

This manual specifically attempts to address critical climate change issues and impacts on vegetables in southern Bhutan, and describes climate-smart production practices for sustainable production and income of the vegetable farmers. The manual is in accordance with the basic principles of environmental, commercial and social sustainability, and provides detailed steps for vegetable production, from land preparation to harvesting, with the adoption of climate resilient farm management practices in each stage of production.



FARMER'S MANUAL



ICIMOD



2017

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FARMER'S MANUAL



ལྷོན་པོ།
MINISTER

ལོ་ནམ་དང་ནགས་ཚལ་ལྷན་ཁག
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
Thimphu : Bhutan



15th May 2017

Message from Hon'ble Lyonpo Yeshey Dorji

Bhutan is predominantly a farming country. More than 68% of our population live in rural areas and depend on subsistence agriculture for livelihood. What makes the farming reality harsher is the fact that only less than seven percent of land is cultivable because of the country's difficult mountain terrain.

In Bhutan, the poorest people live in the most inaccessible parts of the country, often cut off from markets and basic public services. The challenge, therefore, is to get them out of the poverty cycle by building their capacity and introducing activities that improve their livelihoods. One such timely intervention has come through the EU-funded ICIMOD pilot project on rural livelihood that is being implemented in Barshong Gewog in Tsirang. The broad objective of the project is to improve the livelihoods of Barshong farmers through the introduction of new and improved technologies and practices for producing crops and livestock.

I've personally witnessed substantial progress in Barshong in the last three years. Some of the important activities implemented under this project include: introduction of improved goat breed and sheds, promotion of the use of bio-digesters, improved vegetable production, introduction of sustainable land management practices, introduction of rainwater harvesting through the use of plastic ponds, introduction of community-based micro plans and farmer cooperatives, and the construction of a nine-kilometer farm road that has improved access and connectivity of some remote villages in the Gewog.

I am confident that these interventions will further strengthen Brand Tsirang, especially when it comes to vegetable production. It's against this backdrop that the Farmer's Manual must be seen as an important milestone. The Manual will help promote scientific farming methodologies and climate resilient agricultural practices, and can be used by anyone interested in producing vegetables like bean, cabbage, onion, and ginger. We hope to replicate the successes of Barshong Gewog to other parts of the country. In the long run, we hope to help our farmers improve and diversify crop production so that they are able to take advantage of emerging market opportunities.

Finally, I wish to extend my appreciation to everyone involved in the production of this important publication.


Yeshey Dorji



Message from the Director General



Improving the livelihoods of mountain communities in the Hindu Kush Himalaya (HKH) has been central to our initiatives and partnerships. Indeed, as our vision states, ICIMOD believes in a future where the region's mountain people are able to experience enhanced livelihoods, and adapt to new challenges posed by environmental, socioeconomic, and climate change.

Therefore, recognizing the potential of rural economies and communities to make huge contributions in our collective pursuit of a better future for all, ICIMOD has been working on livelihood-related issues through our numerous programmes. We recognize that agriculture is the main source of livelihood in the HKH, and to help our farming communities, we've consciously promoted risk-averting and risk-spreading strategies in agriculture. We're doing this by increasing productivity in sedentary agriculture through improved access to water and energy, diversifying mountain farming systems through increased market linkages and market value chains, and promoting high value cash crops and niche mountain products. We're also training farmers in vegetable and horticulture production and small-scale farm business management, and promoting resilient farming practices.

The various pilots and projects under the EU-funded programme on Rural Livelihoods and Climate Change Adaptation (Himalica) have begun to show visible results. One such success has been the project piloted in Barshong Gewog in Tsirang where the major focus has been on vegetable and livestock production, sustainable water and land management, and empowerment of women entrepreneurs, among others. I've been told that vegetables produced in Barshong are much sought after at the Centenary Farmer's Market in Thimphu. Such heart-warming success stories are what we look for at the end of a project cycle.



I'm glad to see that a Farmer's Manual has been developed as part of the activities implemented in Barshong. This well-designed manual will serve as a handy tailor-made reference not just for farmers, but also for local agriculture officials and others interested in accessing first-hand and accurate information on topics like how to grow vegetables and prepare organic home-based bio-digester and bio-char.

I want to extend my firm appreciation to all who have contributed to the production of this important publication.



David Molden
Director General

International Centre for Integrated Mountain Development
Kathmandu, Nepal





Preface

The International Centre for Integrated Mountain Development (ICIMOD) and Ministry of Agriculture and Forest through Gross National Happiness Commission (GNHC), Royal Government of Bhutan, signed a Letter of Agreement (LoA) to implement pilot activities as part of the EU funded programme 'Support to Rural Livelihoods and Climate Change Adaptation in the Himalaya' (Himalica) in 2014. The objective of the LoA is to support the development of mountain rural livelihoods in the context of socio-economic and climate change in Barshong Geog, Tsirang District. The pilot interventions are designed in line with national priorities that focus on import substitution through promotion of climate resilient agricultural practices. Through consultative processes, two value chains: goat and vegetables (beans, cabbage, onion, and ginger) have been selected as promising options that can improve livelihoods of target beneficiaries, and contribute to reduce food trade deficits.

Himalica pilot interventions aim to: (i) improve yield through promoting climate resilient practices (i.e. effectively manage water, land/soil nutrients and other resources, and adopt farming practices considering micro-climatic conditions), (ii) facilitate market linkages and support processing and value adding activities, and (iii) strengthen institutional mechanism (community-led microplans and formation of farmers groups/cooperatives). This Farmers' Manual has been developed within considerations of the prevailing factors and conditions of the local context of Barshong, Tsirang.

This manual specifically attempts to address critical climate change issues and impacts on vegetables in southern Bhutan, and describes climate-smart production practices for sustainable production and income of the vegetable farmers. This manual is in accordance with the basic principles of environmental, commercial and social sustainability, and provides detailed steps for vegetable production, from land preparation to harvesting, with the adoption of climate resilient farm management practices in each stage of production.

Like many other countries, Bhutan has also experienced the impacts of climate change increasingly over the years and the agriculture sector is the most affected. Reports indicated that the heavy rain caused flash floods in 2004 that damaged 162

houses, 39 irrigation channels, and washed away 22 bridges in eastern districts; in 2007, northern corn blight ruined 50 percent of total production. The impacts of climate change are often localized and differ as per the region and specific climatic zone. At many places the erratic rainfall has resulted in decline in crop production. The increasing temperatures have led to the emergence of new pests posing new challenges to the entire farming system ultimately increasing farm expenses. Climate change has been a big threat in producing agricultural crops including fresh vegetable, vegetable seed, cereal crops and legumes since last few decades and affecting livelihoods. Therefore, climate resilient technologies are the demand of the day.

Based on lessons and findings from similar agro-ecological zones, this manual is prepared to make the community and concerned stakeholders capable to reduce risks of extreme events such as too little or too much water, drought, and have resilient practices adapted and expanded. The recommended technologies and practices are simple and affordable, yet make sense to address bigger risks of climate change. As Bhutan aspires to go organic and ensure self-reliance in vegetable production, much of the recommended practices will contribute to achieving the goal of the Royal Government of Bhutan.

Mr. Pema Chofil, Mr. Surjay Lepcha, Mr. Sanjeev Bhuchar, Mr. Tshering Samdrup, Mr. Gopilal Acharya, who put untiring efforts to develop this manual, deserve special appreciation and gratitude.

I would like to extend special appreciation to Secretary Dasho Rinzin Dorji (MoAF, Bhutan), Dasho Dzungda Ngawang Pem (Tsirang), Dr. Eklabya Sharma (Deputy Director General, ICIMOD), and Dr. Dhrupad Choudhury (Regional Programme Manager, ICIMOD) for their overall guidance and support. Many thanks to the communities of Barshong who participated in the Himalica pilot and provided inputs during focus group discussions and field visits.

Dr. Surendra Raj Joshi
Programme Coordinator, Himalica
International Centre for Integrated Mountain Development
Kathmandu, Nepal



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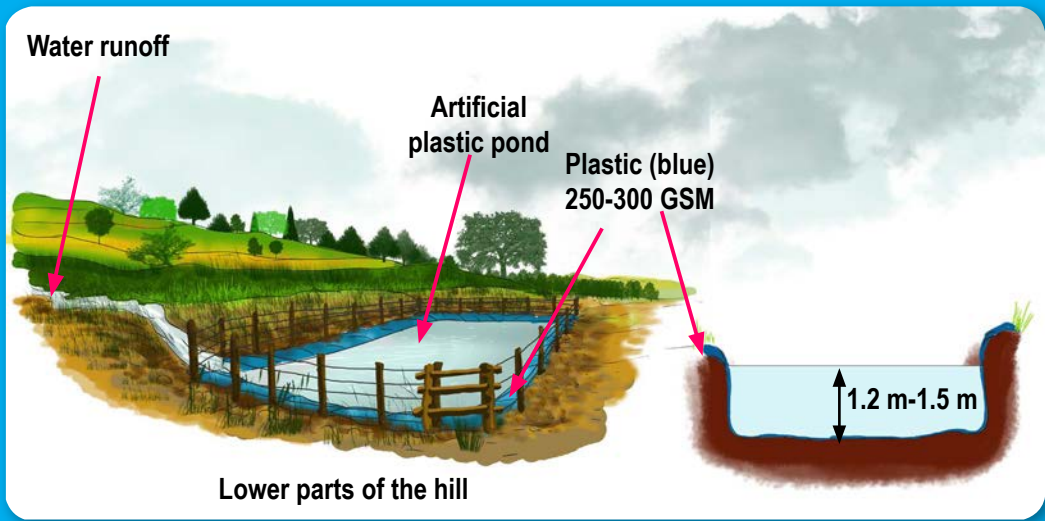


