Ministry of Agriculture, Forestry and Food Security
The Republic of Sierra Leone

The Agricultural Development Project in Kambia in the Republic of Sierra Leone

Final Report

Agricultural Technical Support Guidelines

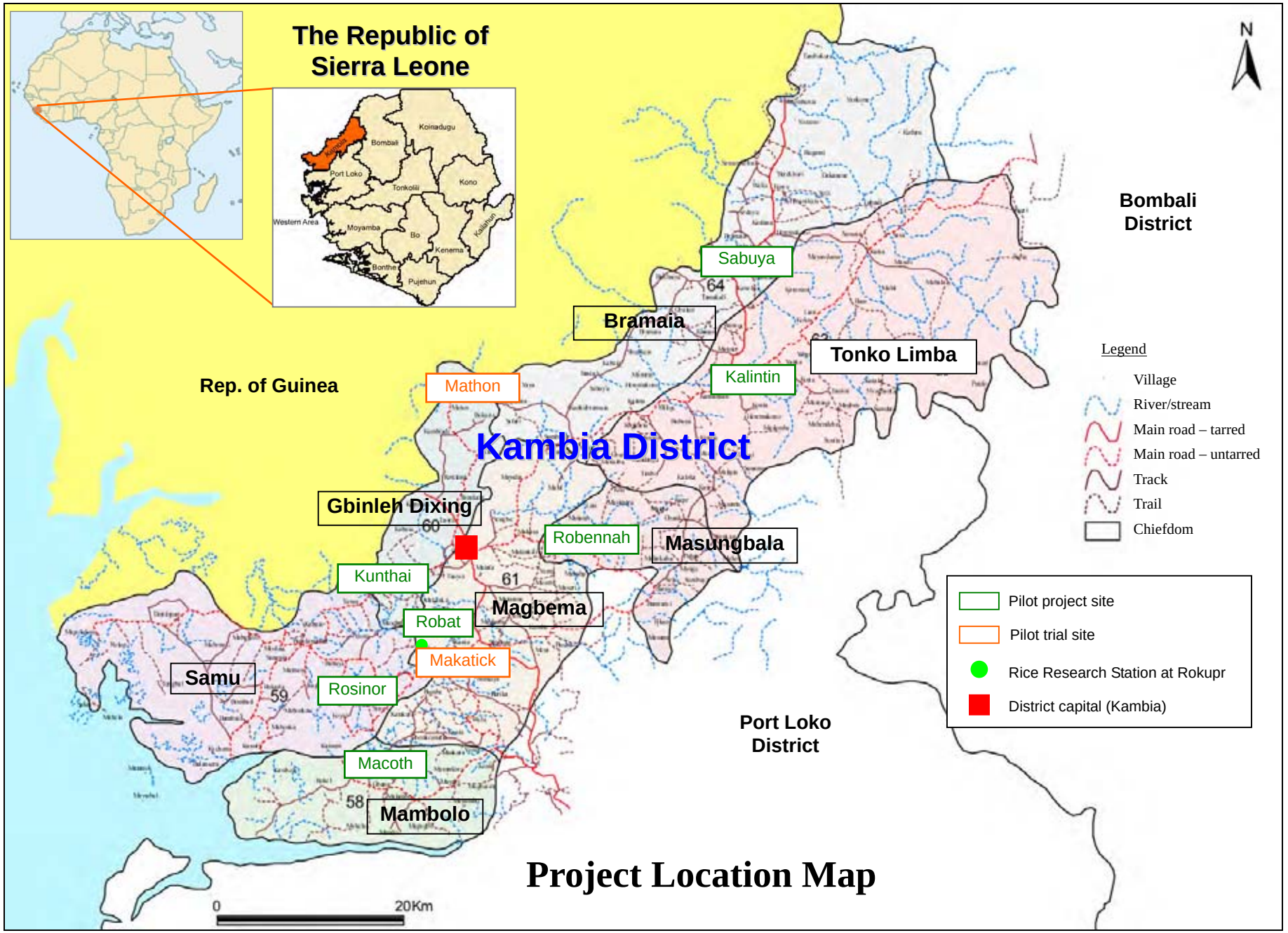
Part III
Agricultural Technical Manuals

March 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

RECS International Inc.

