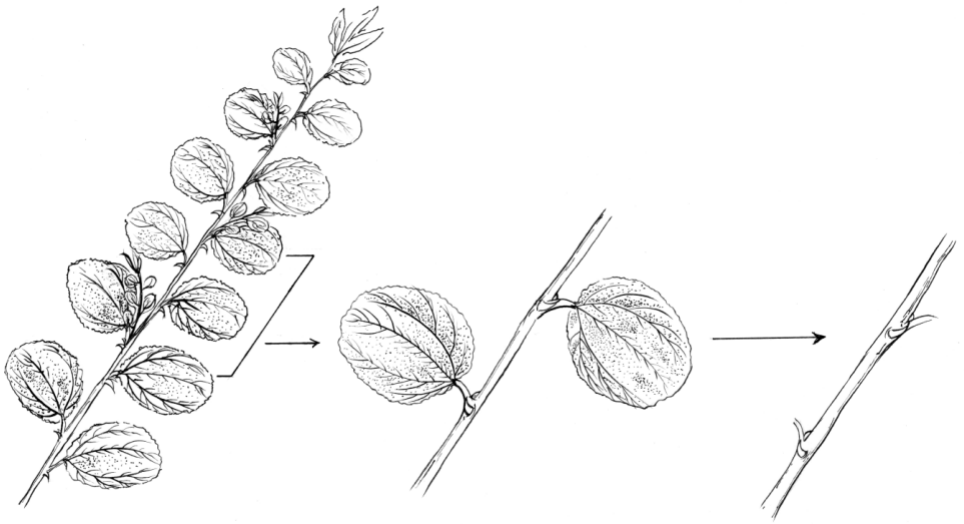


Figure 4.5. Budwood

After collection, the budwood may be stored for some period or may need to be transported. The budwood retains good viability when kept under ventilated conditions and wrapped in moist jute cloth or in polythene sheeting and moist sphagnum moss.

Budding should ideally be carried out in the field, either with field-grown rootstock plants or transplanted from the nursery. Budding should be carried out as close to the ground as possible to stop sprouting from the rootstock portion. Lopping and topping of the rootstock from 8 to 15 days after budding in the nursery beds has been found to ensure 90 to 100% success. Just before *in situ* budding in the field, rootstock seedlings should be lopped (cut) to 30-45cm height (Fig. 4.6d).

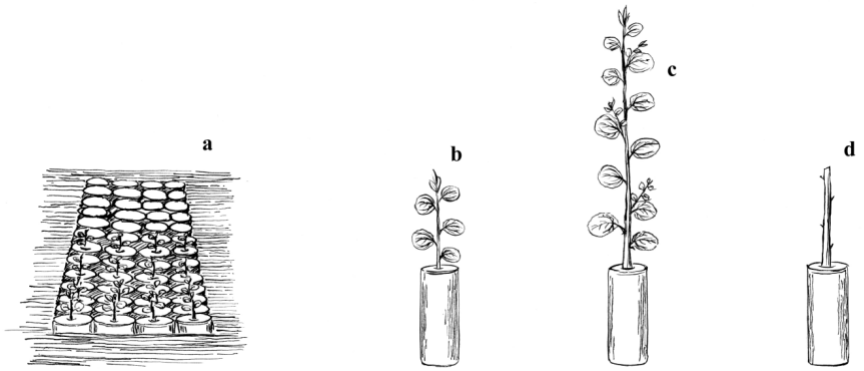


Figure. 4.6. Raising rootstock seedlings, a**) seed sowing in polythene tubes,** b**) 30 day old seedling,** c**) 100 day old seedling,** d**) rootstock seedling prepared for budding.**

Budding can be carried out by different methods such as I or T (shield), ring, patch, chip, flute and forkert; but shield or patch budding are the most commonly used methods for ber (Fig. 4.7).