A. Climate Resilient Agricultural Practices

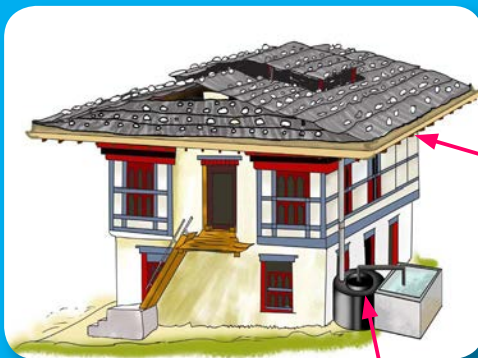


A1. Water harvesting techniques

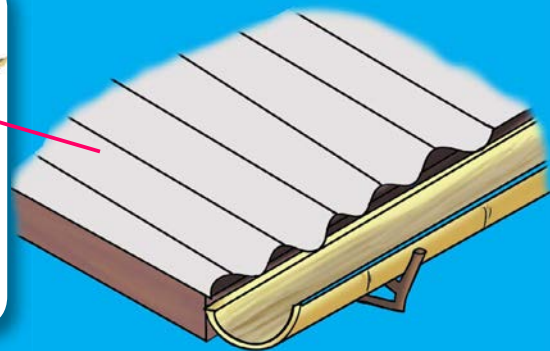
Surface runoff water harvesting



Rooftop rainwater harvesting



Rain water
reservoir tank

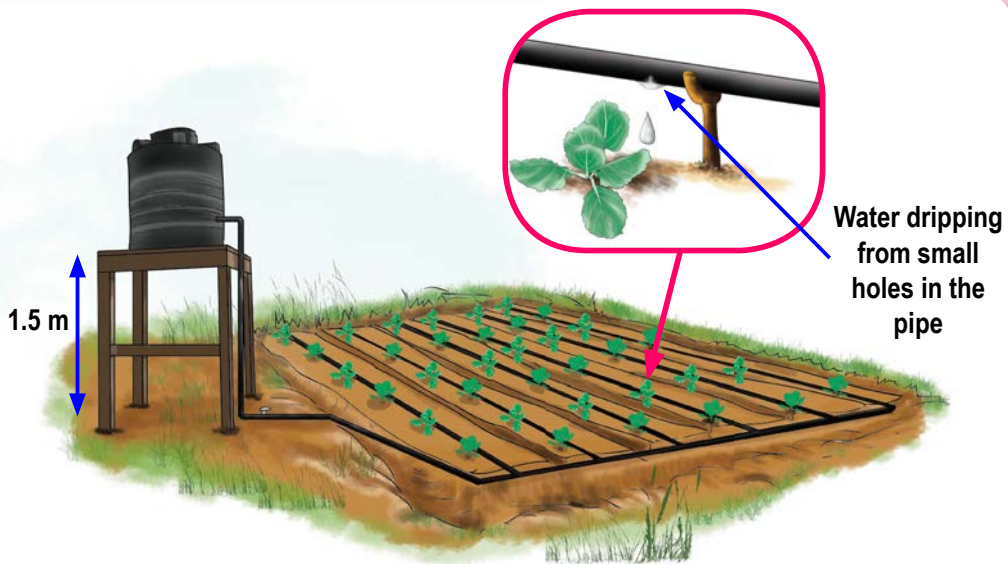


Rain water
collection
channel

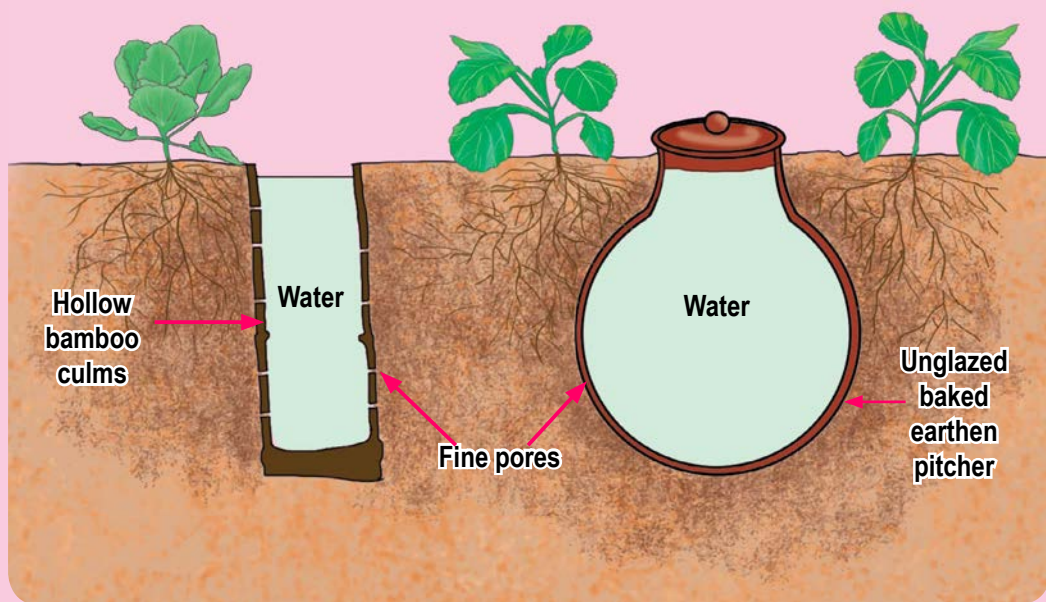


A2. Water efficient irrigation techniques

Drip irrigation



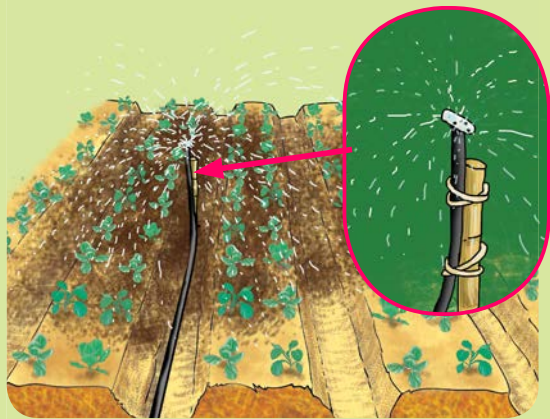
Pitcher irrigation



Irrigating with watering can

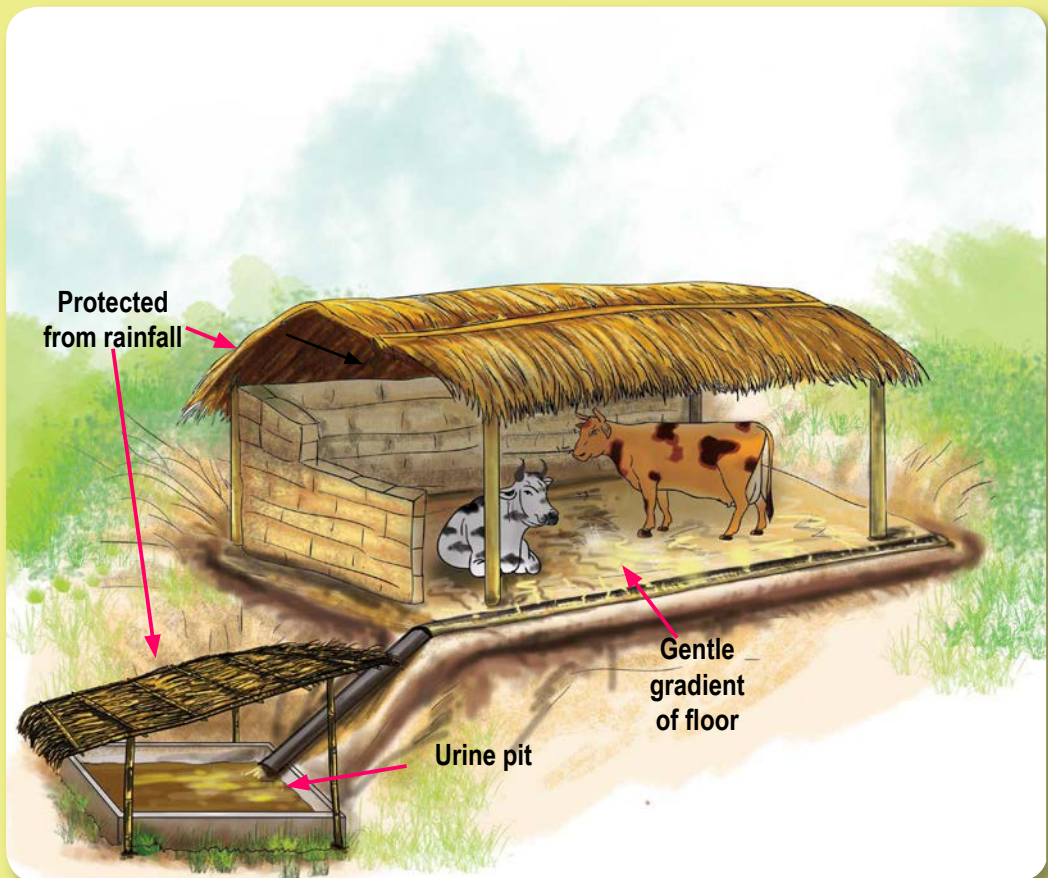


Sprinkler irrigation



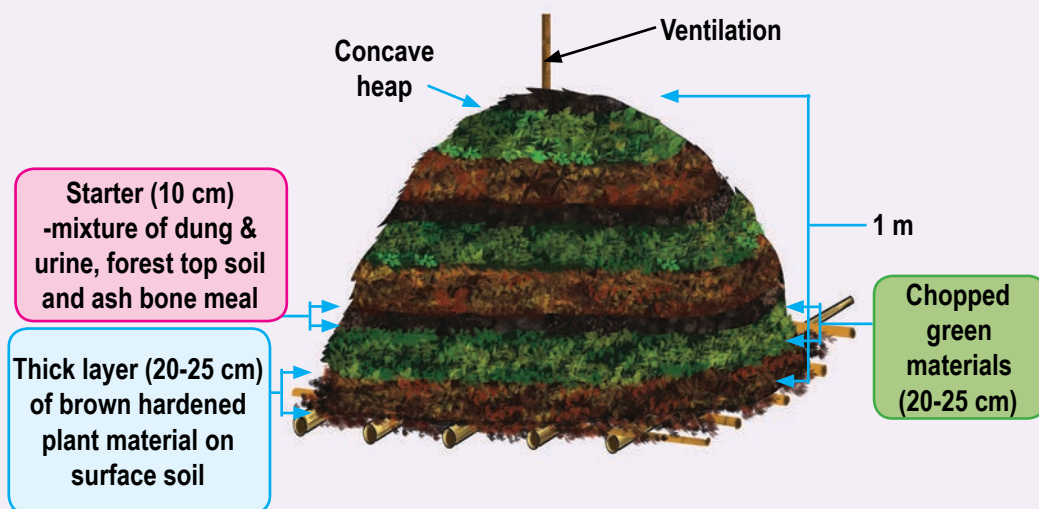
A3. Soil and nutrient management practices

Cattle urine collection





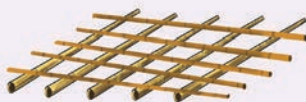
Compost heap



Making pile of compost

1

Make a base using bamboo



2

Pile the materials in order and thickness



3

Cover the heap with a plastic sheet (or thatch)

During winter in cold regions

Plastic sheet cover



Thatch to reduce water and nutrient loss

4

Turn the inner and outer layers upside down



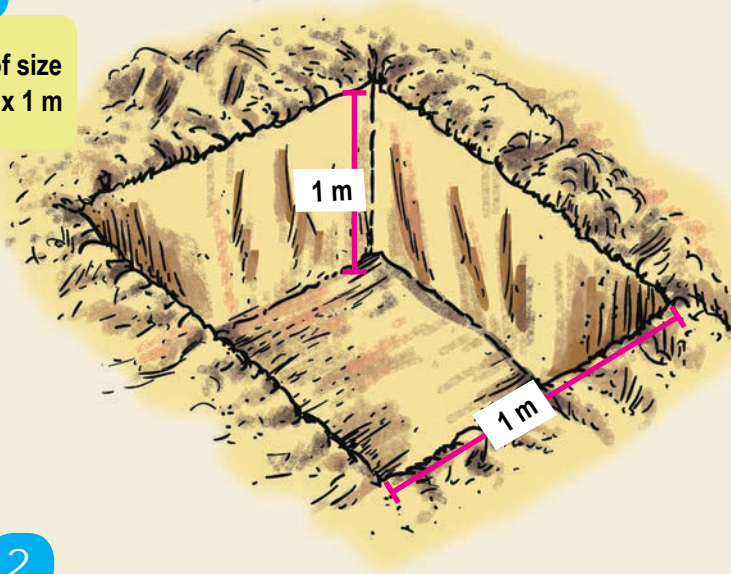
Note

Once the material is turned, add water if it is dry, so that the heap maintains at least 60% moisture.

Pit method compost preparation

1

Dig a pit of size
1 m x 1 m x 1 m

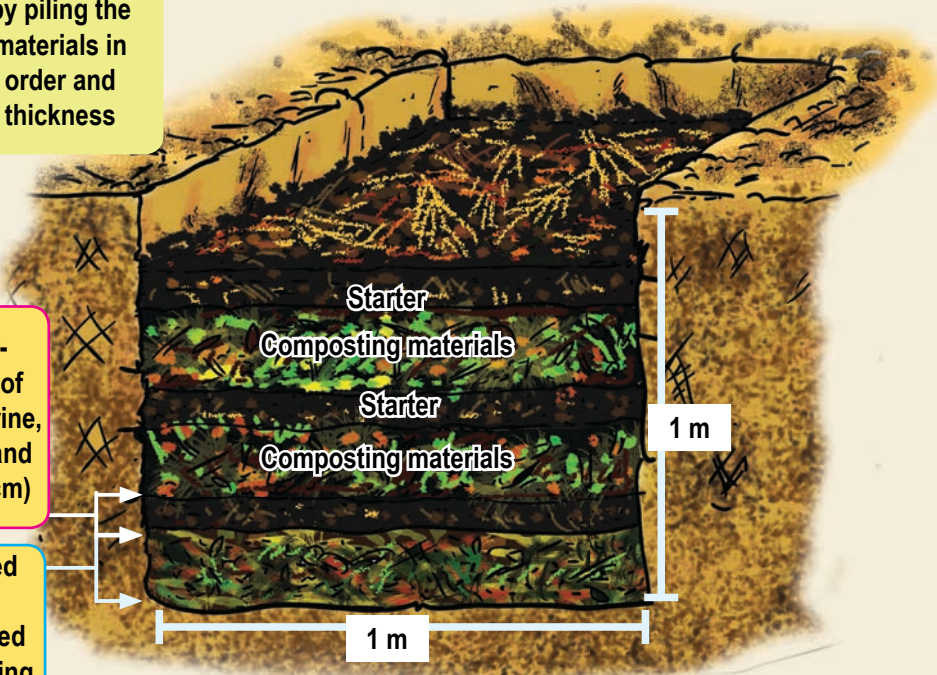


2

Fill the pit
by piling the
materials in
order and
thickness

Starter-
mixture of
dung & urine,
top soil and
ash (10 cm)

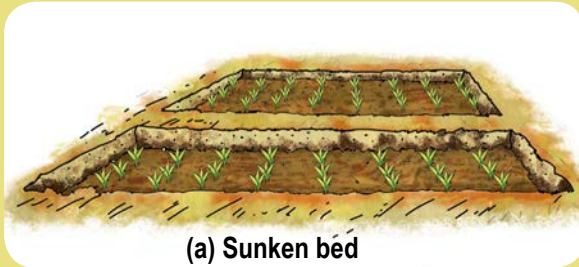
Chopped
and
moistened
composting
materials
(20-25 cm)