List of Reports


The Republic of Sierra Leone
Koinadugu
Bombali
Kambia
Port Loko
Tonkolili
Kono
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Moyamba
Bo
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Bonthe
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Bombali District
Sabuya
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Tonko Limba
Kalintin
Mathon
Rep. of Guinea
Kambia District
Gbinleh Dixing
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Samu
Rosinor
Macoth
Mambolo
Port Loko District
64
60
61
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58
Legend
Village
River/stream
Main road – tarred
Main road – untarred
Track
Trail
Chiefdom
Pilot project site
Pilot trial site
Rice Research Station at Rokupr
District capital (Kambia)
0
20Km
Project Location Map

The Agricultural Development Project in Kambia in the Republic of Sierra Leone

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Exchange Rate (January, 2009)		
US$ 1.00	=	Le 3,000
Le 1.00	=	US$ 0.0003
US$ 1.00	=	Yen 90.44

Abbreviations

FEW	Frontline Extension Worker
IVS	Inland Valley Swamp
MAFFS-K	Ministry of Agriculture, Forestry and Food Security, Kambia District Office
TM	Agricultural Technical Manual
TP	Agricultural Technical Package

Chapter 1 Introduction

Chapter 1 Introduction

1.1 Organization of the Agricultural Technical Manuals

The Agricultural Technical Manuals (TMs) have been compiled based on the Agricultural Technical Packages (TPs) developed through a series of field trials. While the TPs present techniques with background theories to improve crop productivity, the TMs describe how to adopt those techniques in the field. In this sense, the TMs are an interpreted version of the TPs for practical use. In aid of the users, photographs and illustrations are placed throughout the manuals so that the introduced techniques can easily be understood and explained.

The TMs are composed of four chapters. This chapter (Chapter 1) describes the organization of the TMs and how to use them. Chapter 2 is the rice cultivation manual. It presents improved cultural practices to attain higher yield of rice by in two different agro-ecologies: lowland and upland. It emphasizes the importance of preparing a farming plan, particularly a farming calendar and the respect for it. Important practices are focused and described more in detail.

Chapter 3 is the post-harvest handling manual. It consists of two parts: (i) manual on how to reduce losses in the process of post-harvest handling and (ii) manual on how to operate and maintain agro-machinery, namely, pedal thresher, manual winnower and motorized rice huller. Since the TP on post-harvest handling focuses on post-harvest losses, the manual emphasizes the operation and maintenance of agro-machinery.

Chapter 4 is the vegetable cultivation manual. It deals with how to grow three vegetables: water melon, eggplant and chili pepper. For each crop, cultivation methods with new techniques are described in the sequence of crop growth.

1.2 Utilization of the Agricultural Technical Manual

The TMs are intended primarily for the use of field extension workers (FEWs) as technical extension materials when they present and instruct on new techniques to the farmers. It is expected that the FEWs will learn theories behind the techniques introduced by the TPs and they will disseminate the new techniques to the farmers in the field using the TMs. Advanced farmers are also expected to benefit from the TMs as well as TPs and disseminate the new techniques to other farmers.

Chapter 2 Rice Cultivation Manual

Chapter 2 Rice Cultivation Manual

2.1 Introduction

This rice cultivation manual is prepared as a tool for effective agricultural extension, which is intended mainly for the use of FEWs. With this manual, FEWs instruct the farmers on how to improve their rice cultivation techniques. It is advised that the manual is used together with the TP that provides the background theories of the key techniques or recommended farming practices introduced.

The manual is compiled in the following manner.

The life cycle of the rice plant is presented in Section 2.2 as basic knowledge to be learnt by the farmers. Three growth stages are described highlighting the signs of developmental changes. With a schematic, the differences in growth duration between early maturing and late maturing varieties are explained.

Section 2.3 describes how to obtain higher yield. Yield components are presented first, followed by a component to be improved and measures to be taken in each growth stage. As shown, the improvement of cultural practice in each growth stage contributes to yield increase in a different manner.

In Section 2.4, the preparation of a farming plan is presented emphasizing the importance of farming purposefully as a business. It is intended to remind the users to be considered in the planning process.

Farming techniques are described in Section 2.5 for direct sowing in the upland and transplanting in the lowland separately. hat-to-dos are explained based on the theoretical background presented in the TP. A checklist is prepared for important activities.

2.2 Life Cycle of Rice Plant

Three growth stages in the life cycle of the rice plant:

(1) Vegetative growth stage: from sowing to panicle initiation (duration variable)

(2) Reproductive stage: from panicle initiation to flowering (duration constant)

(3) Maturity stage: from flowering to harvesting (duration constant)