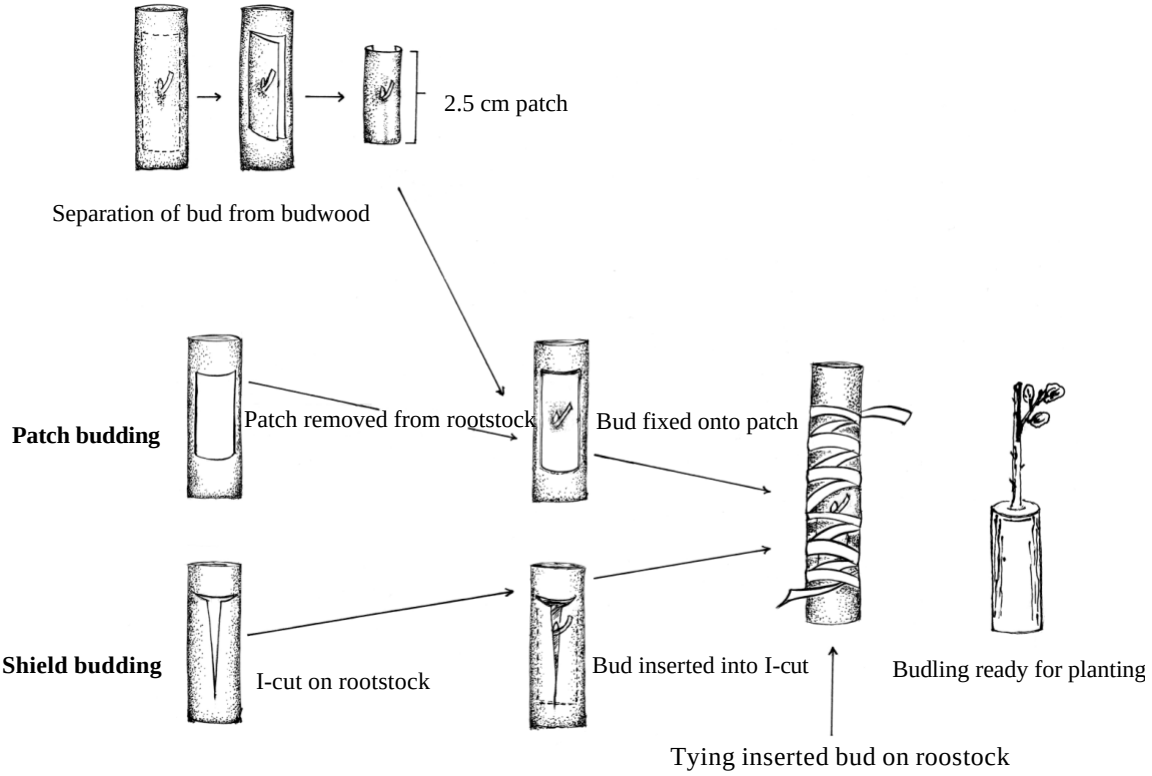


Figure 4.7. Patch and shield budding

While budding onto seedlings raised in polythene tubes, the rootstocks should be prepared by removing all the side shoots and leaves from the stem up to a height of 15cm above ground level. The top of the seedlings are then removed just before budding.

Time of budding

The best time for successful budding is during the active growth period. The active growth period is indicated by easy and clear separation of the bark from the wood in both scion and the rootstock. The best temperature is between 30 and 34°C. Bud take declines when temperatures drop to 18.5-20°C.

Such conditions occur during the summer and rainy season in the arid and semi-arid subtropics.

Transplanting of budded plants

Budlings prepared in the nursery beds should be lifted with large earth balls at about 9 to 12 months after budding for transplanting in the field. A number of these plants may be lost due to root damage while lifting, packaging, transport to the field and transplanting.

Budlings prepared in polytubes become ready for transplanting at about 30 days after budding. The polytubes with the budlings are removed from the nursery and kept in the shade for a week. These can then be easily transported or transplanted in the field with over 90% survival since there is little stress or root damage during lifting, transport and planting. The roots of the plants do not coil and therefore retain the drought hardy character and vigour almost similar to plants raised *in situ*.

4.4.2. Topworking

Topworking is the replacement of the top of a tree by budding or grafting with a desired scion cultivar. Unproductive, less productive and old trees of *ber* and other wild *Ziziphus* species can be made productive by topworking. The top of the old tree is removed at about 60-100cm from the ground or at 2m, if a high-headed tree is to be developed. Several new shoots emerge from the remaining trunk in 15 to 30 days, depending upon the age of the tree. From these shoots one upward growing, well spaced and vigorous shoot on each limb or 2 to 3 such shoots facing different directions on the single trunk should be retained. These shoots can be budded with a suitable scion cultivar. The date of heading back is adjusted so that suitable new shoots become available for budding at the selected time. In the arid and semi-arid subtropics, heading back can be carried out between spring and summer time.

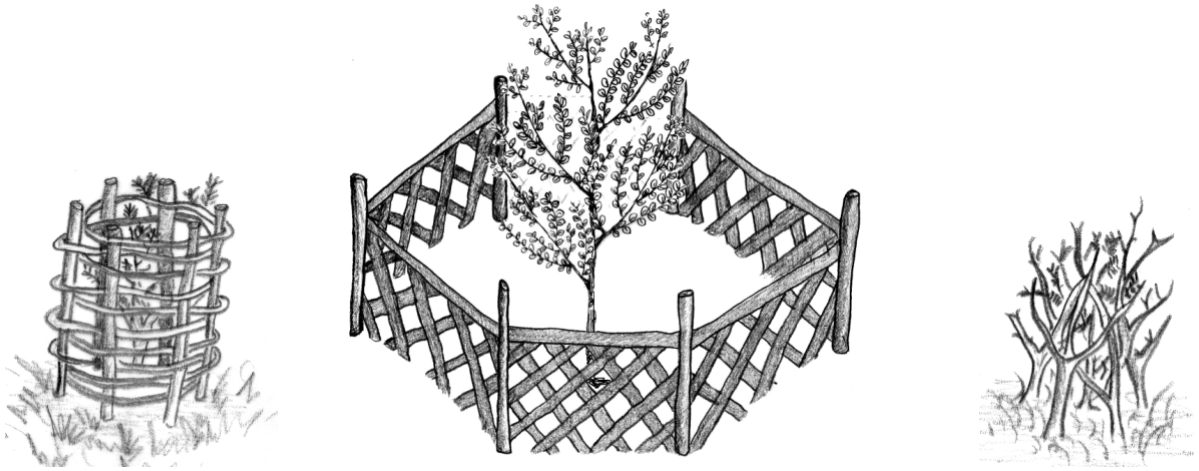
4.5. Field Establishment

4.5.1. Land preparation

Weeding is required on all ber planting sites. If planting a large number of trees in a small orchard, the area must be cleared of all weeds, this can be done with a plough. Planting of a windbreak may also be considered for protection of the young trees, if in a particularly open area. Ber trees can be planted as a windbreak, the deep root system acts as an anchor in strong prevailing winds. Other local species may also be considered. If planting a small number of trees on a homestead, on marginal land or on a grassland, weeds and grass must be cleared up to 1m in diameter or 3-4m in diameter. If creeper weeds and vines are growing, these can choke the young trees.

When preparing the soil for direct seeding, it should be lightly turned to allow aeration.

If a large number of trees are to be planted in areas grazed by cattle or goats: it may be necessary to consider fencing structures. Alternatively, tree guards can be used to protect individual trees. Branches or thorny scrub placed around the base of each tree to a height of about 120cm, can protect against animal damage.