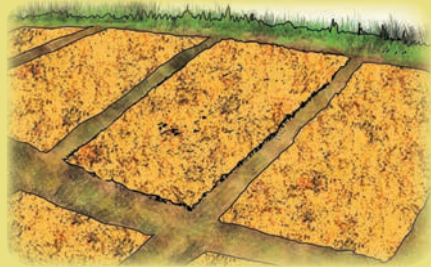


A4. Nursery management

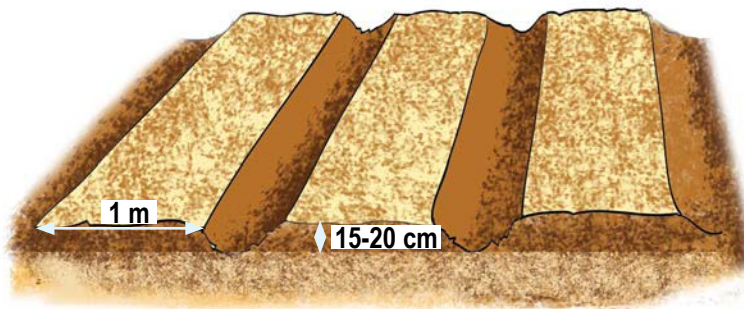
Nursery Type



(a) Sunken bed



(b) Flat bed



(c) Raised bed



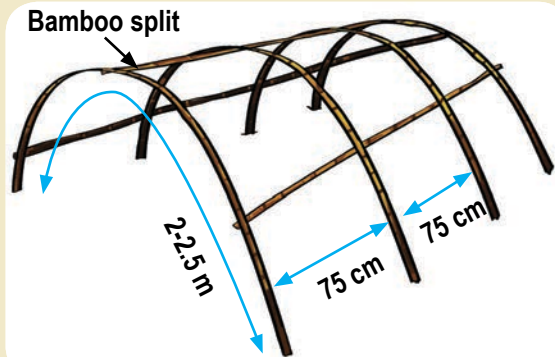
(d) Bench nursery

A5. Nursery Structure

Poly tunnel

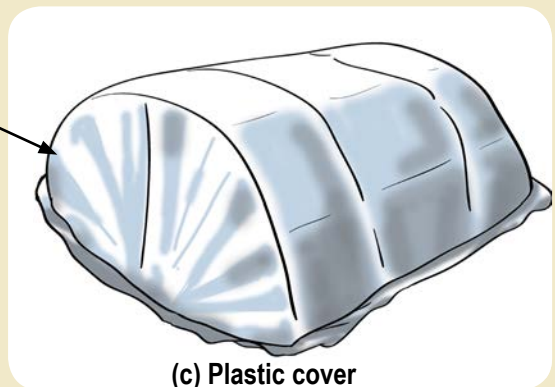


(a) Bamboo splits

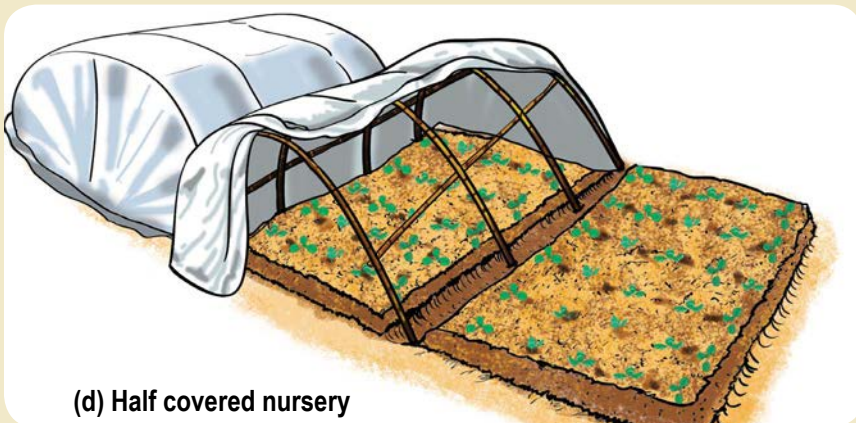


(b) Bamboo split tunnel frame

White plastic sheet of width 2 m and length 1 m longer than tunnel frame



(c) Plastic cover



(d) Half covered nursery



Nursery bed preparation



Plough the field

Dig and break the clod



Raise the bed to 15-20 cm



Soil sterilization by solarization

Water
nursery bed
(10 cm deep)



After 1
week
Sow
seed

Sow the
seeds



3 weeks
Sunny
days



Cover the moistened
bed by plastic sheet
(300 gauge)

Soil sterilization by chemical

Prepare solution of
carbendazim (50% WP) at a
rate of 2 g/L of water



Cover the
moistened bed
by plastic sheet
(250 gauge)

3
Nights



Drench the prepared
nursery bed (7-8 cm
deep) by solution





Seed sowing

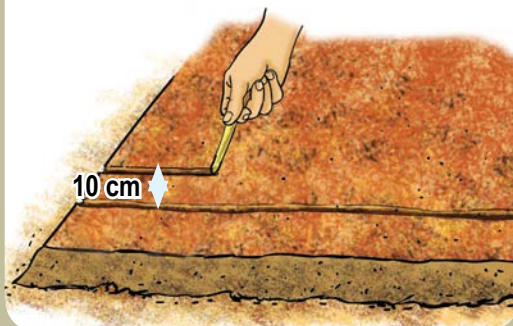
1

Level the bed



2

Make 3 cm deep lines. Maintain a gap of 10 cm between the lines.



3

Apply thumb rule while sowing seed

Depth
should be
3 times the
diameter of
seed



4

*Use straw or dry grass
to mulch, then water
the bed.*



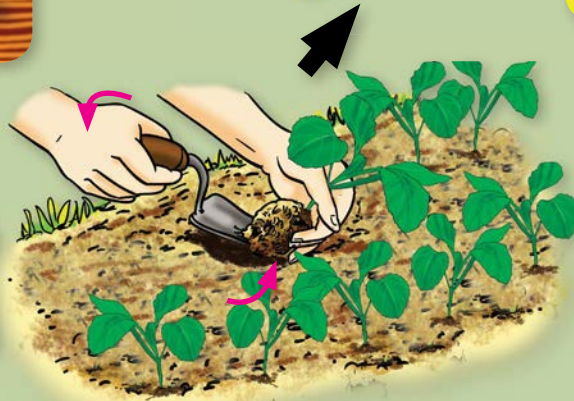
Uprooting Seedlings

Before
3 hours



Water the bed to moisten the soil

Uproot each seedling using spatula



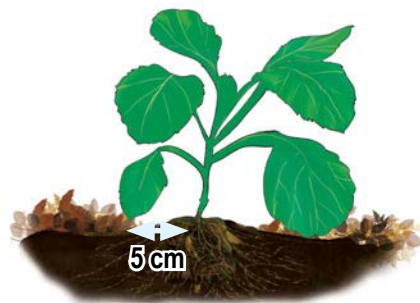
Place seedlings on a tray to transport them to field

Transplanting seedlings



Press the seedling with fingers

Mulch, keeping a distance of 5 cm from the stem.

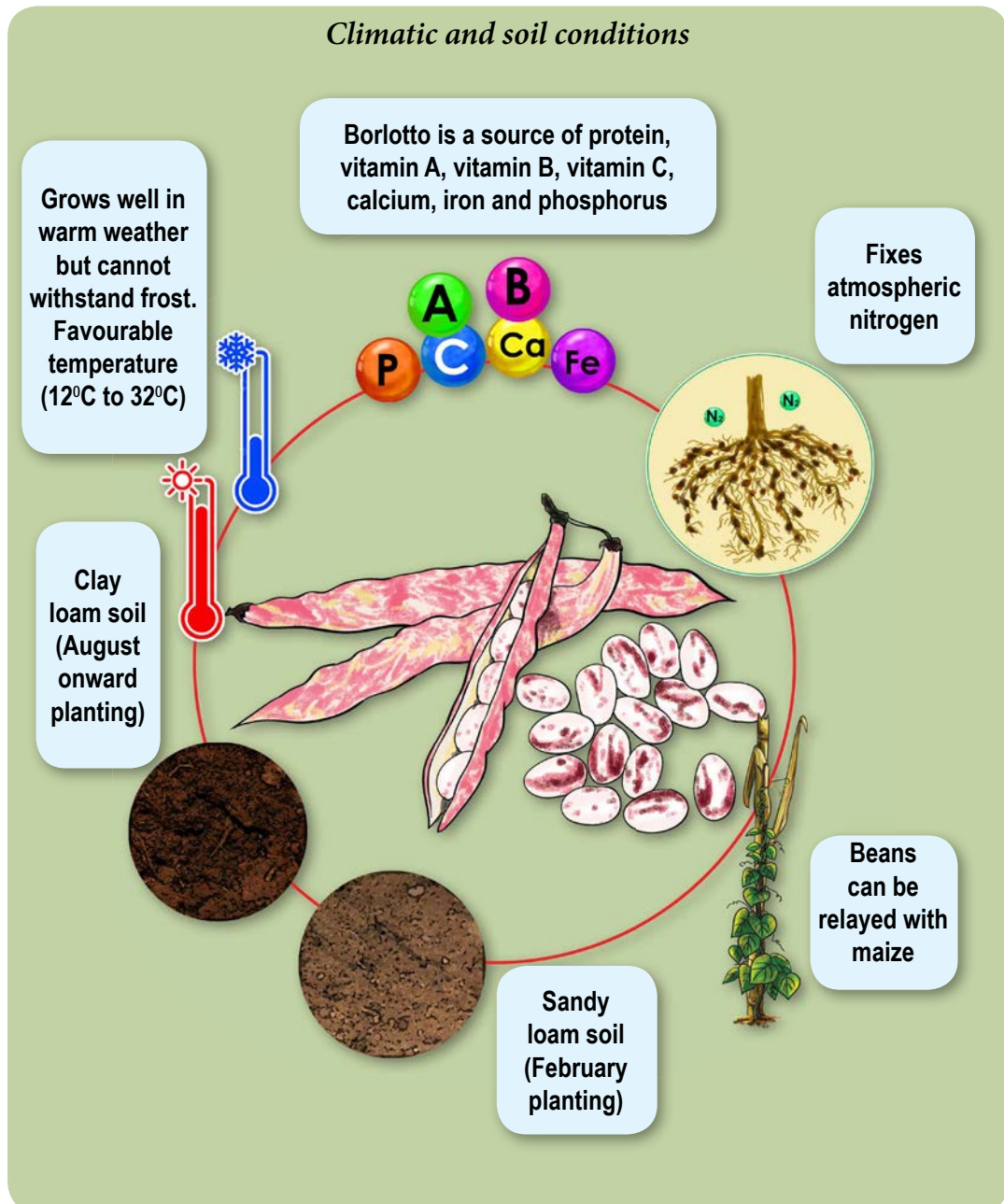




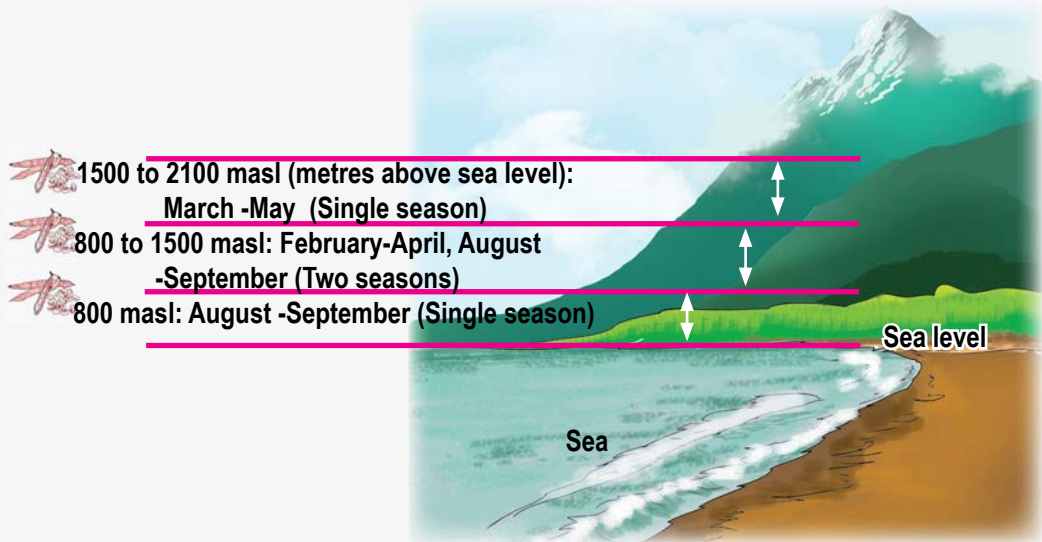
B. Bean (Borlotto)