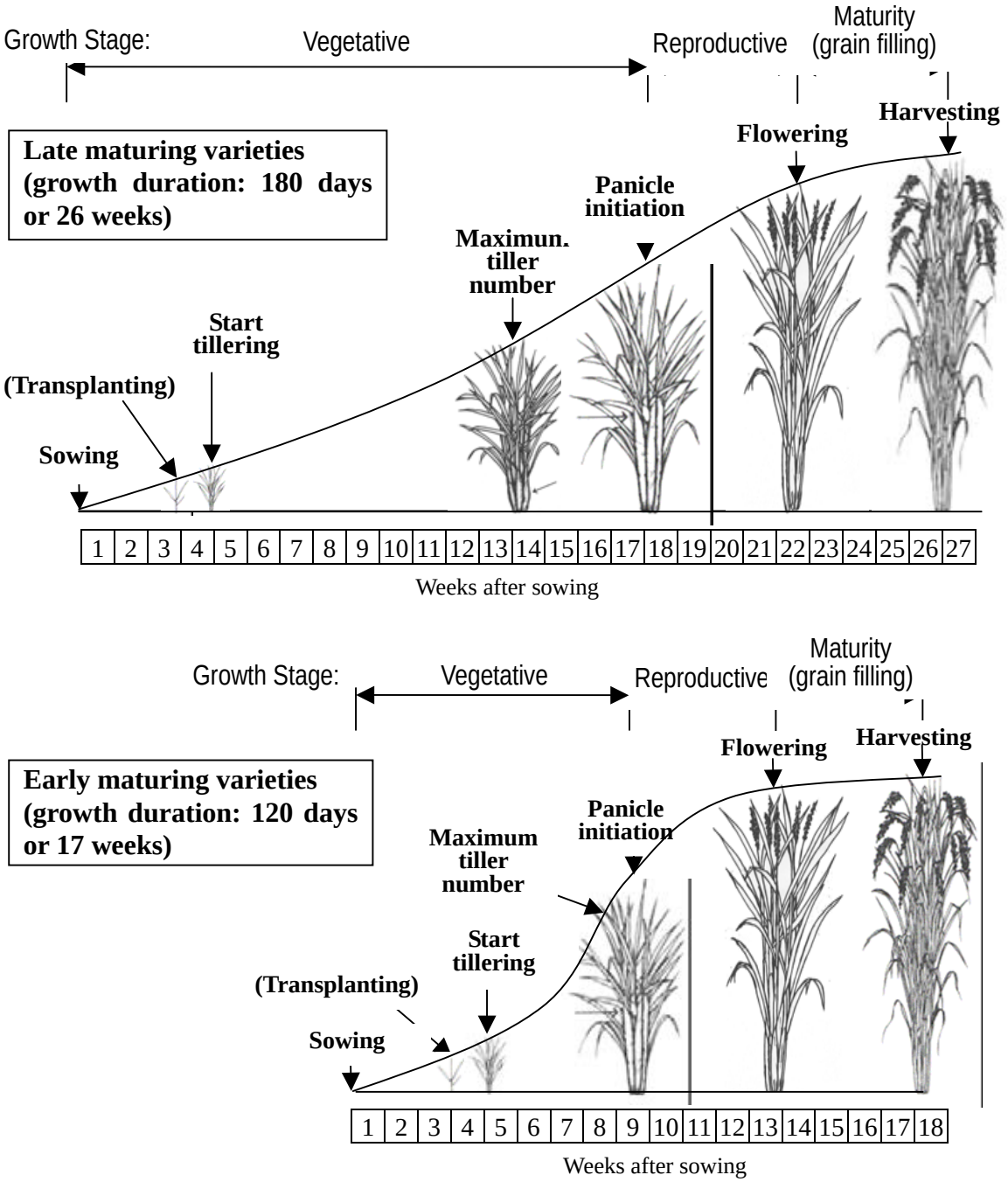


Figure 2.2-1 Life Cycle of Rice Plant

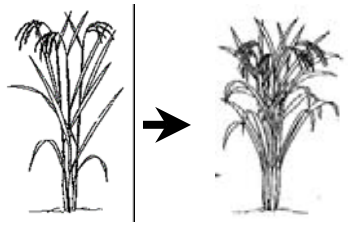
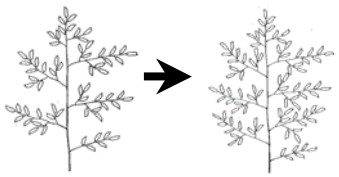
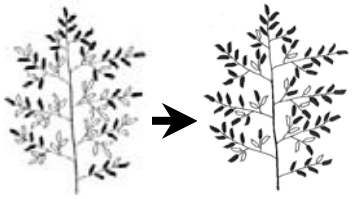
2.3 How to Obtain Higher Yield

Yield of rice is determined by the product of:

(1) Number of filled grains per unit field area

(2) Size (weight) of filled grain

To obtain higher yield, efforts should be directed to increase the number of grains per unit field area. This is important since the grain size does not vary much between cultural practices.