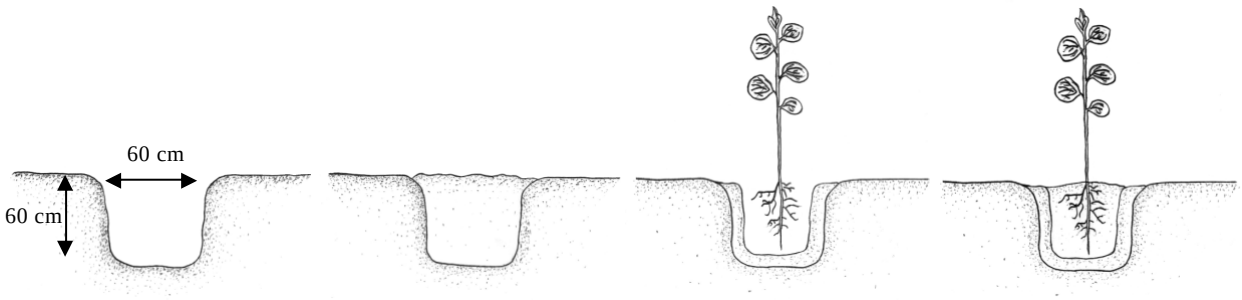


Lattice-work structure | Fence | Thorn branches

Figure 4.8. Tree guards

4.5.2. Transplanting

Transplants will be in the form of either rootstock seedlings or budlings. The layout is prepared well in advance following the same spacing as for the direct seeding. After preparing the layout, pits of 60x60x60cm deep are dug about one month in advance so that they can be filled with manure and soil before planting time. For filling the pit, topsoil is mixed with about 20kg of farm yard manure. After the soil in the pits is well settled, the budlings or rootstock seedlings are planted and immediately watered. The plants should be watered every 4-5 days for the first two months after planting.



1. Planting pit is prepared 60 cm deep and 60 cm in diameter.

2. The pit is with manure and soil about 1 month before planting.

3. A hole is made in the soil/ manure mix and the tree placed in the hole.

4. The roots of the tree are covered with soil and flattened.

Figure 4.9 Transplanting young trees

4.5.3. Time of planting

Planting of seeds, seedlings or budlings should take place at the onset of the rainy season. This ensures plenty of water during their establishment in the field.

4.6. Managing Ber Trees

4.6.1. Training

In nature, ber has a bushy and spreading growth form with long straggly branches and several weak crotches. The wood is weak and brittle and can split easily. A strong, upright and open frame should be encouraged by training the tree. This will help to achieve good fruit production. Training is done during the first two to three years after transplanting into the field or after budding of rootstocks in the field.

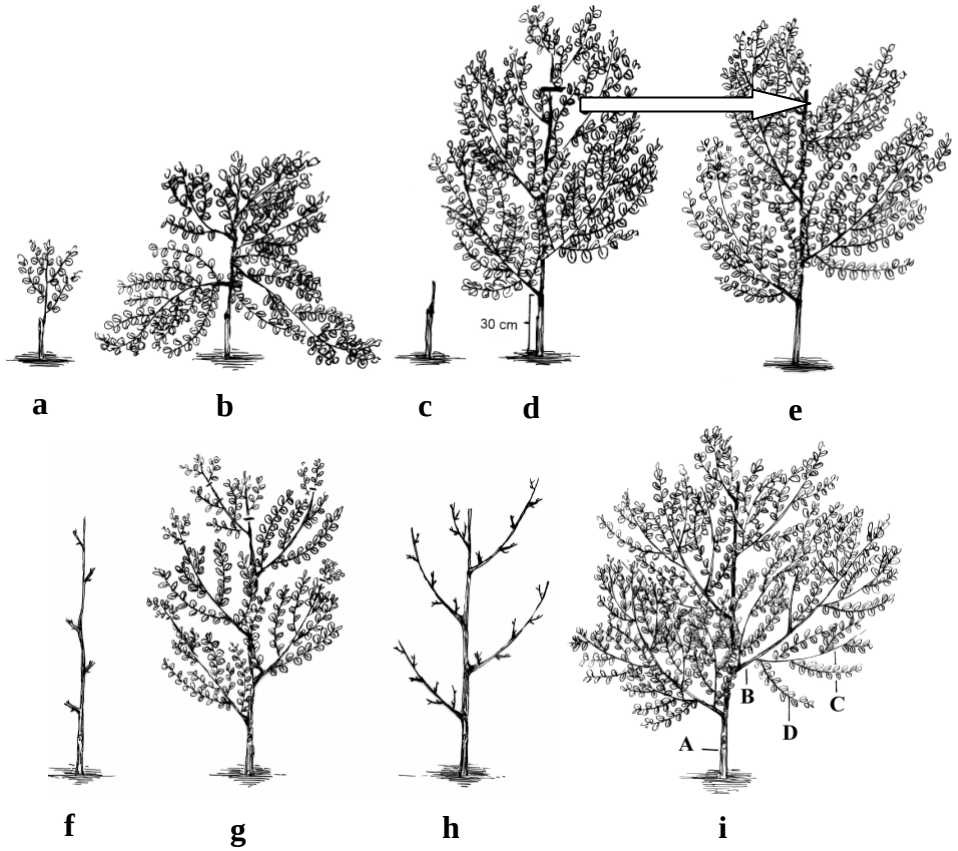


Figure 4.10. Training in ber.
A - Trunk, **B** - Main branch, **C** - Secondary branch, **D** - Tertiary branch.