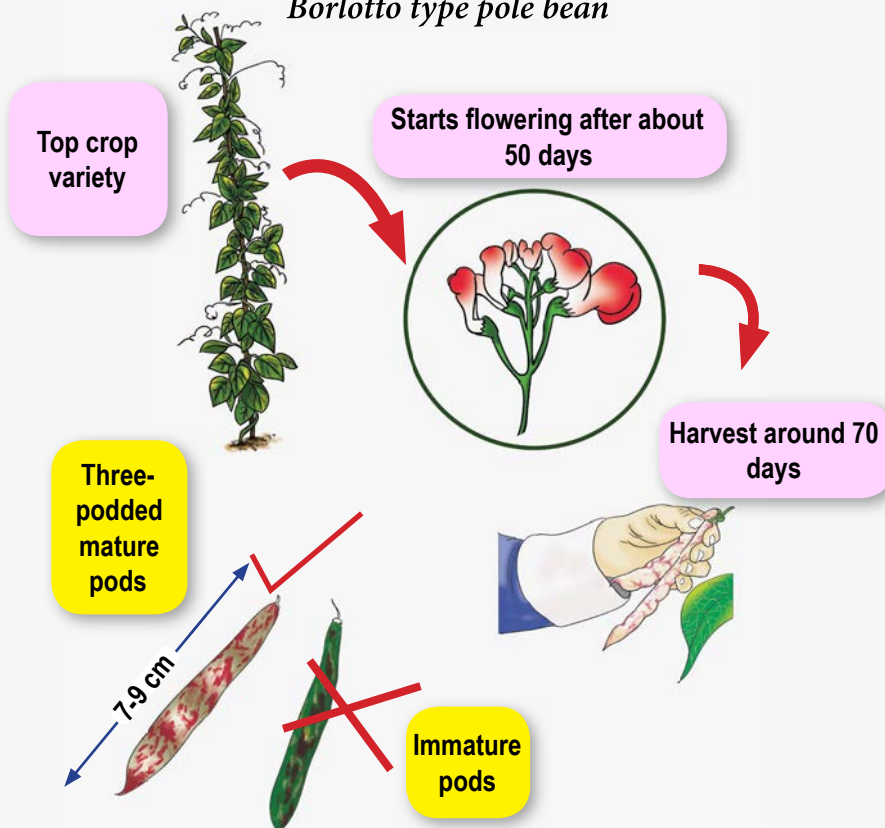
B1. Cultivating beans



Planting seasons



Borlotto type pole bean





B2. Land preparation and plantation

Preparing bed for bean

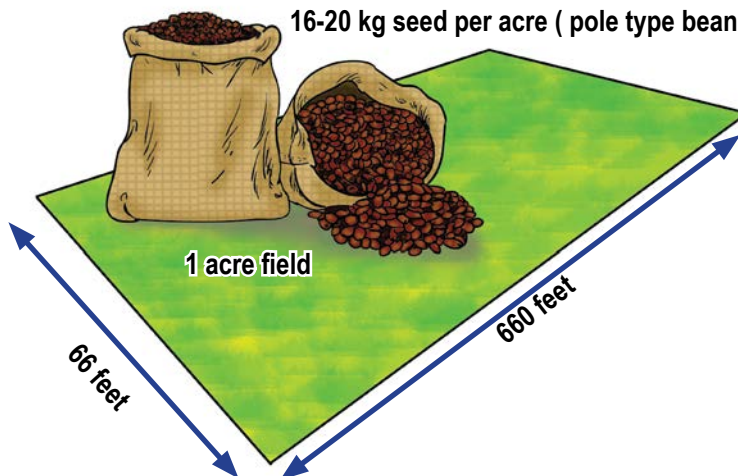
Plough
twice
for bed
preparation



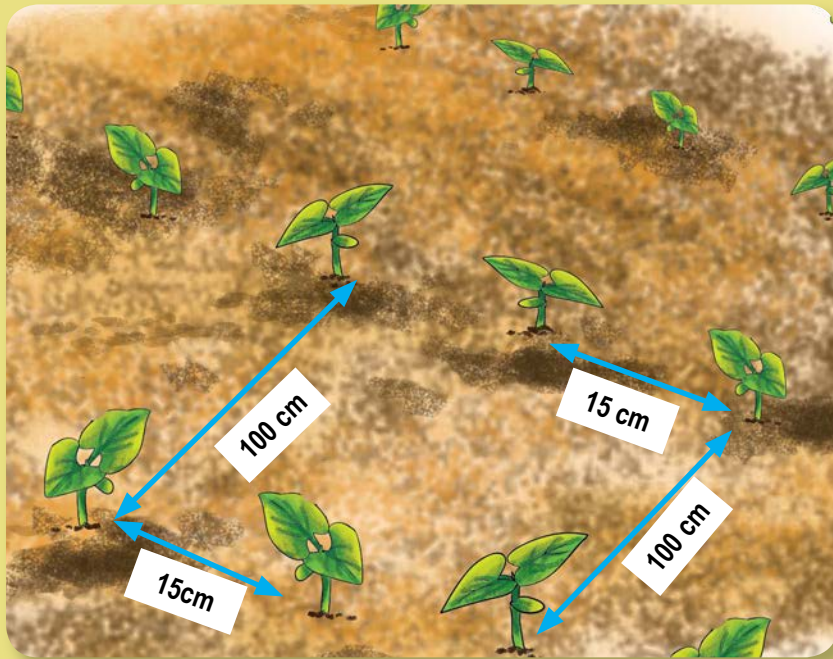
Apply organic
manure
during soil
preparation
to improve
soil structure
and increase
water holding
capacity

Seed rate

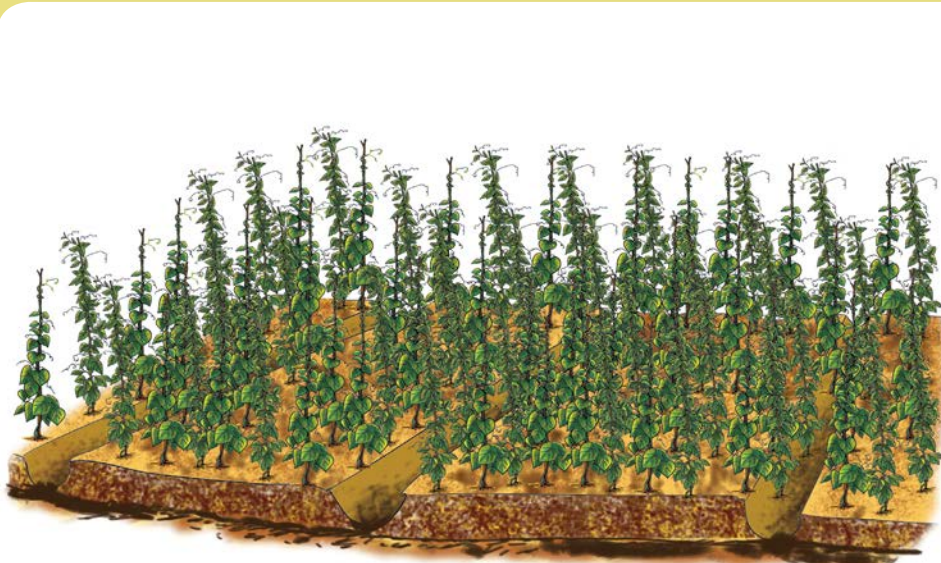
16-20 kg seed per acre (pole type bean)



Planting pole bean

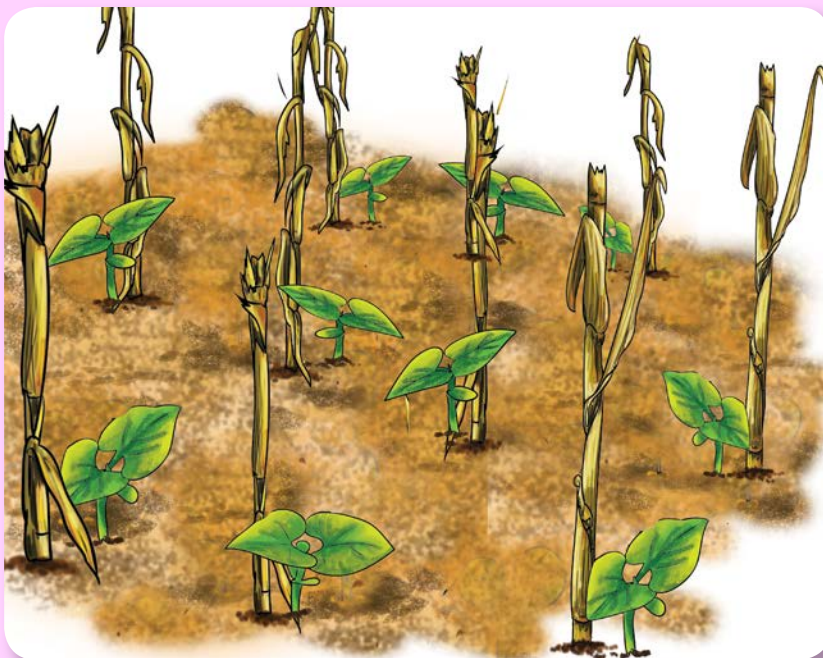


Stake bean plants on poles





Maize sown in line for mix or relay cropping



Taking care of bean plants



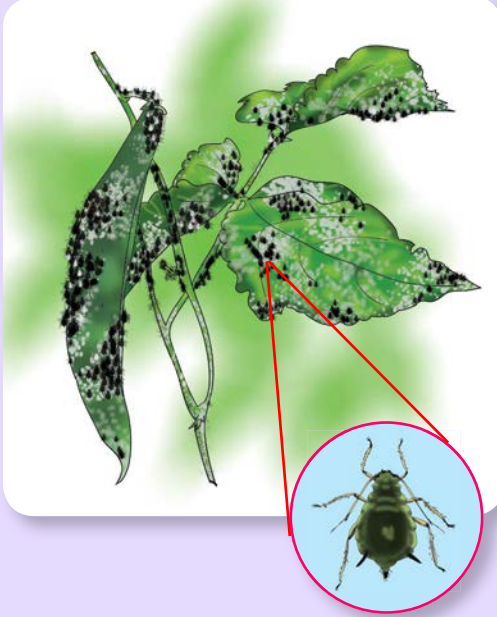
Mulch to conserve
soil moisture

Weed at early crop stage

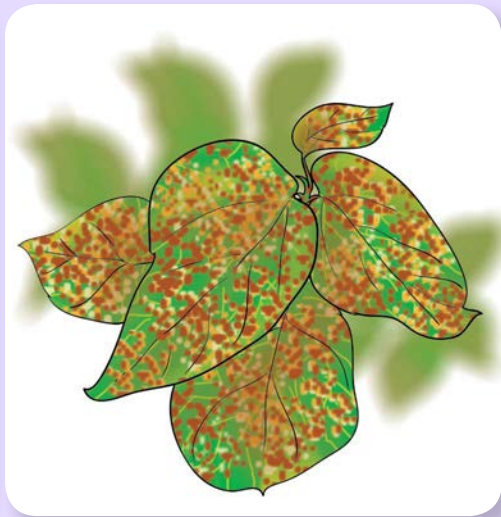


B3. Pest and disease management

Aphid on bean plant



Bean rust



Borers feeding on leaves and pods



Anthracnose





Preparing insecticides and spraying

1

Prepare a solution
using ordinary
detergent (20 g/L)
OR
Nimbicidine
(2 millilitre per litre
of water)