How can we increase number of filled grain in each growth stage?		
Vegetative growth stage:	Reproductive stage:	Maturity stage:
Increase panicle number 	Increase spikelets number per panicle 	Increase grain filling rate 

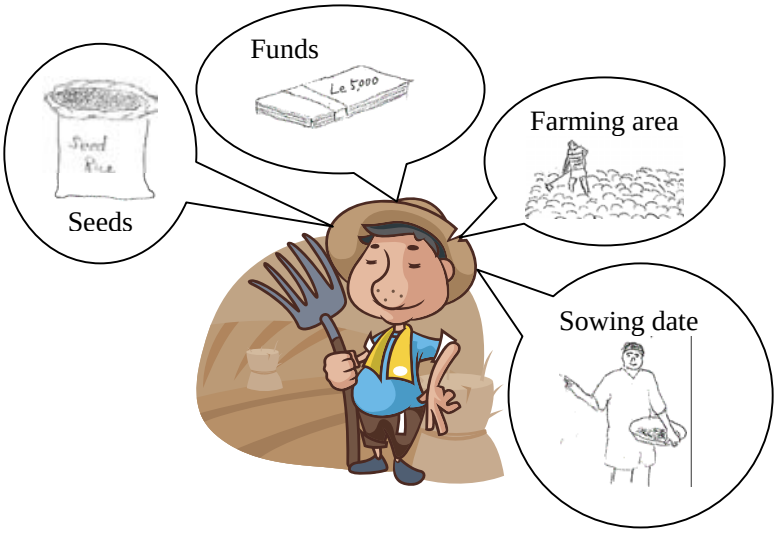
How can we achieve the target?		
(1) Direct sowing in upland: a) Select fertile land after sufficient fallowing. b) Secure seeds with high germination rate. c) Weed timely. d) Apply just enough fertilizer timely.	(1) Direct sowing in upland: a) Apply just enough fertilizer timely. b) Expose plants to sunlight.	(1) Direct sowing in upland: a) Expose plants to sunlight.
(2) Transplanting in lowland: a) Grow healthy seedlings. b) Prepare main field well. c) Uproot seedlings with care. d) Transplant seedlings properly. e) Manage water well. f) Weed timely. g) Apply just enough fertilizer timely.	(2) Transplanting in lowland a) Manage water well. b) Apply just enough fertilizer timely. c) Expose plants to sunlight.	(2) Transplanting in lowland a) Manage water well. b) Expose plants to sunlight.

2.4 Preparation of Farming Plan

Farming is a business. It should yield a benefit in both tangible and intangible. To bring about profit, a farming plan should deliberately be prepared. The farming plan should be worked out in the following procedure.

Work out a farming plan at first:

(1) Secure enough labor and funds.
(2) Determine conditions and scale of farming (e.g., location and area).
(3) Decide rice variety to cultivate.
(4) Calculate required amount of inputs.
(5) Secure seed rice and conduct germination test.
(6) Secure fertilizers.
(7) Prepare farming calendar.



Labor and funds are important factors in determining the farming scale. The location of the farming area influences farming practices and the amount of inputs. The variety of rice defines the farming calendar. The effects of fertilizer on yield of rice depend on the level of farming practices.

2.5 Farming Practices

2.5.1 Upland

Upland rice is normally cultivated by direct sowing. As it is grown under rainfed conditions, there are not many practices influencing yield. However, careful observation in the field and deliberate planning will lead to a good result. Advise the farmers to visit their farms frequently to observe the growth of rice throughout the farming season.

(1) Site selection

Select the site in the following conditions for upland rice production as a first year crop of slash and burn cultivation:

a) Fallowed for at least 7 years
b) Rich in biomass accumulation
c) On a slope but not too steep
d) Oil palm sparsely planted

(2) Seed procurement

Procure seed rice in the following steps.

a) Contact seed providers to confirm the availability of seed rice required.
b) Check the purity of seeds by grain color, grain length, awn, etc.
c) Conduct a germination test to make sure of the viability of seeds.
d) Collect information on the characteristics of seed rice.
e) Procure the necessary amount of seeds based on the planned scale of farming.

Procure seeds from reliable sources. It is highly recommended that a germination test be conducted before procure the seeds. When the information on 1,000-grain weight is not available for the seed rice, the following is the standard 1,000-grain weight for varieties of seed rice (Table 2.5-1 and Photo 2.5-1).

Table 2.5-1 1,000-grain Weight of Rice Varieties

Variety	1,000-grain weight (g)
ROK 3*	30
Kissy Fundy*	15
ROK 10	21
ROK 14	23
ROK 24	20
Yam Gbessay	27
CP4 (Tonsor Kayrain)	19
Lansana Conteh	27

*Adapted to upland conditions

Photo 2.5-1 Various Grains of Rice

(3) Farming calendar preparation

Prepare a farming calendar in the following steps to ensure timely farming practices to obtain higher yield.

a) Estimate the desirable harvest time.
b) Decide the time of sowing (rough schedule) taking into account growth duration of rice variety to be used.
c) Decide the time to start slashing taking into consideration how long it will take to prepare land, based on farm size, vegetation conditions and labor availability.
d) Decide the time of weeding 4-6 weeks after sowing.
e) Decide the time for top dressing about 2 month before harvest.
f) Decide the period of bird scaring about 1 month before harvest.

