Practical Manual No. 10

Jackfruit

Artocarpus heterophyllus

Field Manual for
Extension Workers and Farmers

2006

Copies of this handbook, as well as related literature, including a monograph and factsheet can be obtained by writing to the address below:

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ISBN: 0854328343
© 2006 Southampton Centre for Underutilised Crops
Printed at RPM Print and Design, Chichester, England, UK

Citation: SCUC (2006). Jackfruit *Artocarpus heterophyllus*, Field Manual for Extension Workers and Farmers, SCUC, Southampton, UK.

The manual was originally prepared by A. K. M. A. Hossain and N. Haq, and edited according to an agreed format.

THE FRUITS FOR THE FUTURE PROJECT

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID [R7187 Forestry Research Programme].

A series of underutilised fruits are being researched and this is Practical Manual No. 10 dealing specifically with *Artocarpus heterophyllus*.

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PREFACE

Fruits for the Future is a programme implemented by the International Centre for Underutilised Crops (ICUC) and its partner organisations, the World Agroforestry Centre (ICRAF) and the International Plant Genetic Resources Institute (IPGRI). This project provides information enabling further research on underutilised fruit trees and also provides information on practical techniques that can be used by farmers and rural communities to increase their product output and ultimately the income from their land.

The project has now been taken forward by ICUC in consultation with stakeholders and includes 10 underutilised fruits that have potential for immediate development. For each, ICUC is issuing a monograph summarising known information and a manual for the use by extension workers and farmers. This publication is the manual for jackfruit *(Artocarpus heterophyllus)*. Demand for the production of scientific and extension materials on jackfruit has been expressed by local, national and regional stakeholders in meetings with UTFANET and SEANUC and in discussion with ICRAF, FAO, IPGRI and other interested organisations. The opinions expressed in this book are those of the authors alone and do not imply any acceptance or obligation whatsoever on the part of ICUC, SCUC, ICRAF or IPGRI.

The information contained within this manual is for use in the field and can be used by forestry and agricultural extension staff working with farmers in Asia. The manual provides practical advice on propagation techniques, selection of high quality materials, and the management of jackfruit trees. Information is also provided on the processing and marketing; however, the products and market strategies may vary from farmer to farmer and country to country. This manual has been published in English. Any part of this manual can be freely copied or translated into other languages, in order to aid effective extension work.

The manual is presented in two sections. The first section gives background information for the effective utilisation of this tree. The second section is made up of a set of leaflets, each covering a defined topic. These can be used for guidance during work in the field, or for copying and distribution. Where S.I. units are used in the text, these should be changed to local units where appropriate. Further detailed information on jackfruit can also be found in an accompanying monograph by Haq (2006) and in a video produced for propagation and processing products, available from ICUC, Sri Lanka and SCUC, University of Southampton, UK.

Editors
2006

1. INTRODUCTION

Artocarpus heterophyllus Lam. belongs to the family Moraceae and is known by various names in different countries, but is popularly known as jackfruit or Ceylon jak. It is the national fruit of Bangladesh.

- Description. Jackfruit (*Artocarpus heterophyllus* Lam.) is an evergreen tree, 10 to 15 m tall with dark green oval shaped leaves. All parts of it contain sticky white latex. It is a very long-lived tree and generally has a life span of 60 to 70 years.

- Flowering and fruiting. Flowering twigs emerge from the trunk and the main branches. Male and female flowers are borne separately on the same tree. The female flower, which has a fleshy ring at the base, is larger than the male flower. Jackfruit is a multiple fruit. It contains a large number of bulbs and each bulb is a fruit. The composite fruit may be as large as 20 kg or more. Jackfruits are broadly classified into two groups: (i) soft pulp varieties having plenty of juice; and (ii) firm pulp varieties, which are crispy and less juicy. There are also intermediate types.

  Besides peak season varieties, there are early and late varieties. Fruiting season varies from country to country (see Haq 2006). While a jackfruit crop is seasonal in many countries, it is available year round in Malaysia, Indonesia, Thailand and Australia.

- Distribution. Jackfruit (*Artocarpus heterophyllus* Lam.) probably originated in India. It is now widely cultivated in south and south-east Asia including Bangladesh, Malaysia, Myanmar, India, Indonesia, the Philippines, Sri Lanka, South China, Thailand and Vietnam, in the Caribbean and Latin America, particularly Brazil, and parts of Africa, including Kenya and Uganda. The species was introduced to Kenya, Mauritius and Uganda in Africa and in Australia, and has been cultivated in the Bahamas, Brazil, Florida, Hawaii, Jamaica and Mexico in the western hemisphere.

- Toxicity. No toxicity is known.