2

Fill the sprayer

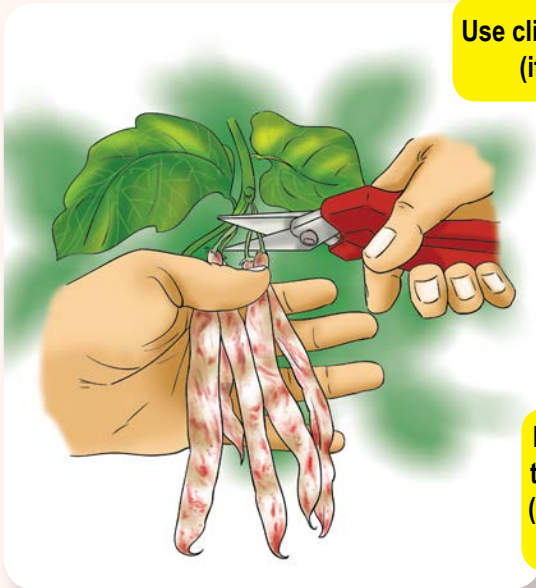


3

Spray the solution
on the dorsal
(under) side of the
leaves

B4. Harvest and transportation

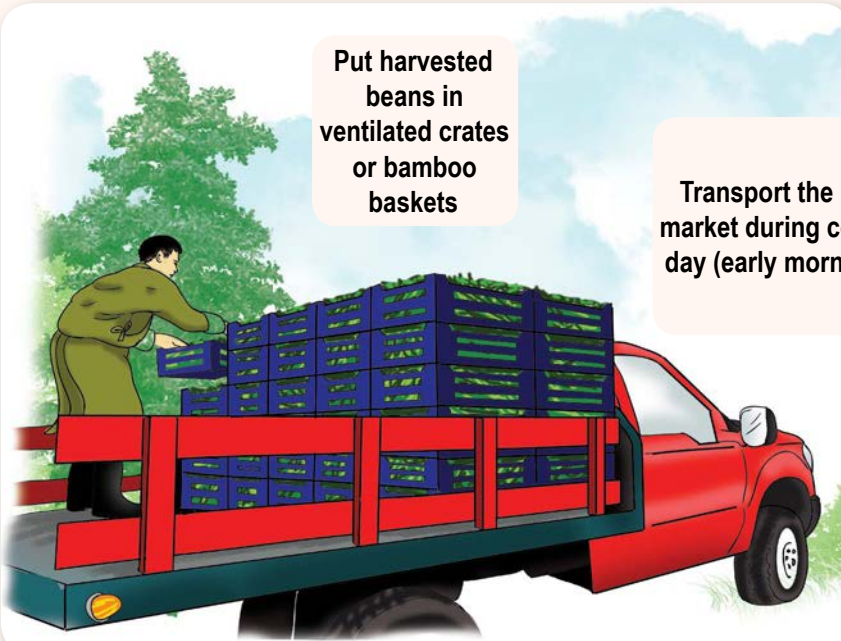
Harvesting



**Use clipper to harvest
(if possible)**

**Beans should be harvested when
they are mature with full pod size
(firm pods) and are mottled red in
colour**

Transporting in trucks



**Put harvested
beans in
ventilated crates
or bamboo
baskets**

**Transport the product to the
market during cool hours of the
day (early morning or evening)**



C. Cabbage

C1. Cultivating cabbage

Planting seasons



High Hills (>2000 masl):

- *early and mid varieties: May – June*
- *late varieties: June – August*



Upper Mid hills (1600 to 2000 masl):

- *open pollinated early varieties: July–August*
- *mid varieties: September – October*
- *late varieties: October – November*



Suitable temperature range

Seed germination: 7°C to 35°C

Vegetative growth: 15 °C to 20 °C

Heading: 15°C to 25 °C

Soil suitability



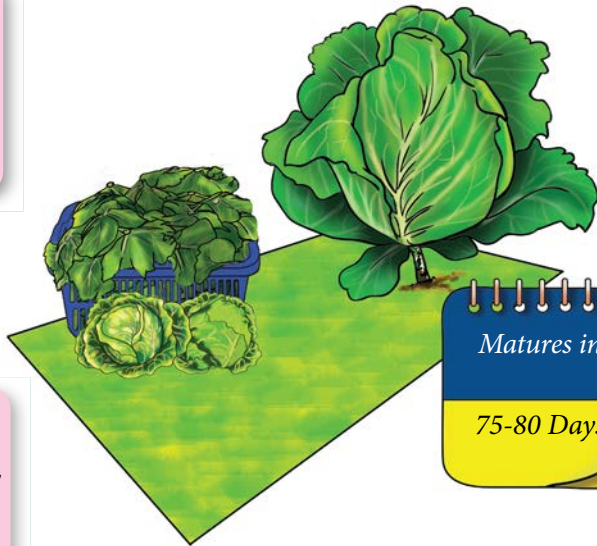
Cabbage does not grow well in sandy soil, clay soil and soils with gravels. Sandy loam is more suitable for early varieties and clay loam is suitable for late varieties.

C2. Cultivars

Copenhagen Market

Round shaped head weighing 2-3 kg.

Yield: about 9,000 kg per acre.



The plant is semi-erect, stem is short, and leaves are light green.

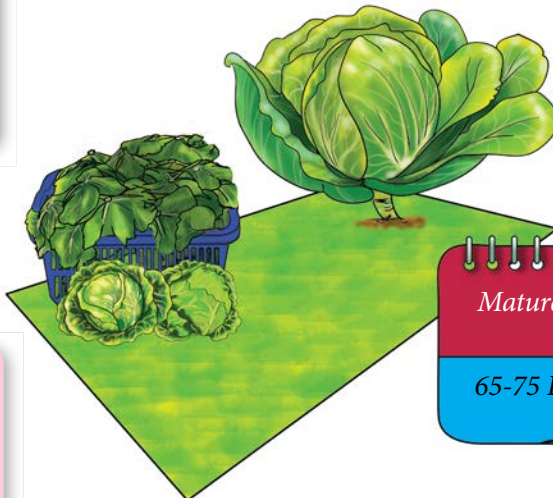
Matures in

75-80 Days

Golden Acre

Small round head weighing 1-1.5 kg.

Yield: about 7,500 kg per acre.



The plant is semi-erect, stem is short, and has few outer leaves.

Matures in

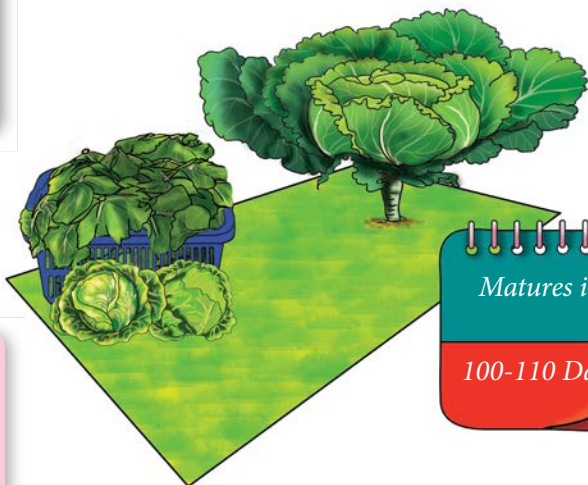
65-75 Days



Late Large Drum Head (LLDH)

Flat and solid head weighing about 4 kg.

Yield: about 9,500- 11,000 kg per acre



Matures in

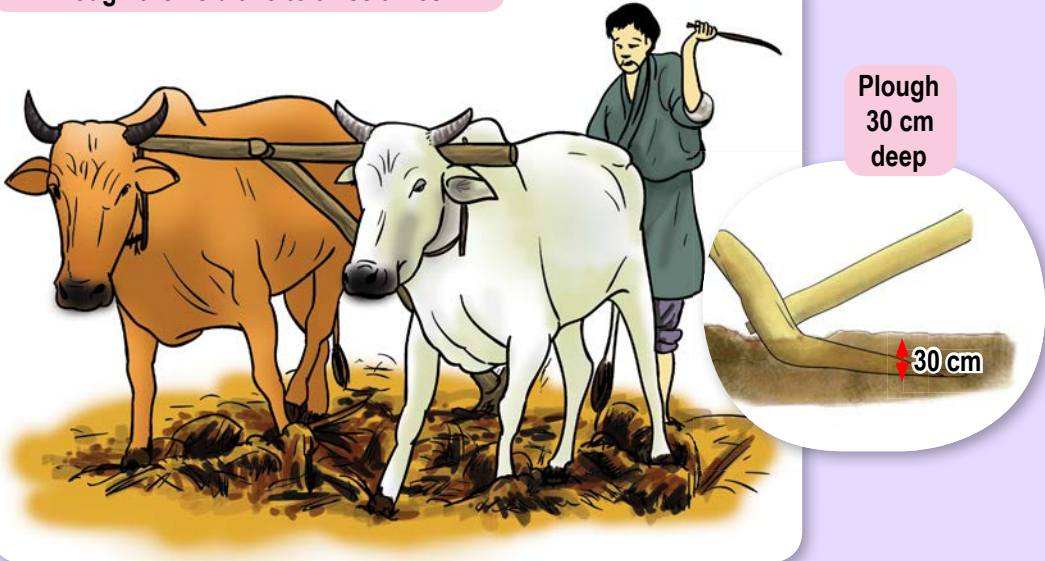
100-110 Days

Plant structure is spreading type. Stalk is short with small frame and few outer leaves, pale green in colour

C3. Land preparation and plantation

Ploughing and bed preparation

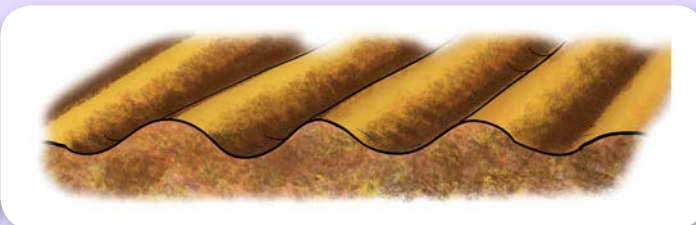
Plough the field two to three times



Raised bed for winter



Ridge bed for monsoon and rainy season





Seed rate

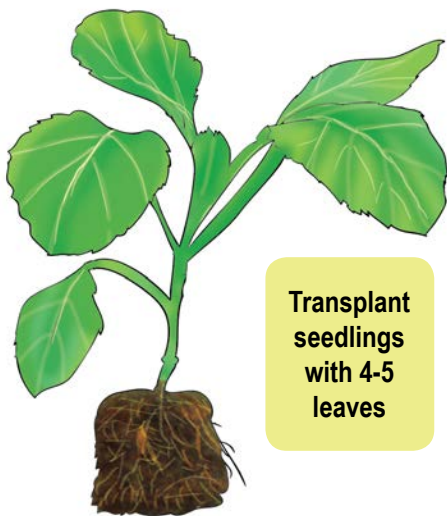
Use about 240
gramme per acre
of open pollinated
(OP) variety



About 150 gramme
per acre of hybrid
variety

Seedling

Healthy and stout seedlings



Transplant
seedlings
with 4-5
leaves

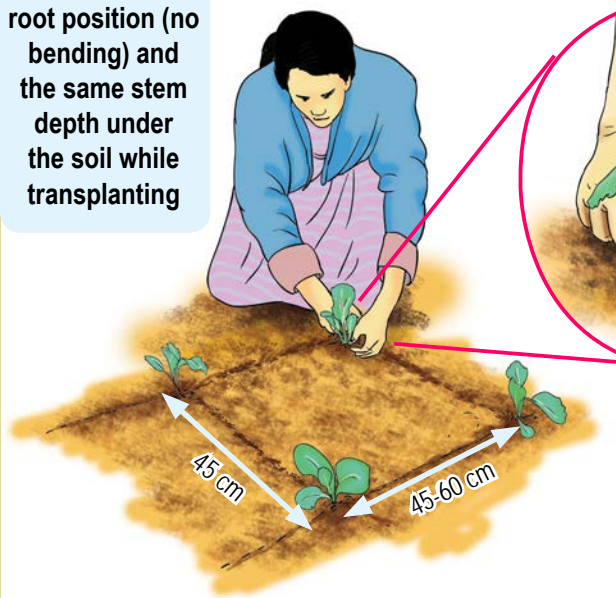
Transplanting weather

*Transplant seedlings in late afternoon
to avoid shock due to heat and sunlight.
Water the seedlings.*



Planting seedlings

Maintain original root position (no bending) and the same stem depth under the soil while transplanting



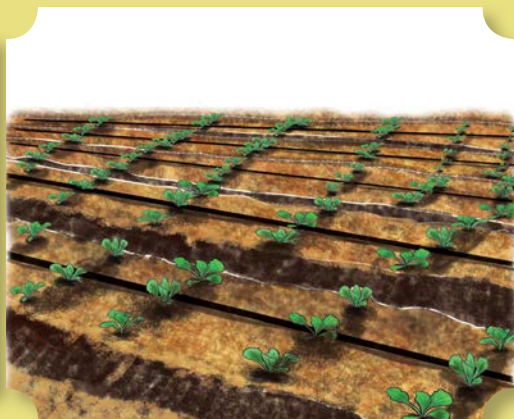
Exert light pressure with fingers to protect from lodging