The following is a standard farming calendar, showing the recommended time range of each activity for reference (Figure 2.5-1). It is not necessary to strictly follow the calendar. Respect the farming calendar that you prepare.

Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Site selection												
2. Procurement of seed and germination test												
3. Slashing, felling, burning and clearing												
4. Basal fertilizer applicaton												
5. Sowing, harrowing, and bird scaring												
6. Fencing												
7. Weeding												
8. Top dressing												
9. Bird scaring												
10. Harvest												

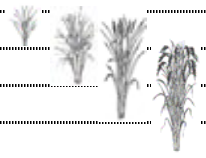


Figure 2.5-1 Standard Farming Calendar for Upland Rice in Kambia District

(4) Slashing, burning and clearing

Allocate sufficient time for slashing, burning and clearing since these activities are laborious and time consuming.

Photo 2.5-2 Land Preparation for Upland Rice Planting: After Slashing (above left), Burning (above right) and Clearing (left)

(5) Sowing, fertilizer application, harrowing, and bird scaring

Consult the experienced farmers or master farmers for the timing of sowing. Sowing is a precarious activity since germination depends much on rainfall.

To sow seeds and fertilizer evenly, divide them into three portions and broadcast them separately at orthogonal angle (Figure 2.5-2). Fertilizer, if available, should be applied in the same way as sowing for even distribution.

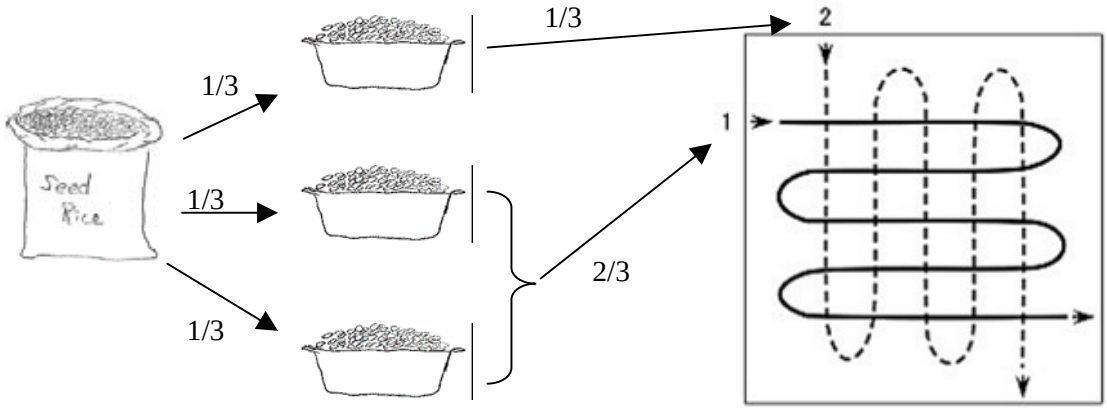


Figure 2.5-2 Method for Uniform Seed Sowing

Photo 2.5-3 Seed Sowing in Upland

Harrowing follows sowing (Photo 2.5-4). Shallow harrowing is recommended to ensure germination. Deep sowing reduces germination and retards the subsequent growth (Photo 2.5-5). However, the seeds should be covered with soil to minimize loss from bird attack, drought, or running water after sowing. Bird scaring should be continued for several days after sowing until germination.

Photo 2.5-4 Harrowing in Group after Sowing

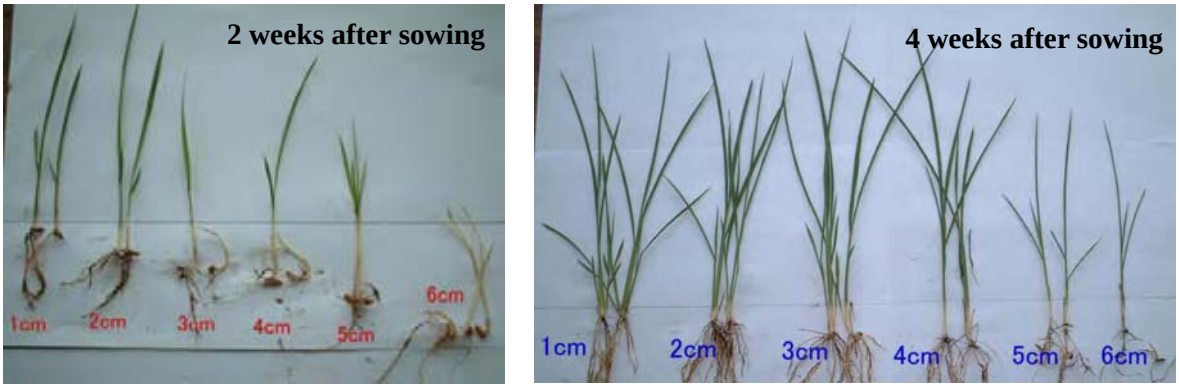


Photo 2.5-5 Effects of Sowing Depth on Germination and Subsequent Growth of Rice (Tsuboi T., 2005)

(6) Weeding

Weed timely and thoroughly to prevent competition with rice.