2. WHY GROW JACKFRUIT TREES?

The jackfruit tree is a multipurpose species. It provides food, fuel, timber and medicinal extracts, and is a potential source of income for both the rural and urban people of the tropics and subtropics. It assumes the role of a secondary staple in certain areas that are particularly prone to variable climatic conditions which lead to food shortage. The different uses of the jackfruit tree are summarized in Appendix 1 and described below.

☞ See also Technical Note 1 in Part II.

2.1 Nutritional value

Both tender and ripe fruits and the seeds are rich in minerals and vitamins. Ripe fruits are rich in vitamin A, which maintain good vision. Vitamin B complex helps convert food into energy. Iron, is present in blood, which is involved in the movement of oxygen through the body. The nutritive value of jackfruit is presented in Table 1.

Table 1. Nutritive value of jackfruit per 100 g edible portion

Constituents	Pulp		Mature seed
	Tender	Ripe	
Moisture (%)	84.0	77.2	64.5
Carbohydrate (g)	9.4	18.9	25.8
Protein (g)	2.6	1.9	6.6
Fat (g)	0.3	0.1	0.4
Fibre (g)	4.4	1.1	1.3
Total mineral matter (g)	0.9	0.8	1.2
Calcium (mg)	50.1	20.0	21.0
Phosphorus (mg)	97.0	30.0	28.0
Iron (mg)	1.5	500.1	0.8
Potassium (mg)	206.0	350.0	246.0
Vitamin A (IU)	0.0	540.0	17.0
Thiamin (mg)	0.2	30.0	0.2
Riboflavin (mg)	0.1	0.1	0.1
Nicotinic acid (mg)	0.2	0.4	0.3
Vitamin C (mg)	11.0	7.0	11.0
Calorific value	50.0	84.0	139.0

2.2 Income generation

- The yield of jackfruit trees may vary year to year depending on management and climatic factors. However, it bears fruits every year and thus provides a source of income. Its average yield is approximately 10 t/ha.
- Tender fruits can be sold as a vegetable, bringing early income before peak fruiting season.
- Ripe fruits can also be sold either fresh or processed for an income.
- Additional income may be earned by intercropping the open space between trees until the tree canopy closes by growing short duration pulses, spices and vegetables, if water availability is not limited.

2.3 Cultural

- Popular fruit in tropical and subtropical countries, and most Asian cultures value jackfruit primarily as a food.
- In Hindu communities, jackfruit leaves are often used in temple worship.
- Buddhist priests use the fruit to colour their robes.
- Wood yields yellow dye when wood chips are boiled.

2.4 Medicinal value

Parts of jackfruit trees are used in traditional medicine throughout tropical Asia. However, no major clinical evidence is available to support these uses and a medical practitioner should be consulted.

- Roots
  - An extract of roots is used in treating skin diseases, asthma and diarrhoea.
- Leaves
  - An extract from leaves and latex treats asthma, prevents ringworm infestation, and heals cracking of the feet.
  - An infusion of mature leaves and bark is used to treat diabetes and gall stones.
  - A tea made with dried and powdered leaves is taken to relieve asthma.
  - Heated leaves can treat wounds, abscesses and ear problems, and relieve pain.
- Bark
  - An extract from bark or rags (the non-edible portion of ripe fruits) or roots is used in the treatment of dysentery and release of the placenta after calving in cows.
  - Ashes produced by burning bark can treat abscesses and ear problems.
  - Extract from seeds or bark helps digestion.
- Other uses
  - Crushed inflorescence is used to reduce bleeding in open wounds.

- Ripe fruits can be used as a laxative.

- Seeds
  - Extract from freshly extracted seeds is used to treat diarrhoea and dysentery.

2.5 Fuel and timber

- Jackfruit trees yield valuable timber for making high quality furniture, for house construction, masts, oars and musical instruments.
- The fallen leaves and pruned twigs and branches can be used as household fuel.

2.6 Fodder

- Leaves are a useful fodder for goats.

2.7 Ecological and environmental value

- The jackfruit canopy provides perennial cover to the soil, acting as a shade tree and absorbing the impact of rain on the soil.
- Soil fertility is improved if fallen leaves are allowed to rot and incorporated in to the soil.
- Weed growth is reduced when leaf mulches are used.
- The action of roots particularly taproots growing into soil benefits soil structure by reducing compaction, and facilitates soil conservation.
- The tree can reduce the effects of wind planted around a homestead.

3. WHERE TO GROW JACKFRUIT TREES

3.1 Climatic requirements for cultivation

Jackfruit can grow from sea level to 1600 m elevation. However, fruit quality is better at lower elevation.

- Jackfruit is well adapted to hot, humid tropics and a humid subtropical climate. Temperatures ranging between 16 to 28°C are considered good for its growth. However, optimum growth and production occurs in continuously warm areas.
- Jackfruit cannot tolerate freezing temperature. It requires watering during long dry periods for optimum growth and production.

The climatic requirements for cultivation of jackfruit are summarized in Table 2.