Table 4.1. Approximate timing for training in the subtopics and tropics.

	a	b	c	d	e	f	g	h	i
Subtropics	June-July Year 1	March Year 2	March Year 2	May Year 2	March Year 3	March Year 3	March Year 4	March Year 4	July Year 5
Tropics	June Year 1	December Year 1	December Year 1	February Year 2	July Year 2	July Year 2	January Year 3	January Year 3	July Year 3

Ber trees are trained to form a strong and crotch-free frame during the first 2 years (tropical climate) to 3 years (subtropical climate). In tropical climates, 5-6 months after transplanting budded plants, the top portion (scion portion) of the young tree should be removed retaining its basal 1-2 buds, just above the graft union (Fig. 4.10c), to encourage a single upright vigorous shoot that will be trained into the main trunk. From the main trunk, 3-4 well-spaced main branches should be allowed to grow, but the trunk should be kept clean of growth up to 30cm height from the ground level (Fig. 4.10d). The terminal

branch (top of the trunk) should be cut back (Fig. 4.10e). After another 6 months growth, the main branches should also be cut back to the basal buds to encourage growth of vigorous branches (Fig. 4.10f). The process should be repeated to develop the frame up to secondary and tertiary branch levels (Fig. 4.10g & h).

In the subtropics, during the first year, after transplanting budded plants or budding in the field at the onset of rainy season, the plants should be allowed to grow until the following spring. As above, the scion portion of the young plant is cut back to the basal bud during the spring, to encourage upright vigorous growth; this will be trained to form the main trunk (Fig. 4.10c). From this trunk, 3-4 well-spaced main branches are allowed to continue growing and the terminal branch (top of the trunk) is cut back (Fig. 4.10d & e). These main branches are then also cut back to the basal bud during the next spring to induce growth of vigorous main branches (Fig. 4.10f). From the main branches, 3-4 well-spaced secondary branches are allowed to grow (Fig. 4.10g & h). These are cut back the following spring. This process is continued to form tertiary branches (Fig. 4.10i).

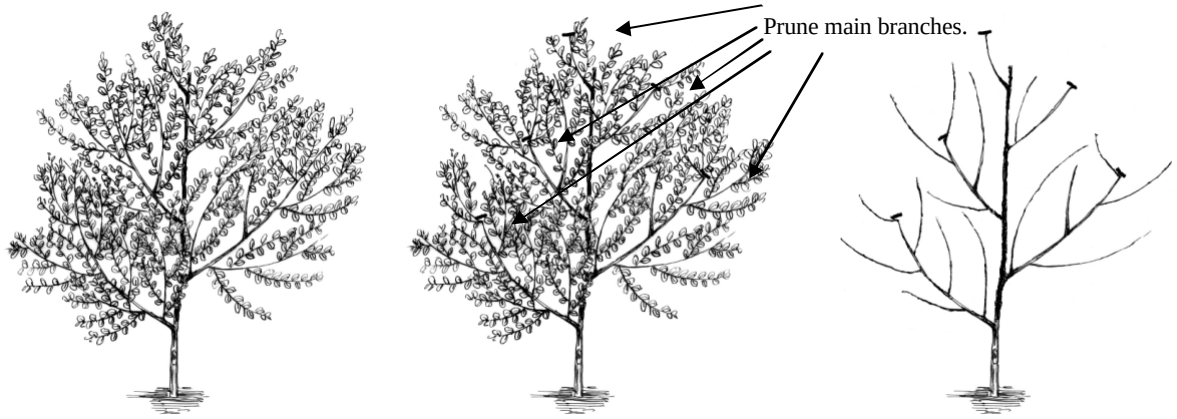
During the process of training, all shoots emerging from the rootstock portion, and weak and damaged branches arising from the scion portion should be continuously thinned out.

4.6.2. Pruning

Pruning is necessary in ber to maintain productivity of the trees and to improve the quality of fruits. Through the pruning operation, the unproductive upper part of the past season's main shoots and their secondary branches, undesirable, weak, diseased and broken branches are removed so that the most healthy and vigorous growth is induced at the most productive nodes. The productivity of the tree is maintained because about 98% of the fruits produced on any pruned branches are borne on vigorous shoots, and only 2% on the other shoots. Pruning also opens up the tree form for sunlight and air.

Pruning is carried out every year to maintain productivity of trees and quality of fruits. During the pruning operation:

1. Only vigorous branches (past season's shoots) should be retained, thin shoots should be completely removed.
2. The main axis of the branches should be pruned keeping 15-25 nodes depending on climatic conditions, i.e. 20-25 nodes in arid areas and 15 nodes in semi-arid areas.
3. All the secondary shoots on the main axis should be completely cut back.
4. All criss-crossing, downward growing, diseased and broken branches should be removed.
5. To avoid pushing the fruit area too far from the tree trunk after several years of annual pruning, half the branches on a tree can be pruned to the basal buds, which serve as foundation buds to provide fruiting shoots during the following year.
6. To induce early bud break and to increase the number of vigorous shoots, one pre-pruning spray (48 hours before pruning) of 3% thiourea combined with two post-pruning sprays of 100ppm benzyladenine or 50ppm TIBA at monthly intervals can be carried out. This is useful under moderate climatic conditions.
7. Pruning should be carried out when the trees shed their leaves and enter into dormancy during the summer. The exact time depends on the local climatic conditions.



1. Tree before pruning.

2. Main branches pruned leaving 15-25 nodes depending on climate.

3. All secondary shoots removed.

Figure 4.11. Pruning

4.6.3. Fertilisers

Ber trees require fertilisation to ensure productivity. Regular manuring is essential to replenish the nutrients removed by the tree through fruit harvests and annual pruning of wood as well as the losses from the soil through vaporisation, leaching and runoff. Deficiencies of nitrogen (N), phosphorous (P) and potassium (K) reduce shoot length, leaf number and size, axillary branch number, flowering and fruit set and consequently productivity of the tree. Organic manures can be applied to the base of the tree and can help to maintain the soil structure in orchard farming. Commercial fertilisers can also be applied as an alternative or in addition to manure. Organic manures and phosphate fertilisers should be applied 30 days after pruning as a single dose. Nitrogenous fertilisers should be applied in 3 split doses (30, 90 and 150 days after pruning). Potassium fertilisers may be applied only when necessary based on the soil conditions at the location.