Watering transplanted seedlings

Water the seedlings immediately after transplanting



Hand watering



Drip system



Mulching



Leave small space
between stems and
mulching material

Mulch
immediately
after
transplanting

Weeding



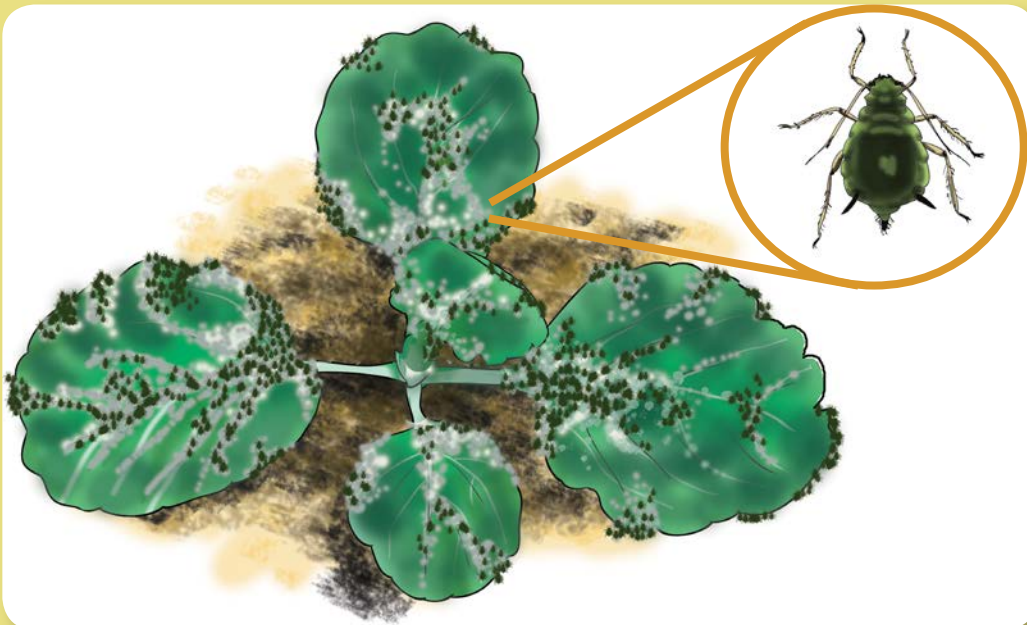
Short Duration Varieties:
Carry out first weeding and earthing-up
15 days after transplanting, followed by
another 2-3 earthing-ups in about 10 days.

Long Duration Varieties:
Carry out weeding followed by earthing-up
30 days after transplanting, followed by more
earthing-up in about 20 days

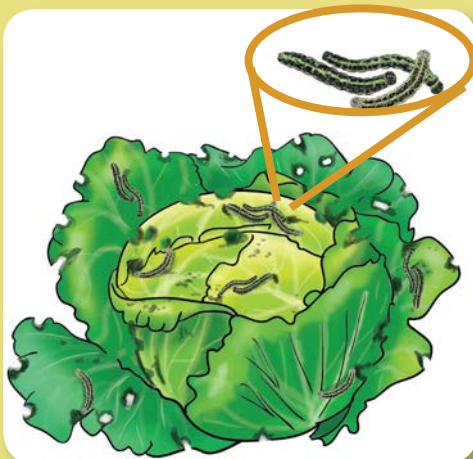


C4. Pest and disease management

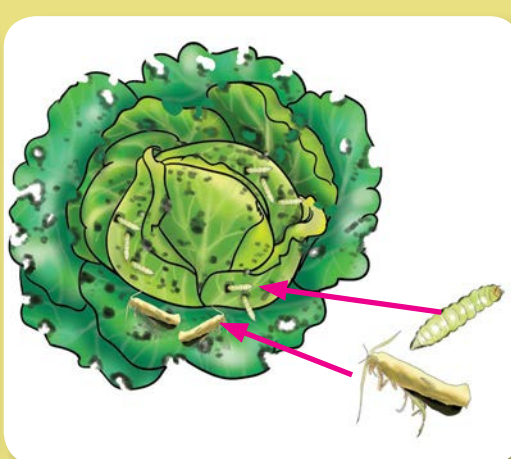
Cabbage aphids



Cabbage butterfly caterpillar



Diamondback moth



Preparing neem-based insecticide solution

1

Crush the neem leaves



2

Pour neem paste into water



4

Stock neem
concentrate in a
large drum



3

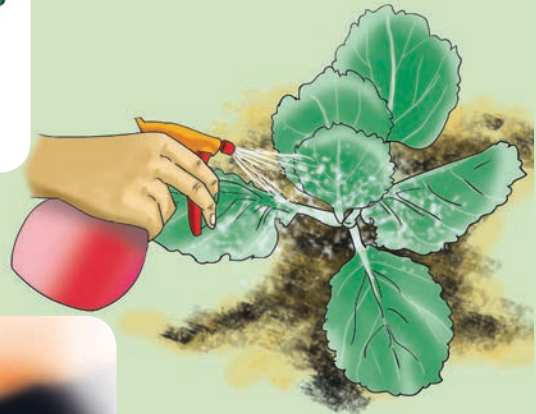
Squeeze and drain the neem
concentrate



Spraying neem-based insecticide solution



Make a neem solution (2 mL neem concentrate/litre of water)



Spray neem-based insecticide on dorsal side of leaf

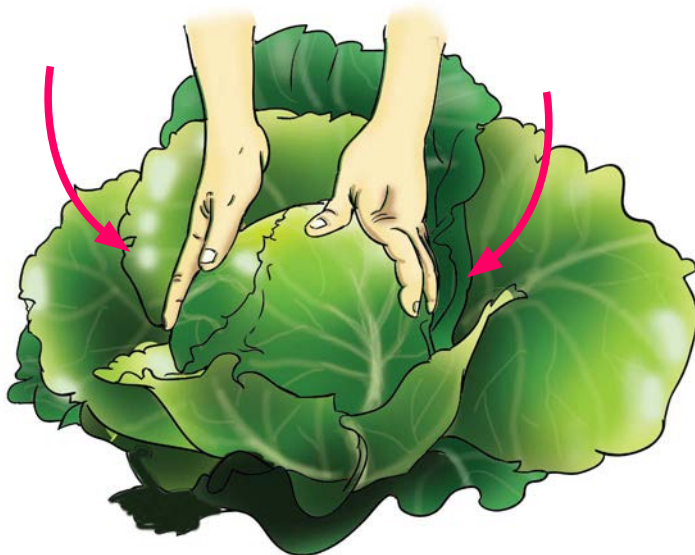


Spray neem-based insecticide solution in late afternoon



C5. Harvest

Checking cabbage maturity



A compact head which is only slightly compressed with moderate hand pressure is ready for harvest.

Harvesting cabbage head



1. Do not harvest if cabbage heads are wet.
2. Leave 4-6 wrapper leaves with the head.
3. Bend the head to one side and cut the stem with a sharp knife.

Post harvest care of cabbage heads

Remove all rotten or damaged leaves after harvest. Handle cabbage heads with care.



Put cabbage heads upside down in a shade for 2-3 hours to dry.





D. Onion



D1. Cultivars

Red creole is a short-day variety. Bulbs are somewhat flat, deep red in color, and have high pungency. Bulb size ranges from 80 g to 120 g. It has good shelf life if stored. Red creole can be harvested in 160 days.



Bombay Red is a short-day variety. Bulbs are red in color, semi round in shape, and are medium to large sized. Flesh is firm with high level of pungency. It matures in about 150 days after transplanting.



Agrifound Dark Red is a day-neutral variety, thus can be cultivated even in rainy season. Bulbs are globular in shape and dark red in color. It matures in 95-110 days.

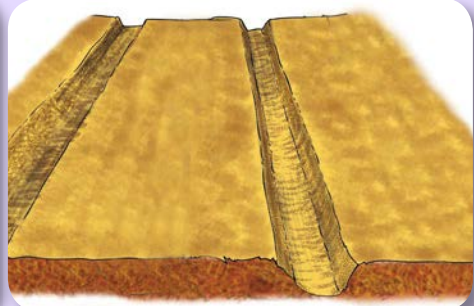


D2. Land Preparation and plantation

Land ploughing



Plough the land 2-3 times



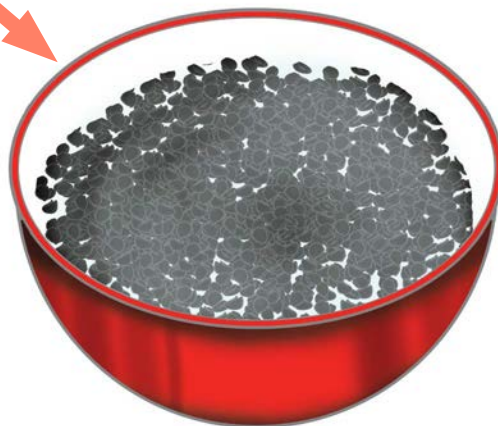
Prepare raised beds of about 30 cm for rainy season cultivation

Onion seeds preparation



4 kg of seeds or about 200 thousand seedlings are required for an acre of land

For quick germination, soak seeds for 24 hours before sowing



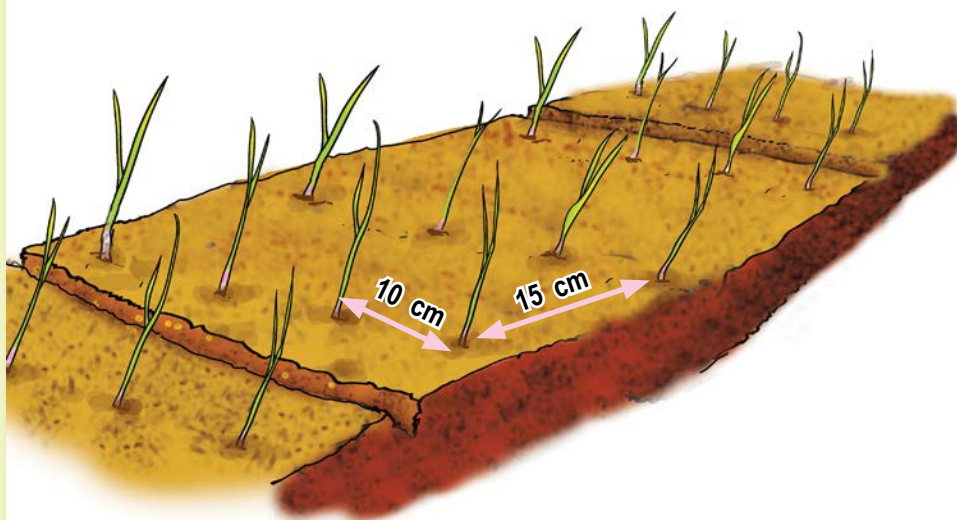


Transplanting onion seedlings

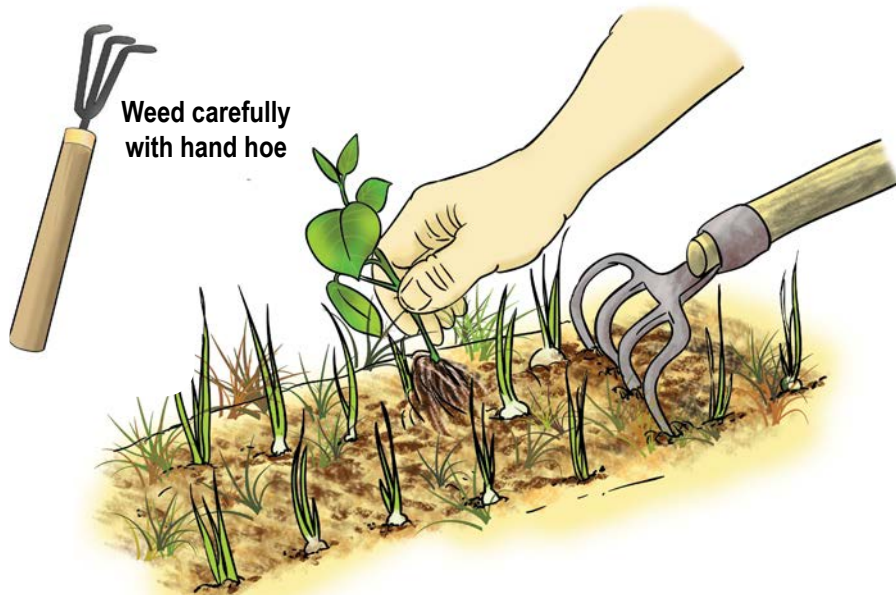
Select only healthy and stout seedlings for transplanting. Remove yellow leaves and one third of leaf-tips in order to minimize water loss through transpiration.



Seedlings should be 45-60 days old



Weeding



Solarization

Note: If solarisation is done for nursery beds, weed management becomes easier.