Table 2. Climatic requirements for jackfruit

Climatic factor	Minimum	Maximum
Altitude (m)	Sea level	1600
Annual rainfall (mm)	1000	2400
Mean annual temperature (°C)	16	28

3.2 Site requirements

☞ See Technical Note 5b in Part II.

Jackfruit grows in a wide variety of conditions.

- Soil. Jackfruit can grow on a wide variety of soil, but grows best on deep alluvial soil. Soil drainage is very important. It cannot tolerate waterlogged conditions. The tree may die in 2–3 days in flooded soil conditions. The general physical soil requirements of the jackfruit tree are shown in Table 3.
- Light. The tree grows well in full light.

Table 3. Suitable habitats for jackfruit

Characteristics	Suitable habitats
Soil type (texture)	Deep alluvial, sandy loam, clay loam, calcareous, lateritic
Topography	Plains to highland, up to 30° slopes observed
Rooting depth	25 cm deep, 2.25 m in spread
Drainage	Well drained
Soil pH	5.0–7.5

3.3 Land-use systems

- Jackfruit can be grown in homesteads, community places, by the roadside and in orchard plantations.
- Forest land. In certain countries it is still abundant in forests. In Sri Lanka it is protected from felling for the conservation of the tree.
- Jackfruit fits well in agroforestry systems. Jackfruit tree is interplanted with annual crops such as vegetables, pineapple and spices, and also with other perennial species such as coconut, cocoa, pepper, etc., in household and secondary agroforestry systems.
- Boundary tree. Used to maintain the boundaries of land (Hocking 1996) by planting on dykes created between fields.
- A component of both village forests and home gardens, jackfruit trees form part of the middle layer of the upper canopy along with other fruit trees.

4. WHAT TO GROW

4.1 Selected superior phenotypes

☞ See Technical Note 2 in Part II.

Superior phenotypes have been identified and selected as baseline materials for crop improvement. The selection of these phenotypes is based on the characteristics summarized in Table 4.

Table 4. Characteristics of selected superior phenotypes of jackfruit

Characteristics	Requirements
Vigour and health of mother plants	Vigour The tree should have a history of good bearing of fruits every year. Fruit shape is uniform and quality is excellent. Free from any disease and pests.
Yield	200–300 fruits/tree/season (variability exists in different locations)
Fruit size	2–5 kg
Good quality Flesh colour Flesh texture Sweetness of fruits	Highly juicy and sweet Golden Medium soft to soft >20% Brix
Seasons	Early and late
Seeds	Small in proportion of pulp

4.2 Propagule type

Two types of propagule:

- Seedlings raised from seeds.
- Grafted plants obtained by vegetative propagation.

4.2.1 Seeds

The advantages of this method are:

- A simple and easy method of reproducing the trees.
- The tree is generally deep rooted with a strong taproot facilitating firm anchorage, and greater resistance to drought as well as high wind.

- It grows taller and thus produces a longer trunk, which is more valuable as timber.
- Seed propagation is practiced in most jackfruit growing countries.

The disadvantages of this method are:

- The characteristics of fruits produced by the seedling trees cannot be guaranteed, and are not necessarily the same as those of the mother tree.
- The time taken by seedling trees to reach fruit-bearing age is usually longer than for those trees propagated by vegetative methods.
- The trees grow taller than those propagated by vegetative methods, which is a constraint in management and harvesting.

4.2.2 Vegetative propagation

- Vegetative propagation can be carried out by different methods. Veneer and epicotyl grafting are commonly practised in jackfruit in Asia (Haq, 2006). Details are described in Section 5.
- Fruiting and fruit quality of vegetatively propagated trees are the same as those of the mother tree.
- Vegetative propagation is particularly favoured in Thailand.

The advantages of this method are:

- The fruit quality of the new tree is assured; it will be the same as the mother tree.
- The tree reaches fruit-bearing age sooner than in seed-propagated trees.
- The trees remain relatively shorter in stature, which makes management and harvesting easier.

The disadvantages of this method are:

- The trees are often shallow rooted.
- Trees tend to be dwarf and to produce branches at a low level, which results in lower quality timber with a shorter trunk.

5. HOW TO GROW JACKFRUIT TREES

5.1 Propagation by seeds

☞ See Technical Notes 2b and 3 in Part II.

5.1.1 Seed collection and handling

You should only collect seeds from selected superior phenotypes with identified characteristics, specified in Table 4.

- Collect seeds from fully mature/ripe fruits.
- Extract seeds carefully without any damage.
- Wash in clean water and plant before seeds dry out.

5.1.2 Seed treatment and germination

- Soon after separating from the pulp, wash the seeds in water to remove the slimy part. Seeds may then be stored for one or two days in closed polythene bags so that they do not dry out. Generally, freshly extracted seeds should be planted.
- Germination is improved by soaking seeds in clean water for 24 hours.
- Germination of jackfruit seed deteriorates quickly with storage. If storage is necessary, keep in airtight polythene containers at ambient temperature. They remain viable for about 7 weeks in this condition (Sonwalker 1951).