The following annual doses of fertilisers and manures are suggested, though they may need to be modified to suit local requirements.

Table 4.2. Fertiliser requirement for ber trees.

Age (in years)	Nitrogen (g)	Phosphate (g)	Potassium (g)	Organic manure m^3 (cft)
1	100	100	50	0.06 (2)
2	200	150	50	0.09 (3)
3	300	200	100	0.11 (4)
4	400	250	100	0.14 (5)
5	500	300	150	0.17 (6)

4.6.4. Water Supply

For optimal production, mature ber trees, in arid and semi-arid areas, require 600mm of water or rains. Water harvesting may be practiced to help irrigate the trees. Catchment areas can be created on the land around a tree or group of trees. Methods such as basin or drip irrigation can be used.

Excessive watering during the flowering period causes the flowers to drop. Irrigation during the time of fruit maturity may delay and prolong the maturity period. Water stress will cause immature fruit drop.

4.6.5. Mulching

Mulching conserves soil moisture by reducing evaporation from the soil surface. Mulching also suppresses weed growth. Available waste materials such as grasses, castor shells, other organic wastes, polythene and even pebbles and pure sand can be used as mulch to reduce moisture loss.

4.6.6. Weeding

The area around the trees should be kept clear of weeds, especially while the trees are young. The weeds can be removed manually if on a homestead or only a small number of trees are grown, if a larger number of trees are grown, then a plough may be more appropriate. By ploughing or removing the weeds manually immediately after summer pruning, the soil is exposed to the sun and kills hibernating insect pests. It also allows penetration of rainwater into the soil. Chemical herbicide can also be used to control the weeds.

4.6.7. Intercropping

In an orchard, a fully-grown ber tree covers the entire inter-row spaces about five years after planting. In the mean time considerable losses occur from these vacant interspaces. By growing intercrops, losses can be minimised and additional income generated. Intercrops such as mung bean, moth bean, cowpea, clusterbean and sesame can be grown under rainfed conditions during the summer.

4.6.8. Pests and diseases

Ber has few serious pests or diseases. The most serious are listed in appendices 2 and 3, along with the nature of attack and the control method.

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 - Several insects infest ber, but only fruitfly, fruit borer, bark eating caterpillar, chafer beetle and hairy caterpillar cause significant damage. Most can be controlled successfully using either bio-control methods or chemical control.

Diseases - The most important disease of ber is powdery mildew, which can defoliate the trees and cause devastation of an entire crop. Other diseases include leaf spots and rusts. A number of ber cultivars have shown resistance or tolerance to some diseases; however, they can also be controlled using chemical methods.

5. HARVESTING

Fruit production starts from the third or fourth year and peak fruit production usually starts from about 10 years of age and continues until about 40 years, depending the management of the tree.

The fruit yield depends on the variety, agroclimatic conditions, age of the tree and management practices. The average yield may range from about 50 to 200kg (2,500-10,000 fruits) per year.

The fruits should be harvested when fully mature which is distinguished by their colour. They can be harvested at a variety of stages depending on the desired end use:

- mature-green (for pickling)
- mature-golden yellow (for pickling, preserve, candying),
- yellow (dessert)
- golden yellow

The stage of maturity differs with variety e.g.

Umran - golden yellow when mature
Kaithli - green-yellow when mature
Gola - green yellow or yellow when mature.

When harvested at the mature-green to mature golden-yellow stages, ber fruits start to ripen at room temperature after 4 to 15 days, depending upon the cultivar and storage environment.

5.1. Harvesting techniques

The fruits can be harvested by manual shaking or beating the tree branches to induce the mature fruits to fall onto a cloth sheet below the tree. However, hand picking using a ladder or clipping (using an iron hook or loop fixed to a long stick e.g. bamboo) is better as less fruits are damaged.

Mature ber trees need to be picked 4-5 times in a season as the fruits do not mature at the same time. A worker is capable of manually harvesting about 50kg (110lbs) per day. If the fruits are harvested with the stalks attached, the storage life may be increased.

Fruits harvested around noon generally have a better storage life.

After harvest, the fruits can be cooled by dipping in cold water for 2 hours or by exposing to cold air for 4 hours to extend their shelf life.