Water
nursery bed
(10 cm deep)



After 1
week
Sow
seed

Sow the
seeds



3 weeks
Sunny
days



Cover the moistened
bed by plastic sheet
(300 gauge)



D3. Pest and disease management

Downy mildew

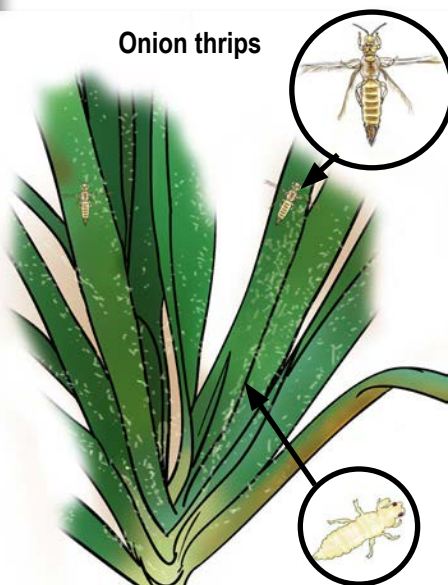


Purple blotch



Spray
neem-based
(Azadirachtin)
insecticide like
Nimbicidine
at a rate of 2-3
millilitre per litre
of water

Onion thrips



Bio-pesticides based on
Beauveria bassiana can be
used at a rate of 2 g powder
formulation and 4 mL liquid
formulation per liter of water

D4. Harvest

Signs of maturity

Onion are ready to harvest when growth stops, neck, becomes completely dry leaves turn yellow and collapse, and the pseudostem bend over the bulb.



For plants that are still standing, tops can be bent two weeks before the harvest in order to enhance bulb maturity.

Harvesting onions



Do not irrigate the field before harvest to avoid the onions from rotting.

Shake off soil from the bulbs while uprooting the plant.



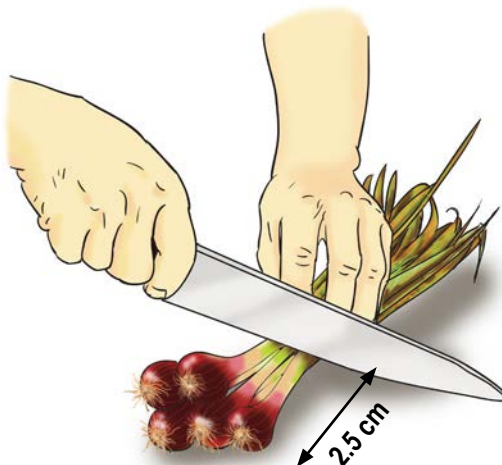
Leave the uprooted plants to dry in the field for 1-2 days. Dry in shed if it rains.



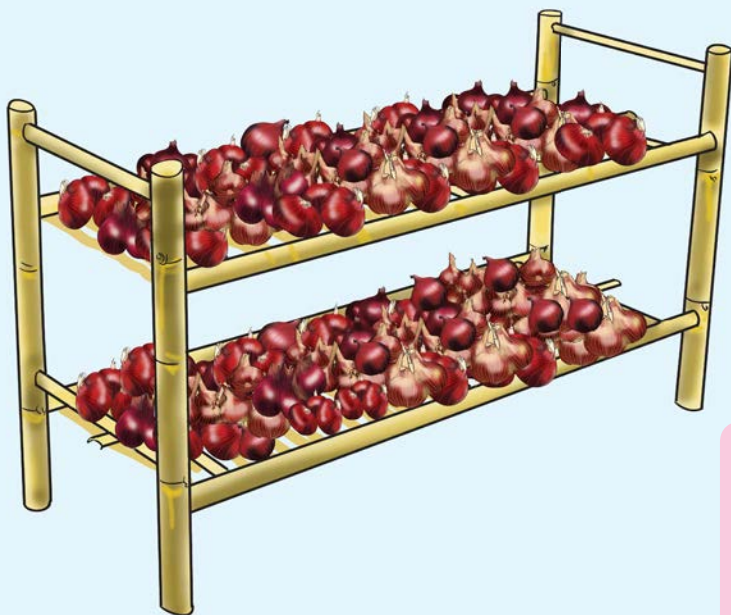
D5. Curing and storage

Curing onions

Keep the harvested onion plants in a shed for about 2 days. Remove roots and soil, then cut the tops 25 cm above the bulb.

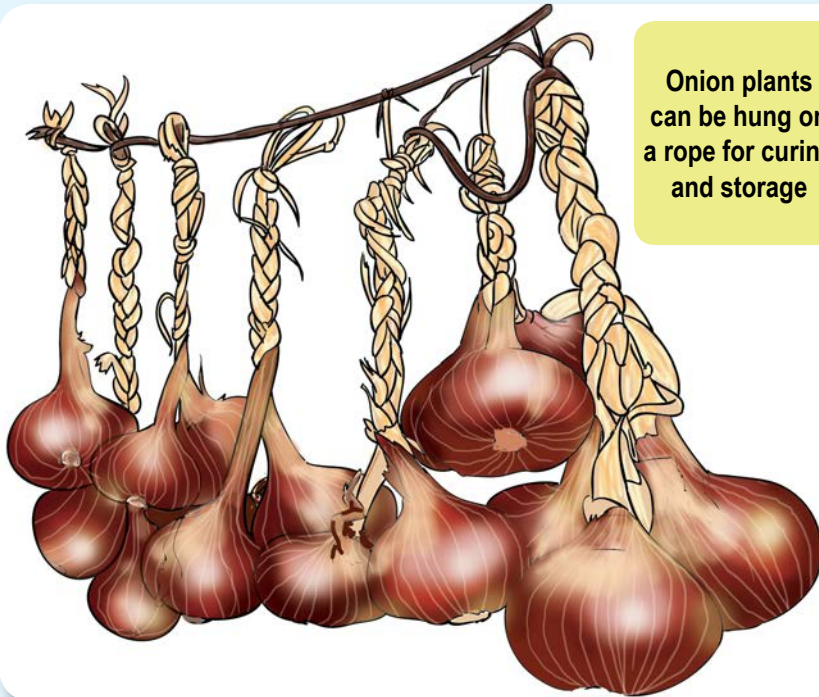


Storing onions



Onion bulbs can be stored in a single layer in wooden or bamboo rack.

Hang dry onions



Onion plants
can be hung on
a rope for curing
and storage

Transporting onions

While loading the
products on a van, avoid
high stacking of sacks
to prevent bruises.
Transport the product to
the market during cool
hours of the day (early
morning or evening).





E. Ginger



E1. Cultivating ginger

Planting seasons



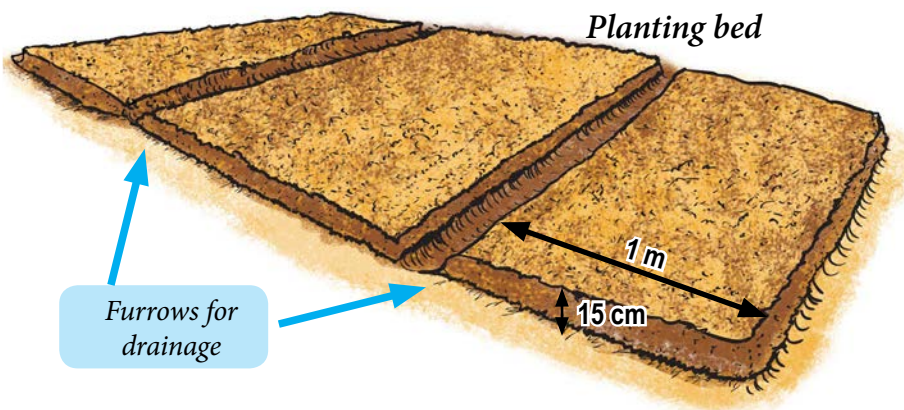
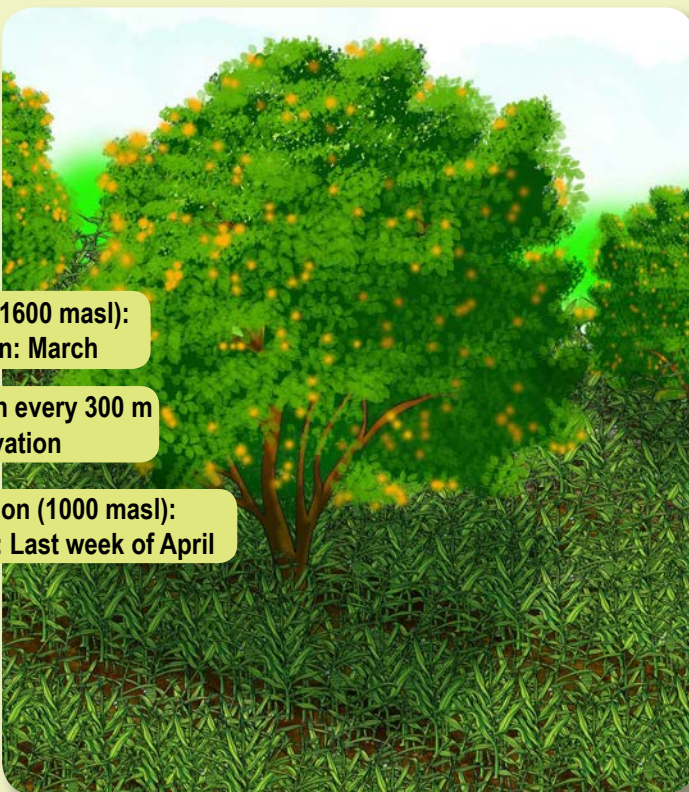
Tolerates moderate shade. Can be cultivated under maize and citrus.



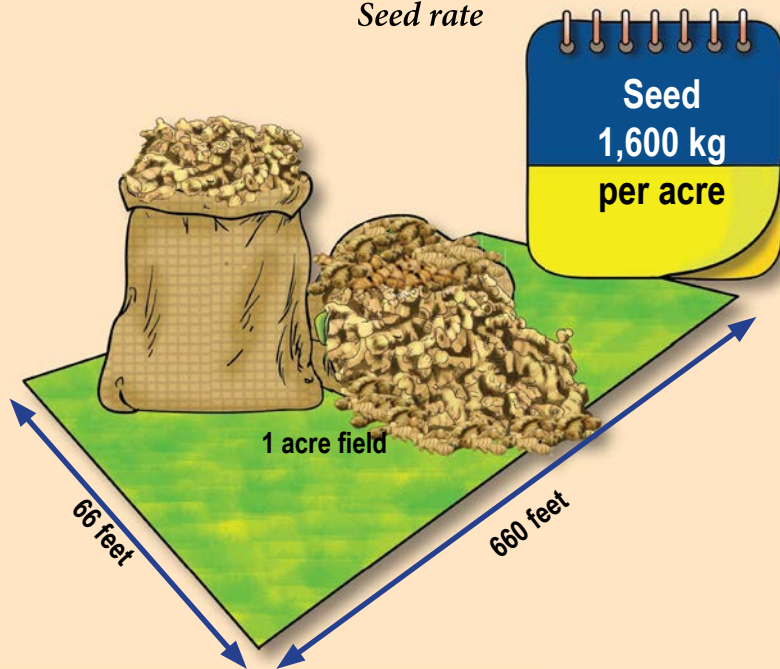
Higher elevation (1600 masl):
Planting season: March

Two weeks later in every 300 m
lower elevation

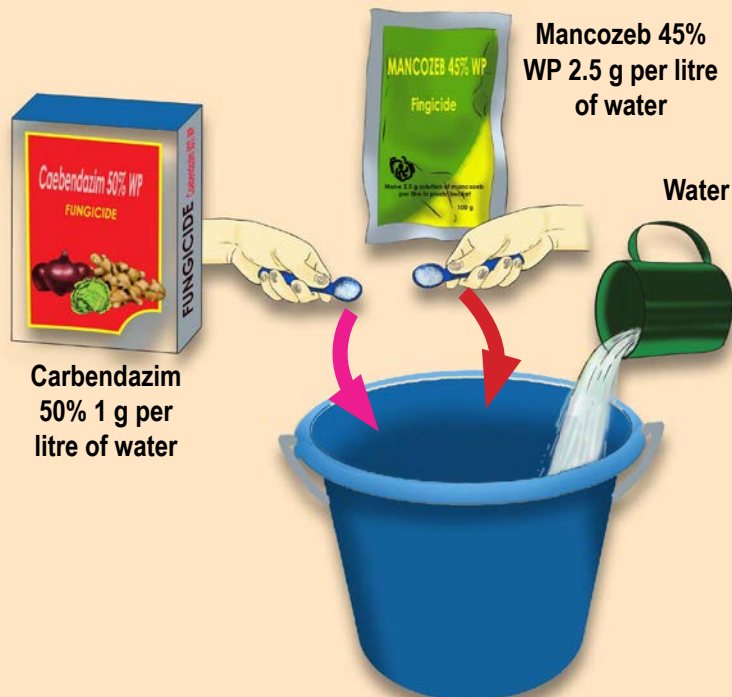
Lower elevation (1000 masl):
Planting season: Last week of April