5.1.3 Sowing

- Sow seeds in line, 30 cm apart, in a well-prepared nursery bed or in polythene bags filled with soil (70%) mixed with organic matter 30%.
- Plant out seeds 2–3 cm deep.
- Seedbed should be shaded partially from direct sun to protect emerging seedlings.

5.2 Vegetative propagation

5.2.1 Cuttings

- Cuttings are formed from a part of a parent plant and grown into a new complete plant.
- Cuttings may be a piece of leaf, stem or root.
- Cuttings should be maintained in humid conditions and planted in a well-aerated growing medium such as mixed sand and soil.
- Cuttings may be treated with rooting powder containing growth regulators if it is available, to encourage greater rooting and establishment.

5.2.2 Grafting

- Grafting can be carried out throughout the year. However, veneer grafting is more successful during spring and summer (March to May), and epicotyl grafting in October and November. The availability of mature dormant scions is a prerequisite for successful grafting.
- Grafting involves the union of a shoot, called a scion, from a selected superior phenotype and a compatible rootstock from a desirable plant. Grafting allows the selection of a root system adapted to the specific climate and soil and resistant to pests and diseases, and its marriage with a highly productive shoot.

Grafting materials

- A clean, sharp knife.
- Polythene tubes and polythene tape (budding tape) (1.5–2.0 cm wide x 30–40 cm long), cut from ordinary polythene tube or polythene bags.

Rootstock preparation

- A rootstock is selected for grafting when it is 9–15 months old and is approximately 1 cm in diameter.
- The stem of the rootstock should be cleaned of any soil or debris. A shallow cut about 6–8 cm long should be made in the rootstock, slanting inward to about a quarter of the diameter of the stem, at the point of active growth or where the bark separates easily from the wood (See Rowe-Dutton, 1976).
- A short, second downward oblique cut should then be made at the base of the first, removing a piece of bark and wood.

Scion collection

The scions should be:

- 5–15 cm long.
- 1 cm in diameter (pencil size).
- Mature and dormant.
- Terminal shoots with several plump unopened buds.
- Collected from mature trees that have already fruited.

Preparation

- Select and cut 5–15 cm long scions from the mother tree, and remove leaves immediately with a sharp knife, retaining the petioles.
- Put scions in a closed polythene bag or in clean water contained in a polythene bag to prevent desiccation and keep them fresh. The scions may be kept like this for several days, but the best rate of success is obtained with freshly severed scions.

The grafting union

- Grow the rootstock in a 15 x 10 cm polythene bag or a well-prepared seedbed until it is 10–15 days old.
- Very carefully uproot the rootstock with the seed.
- Cut off the top of the uprooted rootstock 5–6 cm above soil level.
- Cut vertically down through the middle of the rootstock to a depth of 1.5–2.5 cm.
- Make slanting cuts 1.5–2.5 cm long on both sides of the scion at its lower end.
- Insert the scion into the vertical cut in the rootstock and tie them together with a piece of polythene film 1.5–2.0 cm wide and 10 cm long.
- Put a polythene tube or cap over the scion and the rootstock. As soon as grafting is done, replant it in the same or a similar polythene bag, place under partial shade, and water regularly.
- It may take about 2–3 weeks for complete union of the scion with the rootstock. At this stage, dormant buds will sprout and the cap can be removed. When the leaves are green, the grafts are first replanted in a bigger container of 25 x 20 cm size and transferred to an open nursery.

5.2.3 Other vegetative propagation methods

Several countries have used *in vitro* culture methods for propagation. Air-layering and budding methods have also been practiced (see Haq, 2006).

5.3 Field establishment

☞ See Technical Note 5b in Part II.

This manual is intended for small-scale planting schemes. For those intending to establish a larger plantation of jackfruit, please see Haq (2006).

- Jackfruit grows better in full sun and open areas.
- It can be planted in a range of soils (see above), except in saline and waterlogged soils or those prone to flooding.

5.3.1 Site preparation

- Clear all surrounding weeds.
- If these tools are available, plough, harrow and level the planting area.
- Plan out the planting pits to be dug.
- It is necessary to maintain a fence of 1.5–2.0 m either around the entire area or around the individual trees for a period of 3–4 years during establishment to protect young trees from foraging animals.

5.3.2 Timing of planting

- The best time for planting, either through direct seeding or transplanting, is at the beginning of the rainy season.
- If water is available, direct seeding may be done in early summer so that the seedlings are established before the beginning of the rainy season. The rainy season ensures plenty of water and a favourable environment for the establishment of the trees in the field.
- The best time of day for transplanting is late afternoon to early evening, due to falling temperatures, so that drying of young trees is minimised.