6. PROCESSING AND STORAGE

6.1. Processing

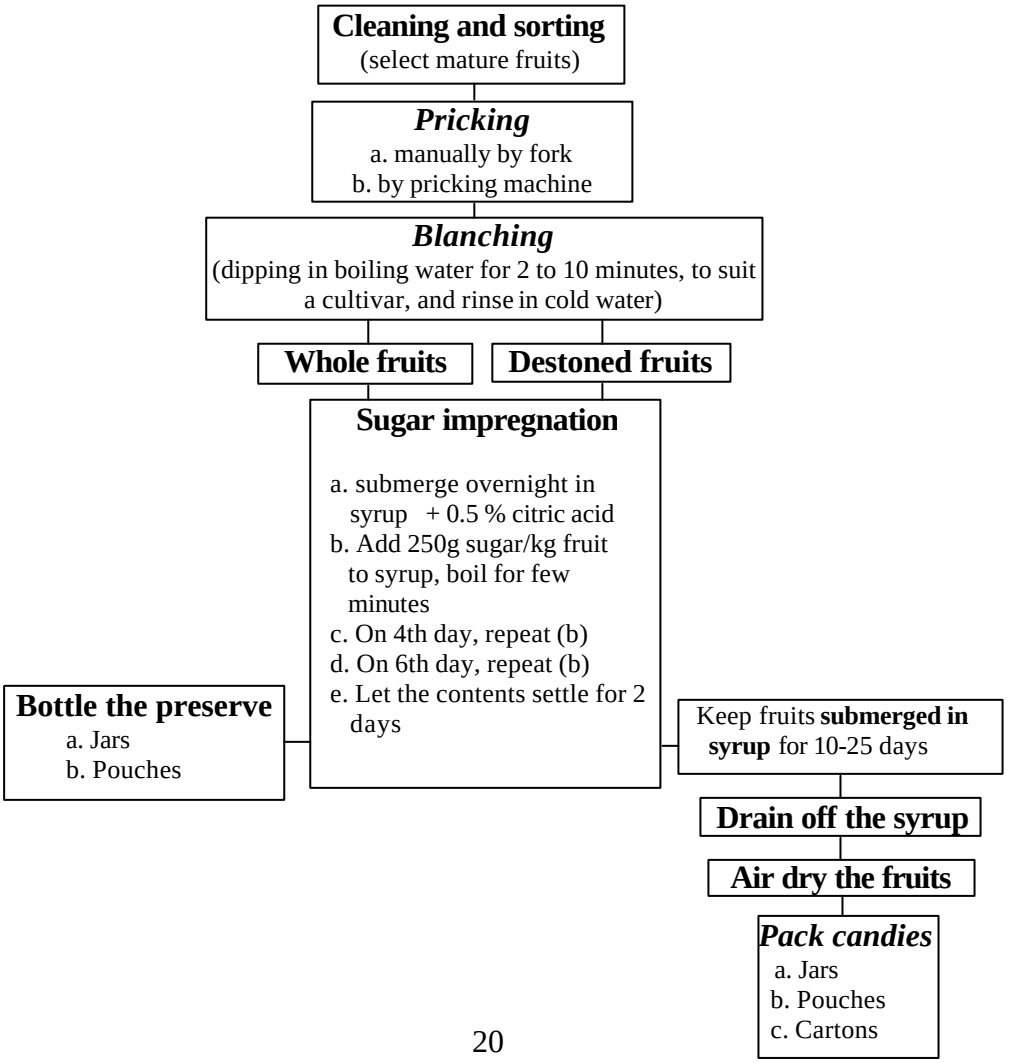
The fruits can be processed for domestic use, to produce dehydrated fruit, pickles, powder and fermented or unfermented drinks.

Dehydrated ber - fruits of Umran, Bagwari, Chhuhara and Sanaur-2 give a good dehydrated product. Golden yellow to reddish brown fruits should be used. The fruits should be washed, drained and sun-dried on mats or polythene sheets for 7 to 10 days. The dehydrated fruits should then be packed in moisture-proof containers, e.g. polythene pouches or biscuit tins.

Candied ber - fruits of Illaichi, Kaithali, Kathaphal, Umran and Narma are good for producing candy. This involves soaking in sugar solution, draining and then drying in the sun or in a warm room. The candies can be packed in jars, tins, and cardboard cartons or in polythene pouches. These fruits can also be rolled in powdered sugar to prepare a crystallised product.

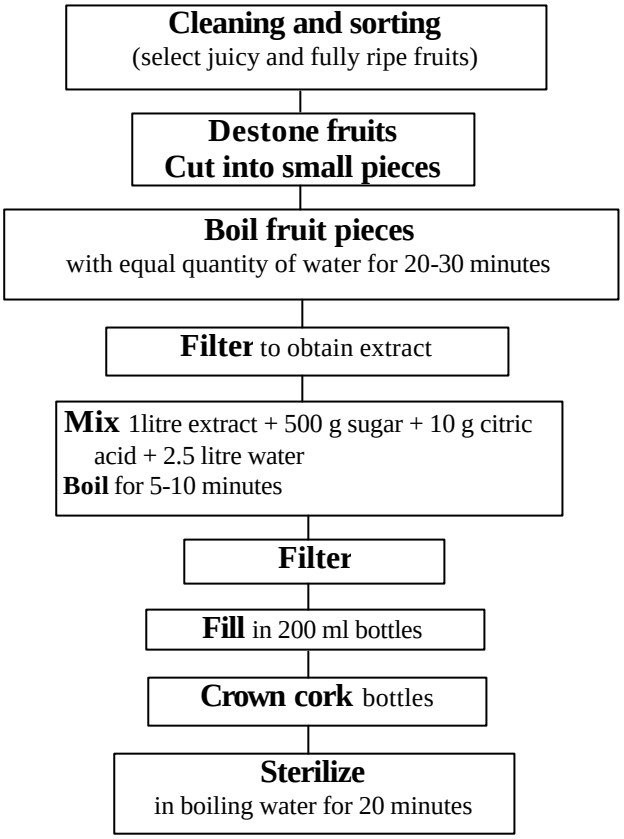
Ber preserve - fruits of Umran, Banarsi Karaka and Kaithali are good for producing preserve. The fruits should be fully matured, then soaked in sugar solution and kept in syrup.

A flow chart showing the preparation of preserve and candy:



Juicy varieties of ber are used for pulp making. After removing the stones, the fruits should be cut into small pieces, heated with water for a few minutes and then passed through a sieve. The pulp can be used for making squash, jam, drinks, nectar and leather.

A flow chart showing the preparation of ber drink.



Dried or fresh fruits can be crushed and fermented for 7 days in earthenware containers using microorganisms (yeast and lactic acid bacteria) to produce an alcoholic drink having 2 % ethanol.

6.2. Storage

The shelf life of different ber cultivars differ from each other. The shelf life depends mainly on the storage temperature, packaging method and stage of harvest (see table 6.1.).

Table 6.1. Storage life of fruits in days of some ber cultivars.

Storage condition	Gola	Kaithli	Umran	Min. Temp. (^{o}C)	Max. Temp. (^{o}C)	Relative humidity (%)
Room temp.	9	7	10	18	29	64
Zero energy chamber	18	14	15	12	20	95
Cold storage	42	28	35	10	--	79

Ber fruits should be stored at room temperature (25-35^{o}C) after harvest and stored in packages such as gunny bags, net bags, polythene bags, cloth packs or boxes. Depending on cultivar and storage conditions, some fruits can be kept for 4 to 15 days without loss of quality. During storage, the fruits

may lose weight and shrivel, change colour and become red, lose acidity but gain in sweetness.