(7) Fencing and clearing

Protect rice from rodents attack (e.g., cutting-grass). Put up a fence and set traps around the rice field, and slash the surrounding bushes.

(8) Bird scaring

Start bird scaring immediately after flowering, and continue it until the maturity stage.

(9) Harvest

Visit the field everyday to determine the date for harvesting when maturity is close.

Checklist for upland rice cultivation

When selecting the field site, confirm the following conditions:

- ☐ **Fallow period (more than 7 years; preferably 10 years or more)**
- ☐ **Biomass accumulation (more biomass accumulation preferable)**
- ☐ **Slope gradient (steep slope should be avoided)**
- ☐ **Density of oil palm trees (densely planted area should be avoided)**

When procuring seed rice, collect the following information:

- ☐ **Name of Variety**
- ☐ **Growth duration (how many months from sowing to harvest)**
- ☐ **Seed source (from which seeds were obtained)**
- ☐ **Germination rate**
- ☐ **1,000-grain weight**
- ☐ **Resistance to diseases and pests**
- ☐ **Plant height**

Before sowing:

- ☐ **Enough amount of seed rice for the farmland area**
- ☐ **Bowls for broadcasting seed rice**
- ☐ **Laborers with hand hoes**
- ☐ **Weather forecast (pick a day for sowing when rain is unlikely)**

When sowing and tending, make sure the following:

- ☐ **Uniform sowing**
- ☐ **Shallow harrowing**
- ☐ **Careful bird scaring**

Respect the farming calendar always!

2.5.2 Lowland

Most lowland rice is cultivated by transplanting. Lowland has the advantage of water. There are many farming practices to be improved to obtain better yield, especially in the vegetative growth stage when the number of panicles is determined.

Key farming practices to obtain higher yield:

(1) At nursery
   a) Smaller amount of seed
   b) Wider nursery area
   c) Shallow harrowing and uniform sowing
   d) Shorter nursery period
(2) Land preparation
   a) Bund construction
   b) Good puddling
(3) Uprooting and transplanting
   a) Careful uprooting
   b) Fewer seedlings per hill
   c) Shallow planting
   d) Proper spacing
(4) Weeding and water management
   a) 4-6 weeks after transplanting
   b) Periodical drainage

(1) Site selection

Collect the following information from the neighboring farmers only when select new lowland area.

a) Past flood record (frequency, duration, time, flood depth, water current, etc.)
b) Past land use (fallow or cultivated)
c) Present vegetation (dominant weed)
d) Water availability (perennial or seasonal, fluctuation of water depth and current)

(2) Procurement of seeds, and germination test

Confer the section 2.5.1 (2).

Calculate the required amount of seeds based on the farm size and 1,000-grain weight of the seeds of the variety to be planted.

Table 2.5-2 Seed Requirement for Transplanting in Various Rice Varieties

Variety	1,000-grain weight (g)	Seed requirement	
		kg/ha	bu/acre
ROK 10	21	21	0.4
ROK 14	23	23	0.4
ROK 24	20	20	0.3
Yam Gbessay	27	27	0.5
CP4 (Tonsor Kayrain)	19	19	0.3
Lansana Conteh	27	27	0.5

Calculated with 20 hills/m^2 as planting density, 80% germination by incubation, 75% emergence (sprout) in nursery, and 3 seedlings/hill for transplanting.

(3) Farming calendar preparation

Prepare a farming calendar in the following steps to ensure timely farming practices to obtain higher yield.

a) Estimate the desirable harvest time.
b) Decide the date of transplanting taking into account growth duration of rice variety to be used for all agro-ecologies and tidal calendar for mangrove swamp.
c) Decide the date of sowing in the nursery taking into consideration nursery period (4 weeks for mangrove swamp and 3 weeks for IVS and boliland).
d) Decide the time of plowing that needs to be completed before nursery preparation.
e) Decide the time of slashing, burning and clearing, which need to be completed before plowing.
f) Decide the time of weeding 4-6 weeks after transplanting.
g) Decide the time for top dressing 2 months before the expected time of harvest or early booting (pregnant) stage.
h) Decide the period of bird scaring from just after flowering through maturity period.