5.3.3 Transplanting

☞ See Technical Note 6 in Part II.

Pit planting

Pit planting is the common method of planting fruit trees.

- Dig planting pits of 1 x 1 x 1 m size at 12 x 12 m spacing in fertile soil with other crops, 10 x 10 m spacing in homestead areas.
- For grafted plants the spacing may be reduced to 8 x 8 m.
- Dig the pits at least 4 weeks before planting, keep open for 2 weeks, and then add to each pit, the soil mixed with 20 kg organic matter and water liberally to help settle the soil in the pit.
- Remove polythene bags around the root system completely before planting.
- Plant 1–2 year old grafted plants or seedlings, 1–2 m tall, positioning them upright at the centre of the pits with the root collar (the bulge in the stem where the roots and the stem meet) at ground level, i.e. plant the tree at the same level as it was in the nursery.
- Press the soil of the pit firmly to flatten the soil around the base of the tree.
- Insert a stake by the side of each tree and tie them together, to give support to the newly planted tree.
- Water the trees immediately after transplanting.
- In the first few months, the trees should be regularly watered to maintain moisture in the soil around the tree, and particularly if they show signs of wilting. The frequency depends on soil conditions and weather.
- The stakes used to support the tree can be removed after one year when the plants are established and able to support themselves.

5.4 Field management

☞ See Technical Note 6 in Part II.

5.4.1 Weeding

- The ground around young trees must be kept weed free during the first 3–4 years. This can be done manually if there are only a few trees.
- Mulching, if possible, should be practised.

5.4.2 Water requirements

Jackfruit does not normally require irrigation. However, it is sensitive to drought at certain growth stages.

- It is not necessary to install piped irrigation. Hand watering is adequate for household plantings.
- Growers should be aware of wilting or stunted or slow growth and supply extra water at these times.
- Newly planted trees are susceptible to drying before the root system develops, particularly during the first 3 years after planting.
- For mature trees watering may be necessary during dry periods from blooming through to fruit development, to prevent flower or fruit drop.
- Make a circular ring of soil about half a metre away from the trunk to concentrate water around the root system and prevent run-off. In small-scale orchards or plantations drip irrigation may be useful.

5.4.3 Fertilising

- Apply farmyard manure (FYM) regularly to jackfruit trees.
- Manure and fertilizers may be applied to enhance growth and productivity.
- The first instalment is applied at the beginning of the rainy season, and the second instalment applied soon after the rainy season is over.
- Look for signs of nutrient deficiencies, which may be seen as yellowing or colour changes of leaves, or stunted growth.
- If possible send leaf samples to an extension officer for mineral testing.

For example doses of manure and fertilizers are presented from Bangladesh in Table 5. Other areas may need adjustment.

Table 5. Yearly doses of manure and fertilizers for jackfruit trees In Bangladesh.

Doses of manure and fertilizers per tree per year	Age of tree in years				
	2–4	5–7	8–10	11–20	>20
FYM (kg)	10	15	20	25	30
Urea (g)	200	250	300	350	500
TSP (g)	250	250	500	750	1000
MP (g)	100	200	250	300	500
Gypsum (g)	100	100	200	300	500

TSP - Triple Super Phosphate
MP - Mauriate of Potash

5.4.4 Pruning

Pruning is not commonly practised in Jackfruit. Non-pruned seedling trees generally develop a strong central leader, which is desirable for its timber value. However, grafted trees have a dwarfing tendency and branch very early in their growth. These branches need to be continually pruned to achieve a reasonable trunk. Thereafter, branches may be allowed to grow at desired intervals.

- Remove the inner branches of the canopy to allow more light and air within the canopy.
- Regularly prune weak, dead and diseased branches, and remove all parasitic plants at the end of the rainy season to prevent insect infestation and disease infection.
- Tree height and size may also be controlled, if desired, by pruning.

5.4.5 Intercropping

- Currently used in pineapple, durian and coconut plantations.
- Also intercropped with annual crops, particularly in homesteads.
- In orchards, the space between the trees may be ploughed and harrowed twice a year, if tools are available, at the beginning and end of the rainy season, to assist intercropping.

5.4.6 Protection from pests and diseases

☞ See Technical Note 7a in Part II.

Pests

Diaphania caesalis

- Among insect pests, the shoot and fruit borer, *Diaphania caesalis*, is a major pest of jackfruit.
- The insects lay eggs on tender shoots and flower buds. On hatching, the reddish brown larvae bore into shoot, flower buds and fruits, resulting in the wetting of affected parts. Larvae make small holes and enter the fruit.
- At the initial stage of damage, a small hole with fresh excreta can be seen. Gradually the hole is extended and at a later stage fungal infection occurs.
- Tender fruits may drop under severe infestation, leading to losses of 30%.
- To protect them from egg laying, fruit may be covered with polythene bags and the affected parts removed and destroyed.
- Infestation may be checked naturally if the trees are regularly pruned of dead and diseased twigs and small shoots within the canopy, to allow sufficient light and air to pass through. Pruning may be done soon after harvest or at the end of rainy season.
- Spraying of carbaryl @ 4 g per litre of water during flowering may be recommended.