The shelf life of the fruits may be extended by storing in a fridge or cool room The fruits of some cultivars remain in a good condition for 28 to 42 days. If possible, fruits should be stored in polythene bags when kept at lower temperatures, but if not available, baskets or boxes will do.

Fungicidal sprays such as thiobendazole (at 500 ppm), or 0.2 % $ZnSO_4$, can reduce decay losses in storage.

APPENDIX 1. USES OF BER TREES

Fruit and pulp	• Fruit is eaten fresh and in a dehydrated form and can also be stewed. • Fruit powder is used in baking and in the preparation of jam. • Unripe, green fruits can be used to prepare chutneys, pickles and jellies, they can also be eaten raw with salt.. • Ripe fruits can be preserved by sun-drying and a powder is prepared for out-of-season purposes. • Dehydrated fruit is also prepared and sold commercially. • The fruit can be made into refreshing drinks both alcoholic and non-alcoholic. • The fruits are also used to dye silk produced from worms reared on the leaves. • Slightly underripe fruits can be candied. • The fruits can be used to stupefy fish.
Seed	• Seeds are a good source of protein and are often eaten in times of famine.
Leaf	• The young leaves can be eaten as a vegetable. • The leaves are also valuable as fodder as they are nutritious and regenerate very quickly, even under stress. • They are used to feed silkworms. • The tree is grown as a host for the lac insect, *Kerria lacca*, which sucks the juice from the leaves and encrusts them with an orange-red resinous substance. The lac has been used for dyeing, but today the purified resin is the shellac of commerce. Low grades of shellac are made into sealing wax and varnish; higher grades are used for fine lacquer work, lithograph-ink, polishes and other products.
Wood	• The wood is reddish, close-grained, fine-textured, hard, tough, durable, and good for planing and polishing. It is used for domestic purposes, such as lining wells, making legs for bedsteads, boat ribs, agricultural implements, house poles, tool handles, yokes, gunstocks, saddle trees, sandals, golf clubs, household utensils, toys and general turning, however, the timber has no real value. • It is a valued fuelwood, and a good source of charcoal. The amount produced is dependent on climate and pruning severity. • The flexible branches can also be used to retain livestock by twining together to form thorny corral walls.
Twigs and bark	• The bark yields a non-fading, cinnamon-colored dye and is used in the tanning industry for tanning hides and dyeing. • Extracts from the bark have shown anti-fungal activity.
Flowers	• They are rated as a minor source of nectar for honeybees. The honey is light and of fair flavour.

For medicinal uses see section 2.6.

APPENDIX 2a. MAJOR PESTS OF BER

COMMON NAME	SCIENTIFIC NAME	NATURE OF ATTACK	BIO-CONTROL	CHEMICAL CONTROL *
Fruitfly	*Carpomyia vesuviana* *Dacus correctus* *D. dorsalis*	Infestation of the fruit, starts at the beginning of the fruiting season.	Collect and destroy fallen fruit. Dig orchard soil under the tree canopy during the summer after fruit harvest	1st spray at pea stage of fruit with 0.03% monocrotophos. 2nd spray at 15 days after the first spray with 0.05% malathion. 3rd spray 15 days after the 2nd with 0.1% carbaryl XLR.
Fruit borer	*Meridarchis scyrodes*	Bores into and feeds on the fruit.	Collect and destroy fallen fruit. Dig orchard soil under the tree canopy during the summer after fruit harvest	1st spray at pea stage of fruit with 0.03% monocrotophos. 2nd spray at 15 days after the first spray with 0.05% malathion. 3rd spray 15 days after the 2nd with 0.1% carbaryl XLR.
Hairy caterpillar	*Dasychira mendosa,* *Thiacidas postica,* *Euprotis fraterna*	Scrapes the leaves and young fruits. Older caterpillars quickly devour leaves, fruits and sometimes tender shoots.	No known bio-control.	0.05 % monocrotophos and 0.2 % carbaryl.
Bark eating caterpillar	*Indarbela quadrinotata,* *I. watsoni, I. tetraonis*	Produces a web of debris on the stem near the forks and angles of branches. The caterpillar remains concealed in the stem in the day-time and eats away the bark during the night.	Web and debris cleaned away. Fumigation of holes in the tree stems by inserting kerosene.	Spray 0.05% monocrotophos and 0.2% carbaryl 50WP.
Cockchafer beetle	*Adoretus* sp. *Holotricha serrata* *Schizonycha* sp. *Adoretus deccanus* *A.kanarensis* *A.stoliczkae* *Holotrichia consanguinea*	Leaves are eaten during the night. Eggs are laid in the soil and hatch at the beginning of the rainy season. Once the larvae hatch, they feed on the roots and foliage.	Use light traps to catch the insect in kerosenised water.	Spray 0.2% carbaryl 50WP and 0.05% monocrotophos.
Lac insect	*Kerria lacca*	Sucks sap from the twigs and branches. The resin produced by the insects forms a hard crust on the twigs and branches.	Remove the affected plant parts at the time of annual pruning. Cultivar Gola has some resistance to the attack of lac insect.	Spray with 0.1% dimethoate or 0.03 % phosphamidon.
COMMON NAME	**SCIENTIFIC NAME**	**NATURE OF ATTACK**	**BIO-CONTROL**	**CHEMICAL CONTROL** *

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

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Scale insect	*Parlatoria zizyphus* *Quadraspidiotus perniciousus* *Drepanococus chiton* *Selenaspis articulatus*	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	*Nipaecoccu viridis* *Drosicha* sp. *Ferrisia consobrina*	Sucks the sap of leaflets, mature and tender shoots and leaf petiole bases. Leaves become chlorotic and defoliate. Immature fruits fall.	Remove affected parts.	Spray with diazinon or carbosulfan at 0.1% solution.
Thrips	*Scirtothrips dorsalis* *Halothrips* sp. *Dolichothrips indicus*	Attacks flowers, bores into flower buds causing bud death and can web flowers together.	No known bio-control.	Spray with dimethoate at 20-40ml/10litres of water.