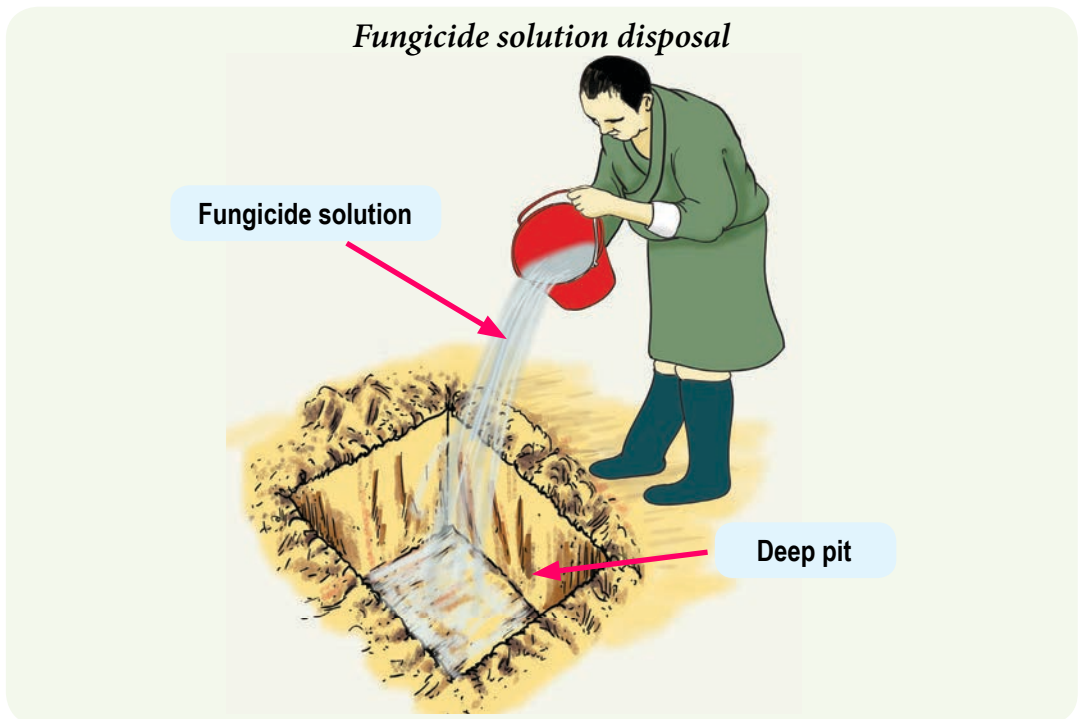
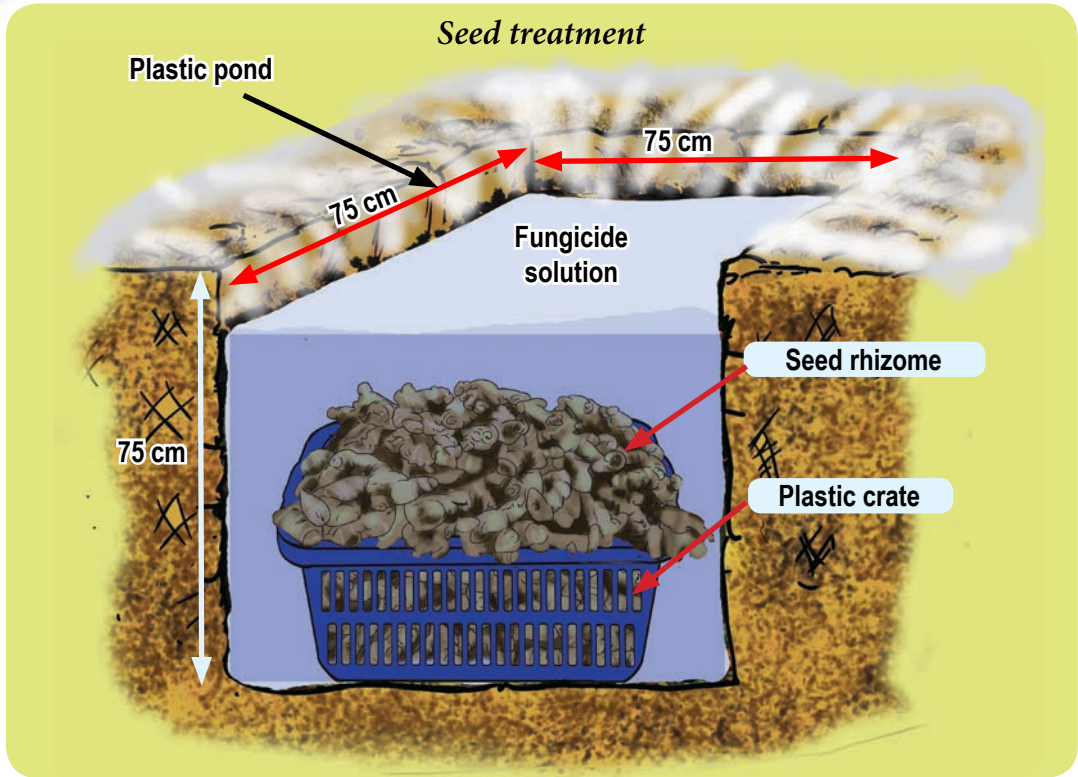


Seed rate

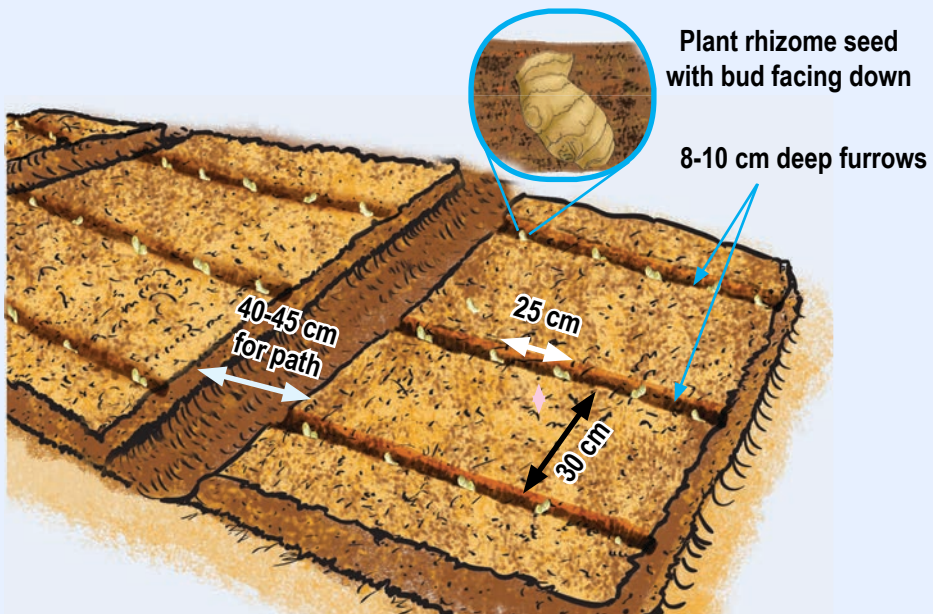


Preparing Fungicide solution





Rhizome planting



Mulching





Earthing up

Earthing up is necessary if the mulch is not thick enough



E2. Pest and disease management

Borer



Yellow peach moth



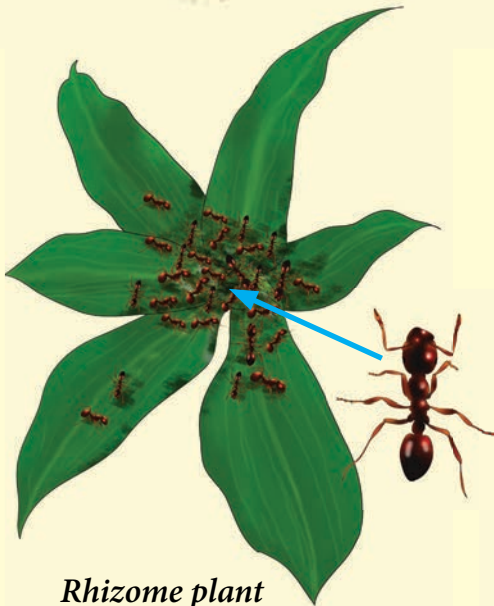
White grub



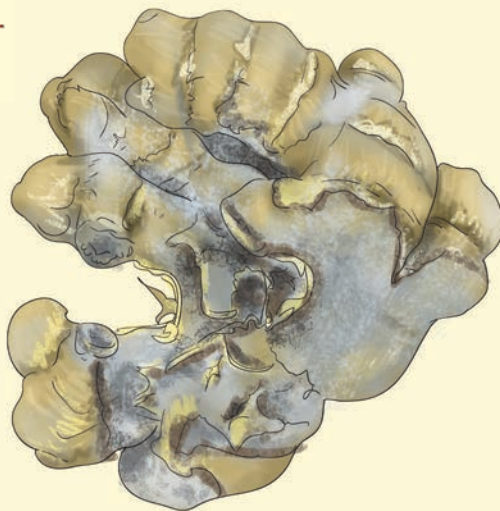
Beetle



Bacterial wilt



*Rhizome plant
infested with red ants*



Storage mold



Rhizome rot



E3. Harvest



Upon loosening the soil, pull the entire plant from the ground with gentle shaking.



Stump of mother rhizome, diseased, damaged, and cut rhizome should be separated from the good ones. Rhizome should be washed thoroughly.

Mother Rhizome

Good rhizome for sale

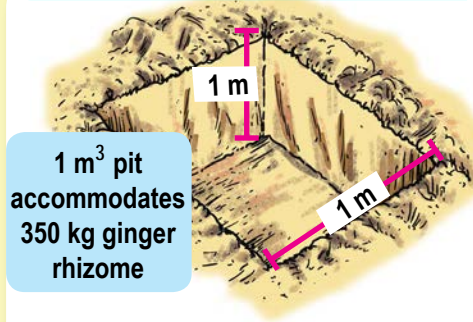
Diseased, damaged or cut rhizome



E4. Postharvest care and storage

1

Dig a pit for rhizome storage



2

Expose the pit for a week and disinfect it by burning dry leaves or twigs inside the pit



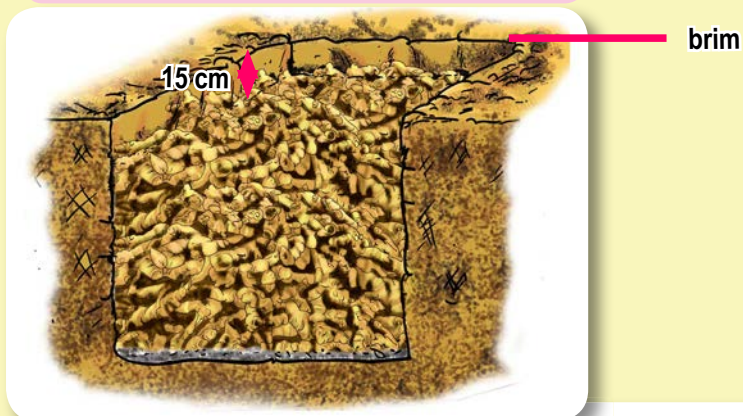
3

Put about 30 cm layer of sand or rice husk or wood ash at the base of the pit

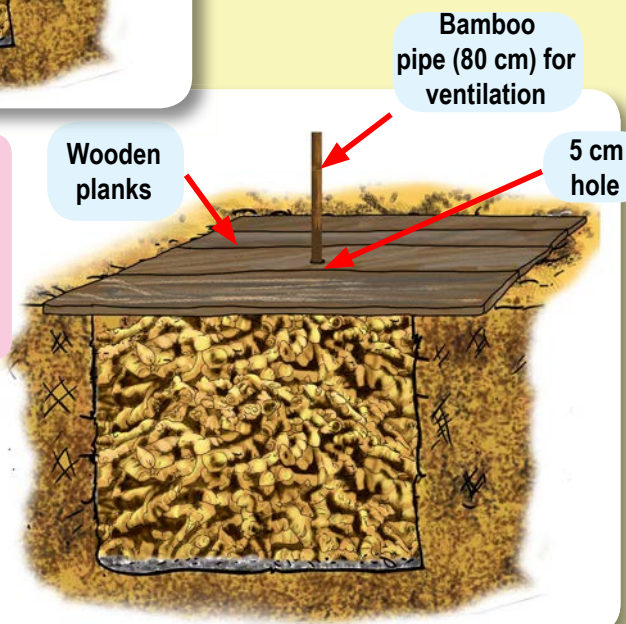




- 4 Put the rhizome in layers up to 15 cm below the brim



- 5 Cover the pit using wooden planks and place a bamboo pipe (80 cm long) for ventilation



- 6 Put a thatch for protection from rain. Prepare a ridge around the pit to protect from run-off water.