Bud weevil (Ochyromera artocarpi)

- The small whitish grubs of bud weevil bore into tender flower buds and fruits and induce premature drop.
- The adult weevils are greenish brown in colour and are found to eat the leaves.
- Remove the infested shoots, flower buds and fruits to check infestation.

Diseases

- Blossom rot, fruit rot or stem rot, all caused by *Rhizopus artocarpi*, are serious diseases, which may cause 15 to 32% crop loss.
- The inflorescence, tips of the flowering shoots or the stalk of the tender fruits are infected and blackened by fungal structures called sporangia.
- Flowers and fruits rot and drop.
- Collect and destroy the fallen leaves and fruits under the tree.
- On appearance of blossom rot, an application of Folicur or Tilt 250 EC @ 0.5 ml per litre of water may be sprayed as a further controlling measure.

6. HARVESTING

6.1 Ripeness and yield

☞ See Technical Note 7b in Part II.

Maturity. Best indicators may be:

- Hollow sound when tapped.
- Spines become flattened and wider.
- Colour of fruit becomes pale.
- Develops a strong aroma.
- 3–8 months after flowering.

Yield. Varies greatly between regions, e.g.

- In India, the expected yield varies according to the region:
  - Kerala: 250–300 fruits/plant.
  - Karnataka: 50–250 fruits/plant.
- In India, a mature tree produces up to 700 fruits per year.
- Each fruit weighs from 0.5 kg up to as high as 50 kg.
- On average one can expect a yield of on average 10 t/ha.

6.2 Harvesting techniques

- Harvest fruits by cutting off the footstalk and lowering the fruits carefully, without dropping on the ground which may damage them.
- Collect fruits in a basket and lower them to the ground using a rope.
- The portion of the stalk attached to the fruits helps in handling.
- Harvest fruits in the morning hours while temperatures are low and transfer immediately to a well-ventilated shed.

7. POST-HARVEST HANDLING AND PROCESSING

7.1 Post-harvest handling

☞ See Technical Note 8a in Part II.

Tender fruits. These are generally handled by vegetable dealers and shopkeepers.

- Avoid damage to the skin which causes browning, resulting in poor external appearance.
- The cut stalk will exude latex, which permanently stains clothing. When latex exudation stops, wrap the fruits individually in newspapers and pack them in a suitable container.

Mature fruits.

- Mechanical damage, exposure to sunlight and rough handling during transport reduce the fruit quality.
- Induced ripening is not necessary for matured fruits.

7.2 Processing and packaging

Post-harvest operations

- Remove immature, over-ripe, damaged and misshapen fruits.
- Grade the remaining fruits according to size as follows:
  - Large: weighing 16 kg and above.
  - Medium: weighing 8 kg to 16 kg.
  - Small: weighing below 8 kg.
- Wash fruits using chlorinated water (100 ppm) to remove dirt, latex stains and any field contamination.
- Drain fruits properly to remove excess moisture from the surface of the fruit for further processing or storing.

Packaging and storage of fresh fruits

- Pack graded and washed fruits into plastic containers or bamboo baskets for storage.
- Freshly harvested ripe fruits can be stored for 4 to 5 days at 25–35°C.
- Fruits can be kept for 2 to 6 weeks at 11–13°C and relative humidity of 85–95%, depending on cultivar and maturity stage.
- Jackfruits stored at temperatures below 12°C before transfer to higher temperatures show injury due to chilling. This includes dark-brown discoloration of the skin, pulp browning, deterioration in flavour and increased susceptibility to decay.

Ripening

- Prior to pre- or minimal processing, jackfruits should be ripened fully to achieve optimum aroma, sweetness, taste and eating quality.
- Keep mature jackfruits at 24–27°C. They will ripen within 3 to 4 days. However, uneven ripening is a major problem in the natural ripening process, especially for large-sized fruits.
- To achieve more uniform ripening, expose fruits to 50 ppm ethylene for 24 hours at 25°C. The fruits ripen within 3 to 4 days after the treatment with ethylene gas when kept at room temperature.

Pre-processing into fruitlets

- Cut fruits in half lengthwise. Latex may exude from the cut surfaces when extracting the flesh. Coat hands, knives and work surfaces with vegetable oil to make clean-up easier.
- Carve out the sticky central core.
- Scoop out the individual fruitlets (bulbs).
- Sort bulbs according to the required size, maturity and colour. Only full bulbs, (not half or partly cut) are recommended for retailing.
- Cut the end of the bulbs to remove the seeds according to consumers' preference.
- Pack fruitlets for storage or direct consumption.