APPENDIX 2b. MAJOR DISEASES OF BER

COMMON NAME	SCIENTIFIC NAME	NATURE OF ATTACK	BIO-CONTROL	CHEMICAL CONTROL*
***Alternaria* Leaf spot**	*Pleospora infectoria* (Alternaria state) *Pleospora caricola* (Alternaria state) *Pleospora passeriniana* (Alternaria state) *Alternaria chartarum* *Alternaria tenuissima*	Produces small, irregular, brown spots on the upper surface of the leaves and dark brown to black on the lower surface. The spots become larger, join and the leaves fall off.	Cultivars Govindgarh Special, Gola Gurgaon, Popular Gola, Seo-Bahadurgarhia, ZG-3, Safed Rohtak and Jhajjar Special have shown some resistance to this disease.	2-3 sprays of mancozeb (2-3%) or captafol (2%) or copper oxychloride (2-3%) or carbendazim (1%).
Black Leaf spot (*Isariopsis* mouldy leaf spot)	*Isariopsis indica* var. *ziziphi*	Sooty tuft-like spots on the underside of the leaves, later, it covers the entire lower surface. The leaves show yellow and brown colour on the upper surface and drop early.	Cultivars Seo, ZG-3, Rohtak and Sanaur-1 have shown some resistance to this disease. Cultivars Mundia Murhera, Banarsi Karaka, Banarsi Pewandi and Bagwadi have shown resistance in some locations.	2-3 sprays of captafol (0.2%), carbendazim (0.1%), mancozeb (0.2%) and copper oxychloride (0.2%) at 15 day intervals.
***Cercospora* Leaf spot**	*Cercospora ziziphae* *C. jujubae*	Circular to oval spots, up to 4mm in diameter, yellow at first, turning to brown with a dark brown margin. Spots become larger and visible on both surfaces of the leaves. Infected leaves fall off.	Cultivars Safed Rohtak, ZG-3, Seo-Bahadurgarhia, Popular Gola, Rashmi and Jhajjar Selection have shown resistance to this disease.	Spraying 0.2% dithane Z-78 or dithane M-45.
***Cladosporium* Leaf spot**	*Cladosporium ziziphi* *C. herbarum*	Small light brown to brown spots on the undersurface of the leaves. The disease starts on the lower surface.	Cultivars Sandhura Narnaul and Jogia have shown resistance to this disease. Cultivars ZG-3, Barnsi, Govindgarh Selection-3 and Jhajjar Selection have also shown resistance.	2 sprays of 0.2% copper oxychloride or zineb or mancozeb applied at 2-week intervals.
Powdery Mildew	*Oidium erisyphoides* f. *ziziphi*	Symptoms first noticed on flowers and newly set fruits. Developing young leaves, show a whitish, powdery mass, which causes them to shrink and defoliate. The spots turn to brown and become raised. Affected fruits may drop off. Sometimes the whole crop may be unmarketable.	Cultivars Illaichi Jhajjar, Gola, Seb and Safed Rohtak have shown tolerance.	2-4 sprays with dinocap (0.1%), carbendazim (0.1%), wettable sulphur (0.2%), trideomorph (0.1%), thiophenate methyl (0.1%) or dusting with sulphur dust (250g/tree) at 15-20 day intervals starting from initiation of the disease.
Rust	*Phakospora ziziphi-vulgaris*	Appears towards the end of winter as small, irregular, reddish-brown, raised blisters on the lower surface.	Cultivars Banarsi, Seo, Katha Gurgaon, Gola-Gurgaon-2, Dandan, Sanaur-1, Safeda Selected and Sanaur-3 have shown resistance to this disease.	0.4% copper oxychloride or 0.2% zineb or captafol.

GLOSSARY

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

Abscise -	when a leaf, flower or fruit falls off the plant naturally.
Basal buds -	buds at the base of a stem.
Basin irrigation -	an artificial method of watering plants in which a level field is surrounded by a ridge of earth so that a shallow body of water may accumulate before it soaks into the soil.
Bud -	a rudimentary structure consisting of meristematic tissue and a potential to develop into a vegetative, reproductive or a mixture of structures.
Bud sticks -	current season's shoots containing vegetative or leaf buds.
Budwood -	shoot sections containing vegetative buds suitable for budding or grafting.
cft -	cubic feet.
Crotch -	the angle formed between two joining branches.
Dormancy -	temporary stopping of growth.
Drip irrigation -	a method of irrigation where tubes or hoses, sometimes porous, are brought close to plants and water is allowed to trickle out at a very slow, but constant rate.
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.
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.
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.
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.
Scion -	a cutting from the upper portion of a plant, which is then grafted onto the rootstock of another plant.
Secondary branches -	branches emerging from the main axis of the current season's shoot (first order sylleptic branches).
Seed propagation -	to produce a new plant from sowing seeds.
Mother plant -	the 'superior' or good quality plant from which cuttings, scion material or seeds can be collected.
Tertiary branches -	branches emerging from the secondary branches on the current season's shoot (second order sylleptic branches).
Topworking -	replacement of the top of the established tree by budding or grafting with a more desirable variety.
Vegetative propagation -	to produce a new plant either by vegetative means involving the rooting or grafting of pieces of plant.

FIELD NOTES

FIELD NOTES