Refer to the standard farming calendars for IVS/boliland and mangrove swamp, respectively (Figures 2.5-3 and 2.5-4). The calendar should be modified as necessary. Respect the farming calendar that you prepare.

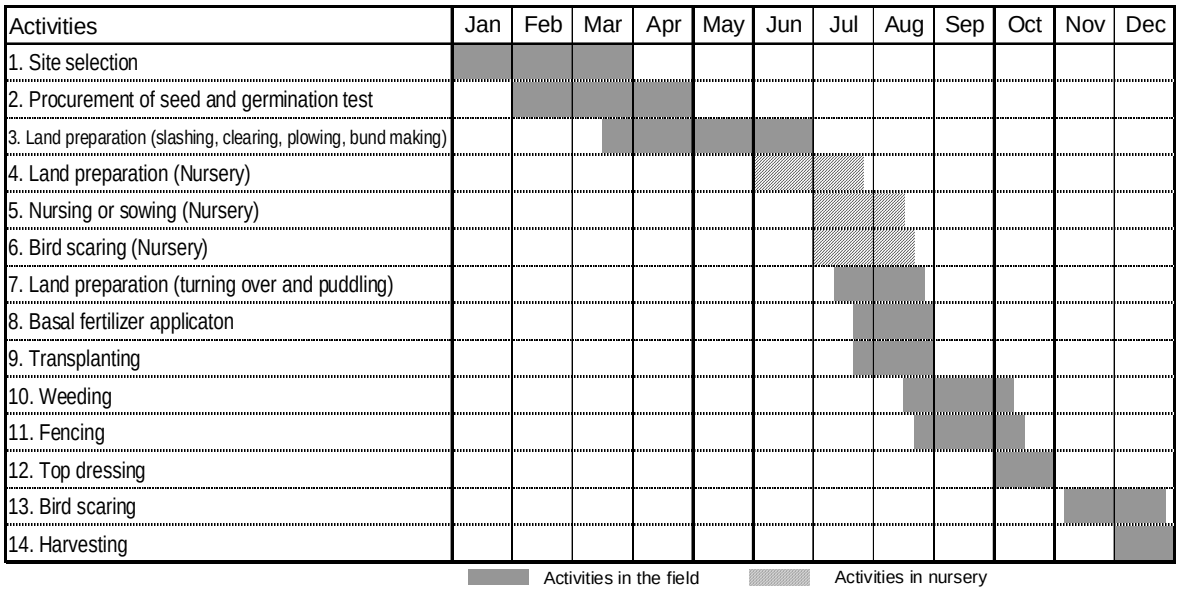


Figure 2.5-3 Standard Farming Calendar for Rice Cultivation (by Transplanting) in IVS and Boliland in Kambia District

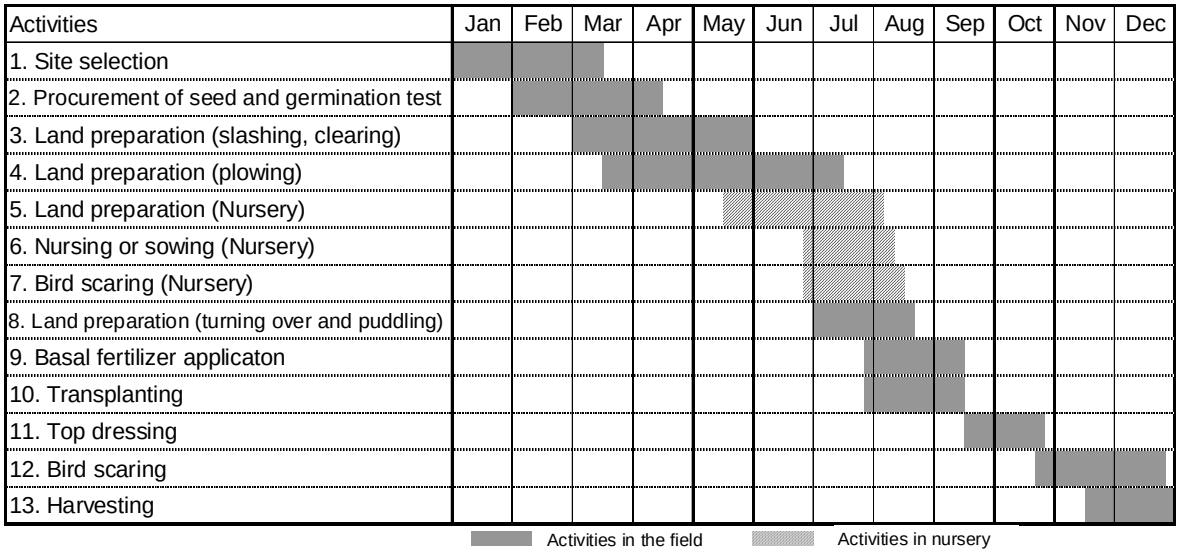


Figure 2.5-4 Standard Farming Calendar for Rice Cultivation (by Transplanting) in Mangrove Swamp in Kambia District

(4) Slashing, burning, clearing, plowing

Make sure to slash, burn, clear, and plow before sowing seed rice on nursery. Burn the slashed vegetation when it is dried. If rain comes early or slashing is delayed, remove slashed weeds outside the main field or heap them up at the designated spot. Plow the main field before nursery preparation. In mangrove swamp, it should be completed well before the nursery preparation starts.