Packaging and storage of jackfruit fruitlets

- Pack bulbs in polythene bags and heat-seal them, or in polypropylene containers with lids. They can be kept for 3 weeks if kept cool, at 12°C.
- Maintain a temperature of 12°C throughout the distribution process to avoid deterioration.

Pre-processing into pulp

- Crush de-seeded jackfruit bulbs using a blender.
- Add 40–45 g of powdered sugar to every 100 g of smashed pulp and mix thoroughly.
- Dry mixture in a hot air drier at 80–85°C until moisture content reaches 20–22%.
- Place pulp in plastic containers and seal.
- Freeze pulp and store for further processing.

8. MARKETING

8.1 Marketing potential

☞ See Technical Note 8b in Part II.

Farmers and collectors face several problems when marketing fruits:

- Proximity of markets. Transportation is a major marketing cost. The means of transport used are by carts or trucks to nearby town or village markets for retail sale or wholesale to visiting tradesmen from larger towns. In Nepal the transport of jackfruits can be considered unlucky.
- International export. The large, heavy and perishable fruit are not well suited for the fresh export trade, but canned and other processed products are exported to Australia and Europe.
- Three groups are involved in marketing: producers, traders (middlemen) including wholesalers, and retailers.
- Farmers lack reliable price information, relying on buyers. With better market intelligence farmers could take shorter routes to final consumers, reducing marketing costs and consumer prices.

Development of markets:

- Determine market channels, outlets and pricing.
- Assess supply and demand of market potentials and corporate marketing systems.
- Establish workable marketing information systems and quality standards.

The following products of jackfruit are considered here for marketing:

- Planting materials. There is a shortage of quality planting materials and demand is increasing.
- Unripe fruits (green vegetables). These are marketed mainly by the producers. In some countries such as Sri Lanka and Nepal these products are more popular than the ripe fruits and are sold either as whole fruit or in sliced form.
- These products are also canned by industries in some countries and the procurement of raw materials is mostly done by the wholesalers.
- Ripe fruits.
- Processed goods, e.g. jam, jelly, candy, powder, juice, cordial, pickle and leather.
    - Pulp is sold in soft cartons.
    - Local industry in Bangladesh uses jackfruit for pickles at 500–1100 kg/month.
    - Chips or papads are packed and sold in plastic bags as snacks.

8.2 Pricing

Some examples are given of current market prices in Asia and Europe.

Fruit:

- Unripe fruit sells in Sri Lanka and Nepal US$ 0.2–0.5 per kg.
- Ripe fruit can bring in an income of US$ 8–20 per tree.
- Processed dried bulbs sell for about US$ 0.55.
- Chips or papads sell for US$ 0.50/100 g bag.
- Can of bulbs in brine 250 g (10 oz) sells in UK for £1.39 in retail market.

Other products:

- Grafted and tissue-cultured saplings US$ 0.75–2.0 each. A small nursery selling seedlings and grafted planting materials can earn US$ 120–150 a month.
- Timber US$ 18–26 per cubic foot or US$ 640–929 per cubic metre in Bangladesh.
- Large sack of dried leaf for fuel sells at US$ 0.6–1.0 in Bangladesh.

9. SOCIO-ECONOMICS

The costs and benefits involved in the utilisation of jackfruit depend on whether or not the species is grown in the homestead or the plantation.

☞ See Technical Note 8b in Part II.

- Combining other crops with jackfruit covers costs for planting, tending, protection and waiting for trees to start bearing fruits.

Generally, exploitation of orchard plantations requires rather large investment involving costs for:

- Nursery establishment and management or purchasing of planting material.
- Orchard establishment and maintenance.
- Transport.

If fruits are used for further processing, costs for grading, cleaning, processing, packaging and storing have to be taken into account.

- Processed products command higher prices in the market and can be more easily transported.
- High transportation costs can be a constraint for fresh, perishable fruit.
- Use grading standards for fruit.
- Improve packaging to minimise spoilage.

The grower can increase the benefits of selling jackfruit by:

- Finding reliable markets
- Forming a co-operative to arrange better:
  - Transport.
  - Cold storage facilities.
  - Negotiation of prices.

APPENDIX 1. MULTIPLE USES OF THE JACKFRUIT TREE

Leaves	Green leaves are fodder for goats. Dried leaves are good fuel, composting, mulching. Temple decoration. Medicinal: to treat asthma, ring worm, cracked skin or wounds, abscesses, diabetes, gall stones, ear complaints, and to relieve pain. * Fuel.
Flowers	Medicinal: to treat wounds. *
Fruits and pulp	Tender fruits are vegetables, pickles. Ripe fruits are eaten fresh, with juice, jam, etc. as processed products. Medicinal: to treat dysentery and as a laxative. *
Seeds	Medicinal: to aid digestion, treat diarrhoea and dysentery. *
Bark	Medicinal: to treat dysentery, abscesses, ear problems, and to aid digestion. * Livestock: to aid calving.
Wood	Dye. Furniture, construction, musical instruments. Fuel.
Root	Medicinal: to treat skin diseases, asthma and diarrhoea. *

* No clinical evidence available.

APPENDIX 2. MAJOR PESTS AND DISEASES OF THE JACKFRUIT TREE

Common name	Scientific name	Nature of attack	Bio-control	Other controls
Shoot and fruit borer	*Diaphania caesalis*	Initial stage: small hole with fresh excreta. Wetting of affected parts.	Cover fruits with polythene bags. Remove affected parts. Prune canopy.	Carbaryl @ 4 g/l
Bud weevil	*Ochyromera artocarpi*	Grubs bore into flower buds and fruits and induce premature drop. Adult eat the leaves.	Remove affected parts. Prune canopy.	
Blossom rot / Fruit rot /Stem rot	*Rhizopus artocarpi*	Inflorescence / flowering shoot tips / fruit stalks blackened by sporangia. Flowers and fruits rot and drop.	Remove affected parts. Prune canopy.	Folicur or Tilt 250 EC @ 0.5 ml/l

APPENDIX 3. HEALTH AND SAFETY WHEN USING CHEMICALS

In general, the use of chemicals should be minimised. Where their use is necessary the rules in the box below should be followed.

- Rules to follow when using chemicals
- Don't splash chemicals in the eyes or on skin or clothes.
- Don't drink or breathe in the vapours.
- Do not eat while preparing and applying chemicals.
- Wash hands thoroughly after use.
- Wear protective clothing where available (gloves, overall, rubber boots, etc.).
- Always store chemicals in their original containers and keep them away from water and fire.
- Keep chemicals away from children.

The following chemicals are examples of those that can be used for control of blossom rot and shoot and fruit borer on jackfruit and the relevant health and safety advice for each. For a complete list of chemical controls and precautions for use, please check with your local extension or agricultural office.

TILT

Active ingredients: propiconazole
Handling and storage: Users should wear protective clothing and avoid contact with the skin and eyes. The chemical may irritate the eyes, nose throat and skin. It should be stored in an airtight container and kept away from water or fire.
Environmental impact: moderately toxic to fish and relatively non-hazardous to bees or birds.

FOLICUR

Active ingredients: tebuconazole
Handling and storage: Users should wear protective clothing and avoid contact with the skin and eyes. The chemical may irritate the eyes, nose throat and skin. It should be stored in an airtight container and kept away from water or fire.
Environmental impact: toxic to fish.

SEVIN

Active ingredients: carbaryl
Handling and storage: Moderately to very toxic. Direct contact of the skin or eyes with moderate levels of this pesticide can cause burns. Users should wear protective clothing and avoid contact with the skin and eyes. It should be stored in an airtight container and kept away from water or fire.
Environmental impact: relatively non-hazardous to birds, but toxic to insects and fish.

GLOSSARY

Agroforestry	A system of land use in which harvestable trees or shrubs are grown among or around annual crops or on pastureland.
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 wra p (plastic). When roots from the plant can be seen the stem can be cut and the plant transplanted.
Brix	Measurement of sugar content. A 1% sugar solution is a solution of 1° brix.
Bud	A protuberance on the stem of a plant that may develop into a flower, leaf or shoot.
Budding	A type of propagation in which a bud is inserted underneath the bark of a related plant.
Cutting	A section of a plant that is cut off and rooted to create a new plant.
Field capacity	Amount of water remaining in a soil after being saturated with water and after free drainage is negligible.
Fungicide	A substance or chemical that kills fungi.
Germplasm	The total genetic variability, represented by germ cells or seeds, available to a particular population of organisms.
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.
Indigenous	Native; originating or occurring naturally in the place specified.
Intercropping	Growing two or more crops simultaneously on the same field.
MS	Mauriate of Potash
Mark-up	The amount that is added to the cost price to achieve the required selling price.
Nursery	An area or structure set aside for growth and protection of young plants.
pH	Scale for measuring acidity.
Propagation	To produce a new plant, either by vegetative means involving the rooting or grafting of pieces of the plant or by sowing seeds.
Propagule	Any structure having the capacity to give rise to a new plant, whether through sexual or vegetative reproduction. This includes seeds, spores and any part of the vegetative body capable of independent growth if detached from the parent.
Pruning	Removal of live or dead branches from standing trees.
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.

Symbiosis	A mutually beneficial relationship between two living organisms of different species living closely together.
Tissue culture	A technique in which portions of a plant or animal are grown on an artificial culture medium (also: in vitro culture).
Topography	Physical features, such as hills, valleys, and plains that shape the surface of the earth.
TSP	Triple Super Phosphate
Turnover	The total amount of income received by a business during a specified period (usually a year).

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