(5) Bund construction (IVS, Boliland)

Construct bunds to control and drain water. Collect hydrological and geographical information as much as possible. Align drainage canal along the lowest point in the field. Construct bund surroundings of the main field.

Photo 2.5-6 Bund Constructed along Drainage Channel

(6) Nursery preparation, sowing seeds, and nursery management

Remember that raising healthy seedlings is the first step to obtain high yield in the transplanting method of rice cultivation. Prepare the nursery and sow seeds in the following steps.

(a) Site selection

Find a suitable dry plot for the nursery according to the criteria below.

Suitable land for nursery:

(1) Exposed land
(2) With not too much gravel
(3) Accessible to water sources
(4) Free from flood
(5) Easily accessible
(6) Not too far from the main field
(7) Not on steep slope

(b) Nursery preparation

Prepare the nursery of a appropriate size based on the amount of seeds to be sown (Table 2.5-3). Remove weeds from their roots, and till the nursery finely.

Table 2.5-3 Standard Nursery Area

Variety of rice	Seed amount		Nursery area (for IVS and Boliland)	
	kg/ha	bu/acre	main land m^2/ha	$Yard^2$/acre
ROK 10	21	21	350	170
ROK 14	23	23		
ROK 24	20	20		
Yam Gbessay	27	27		
CP4 (Tonsor Kayrain)	19	19		
Lansana Conteh	27	27		

Calculated with 20 hills/m^2 as planting density, 80% germination by incubation, 75% emergence (sprout) in nursery, and 3 seedlings/hill for transplanting.
Note: Nursery area presented is for IVS and Boliland. In mangrove swamp it should be 530 m^2/ha or 260 $yard^2$/acre, respectively, since seedlings grow larger due to long nursery period.

(c) Uniform sowing and shallow harrow

Sow seeds evenly (Cf. Sub-section 2.5.1 (5) and Figure 2.5-2). Harrow the soil shallowly to ensure germination.

Cover the nursery soil with mulch (e.g., palm fronds) for a few days after sowing to protect the seedlings from heavy rain and bird attack.

(d) Nursery management

Water the nursery if there is no rain for one day after sowing. Remove the mulch when 50% germination is observed.

(7) Turning over and puddling in the main field

Break large clods made by plow into smaller clods until soils become muddy, allowing for shallow planting.

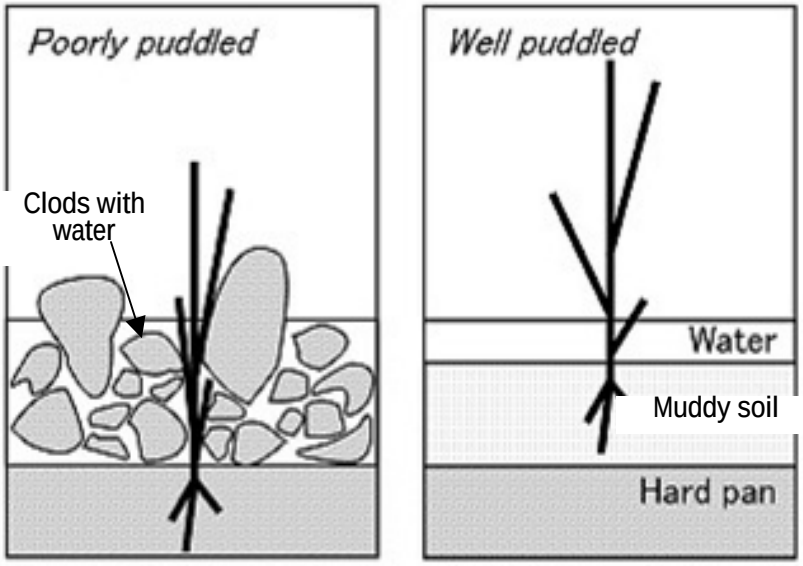


Fig. 2.5-5 Transplanting under Different Puddle Conditions

Level the land as much as possible while puddling. The leveling promotes uniform growth and prevents stagnant growth of rice from submergence.

(8) Uprooting and transplanting

Uproot the seedlings 3 weeks after sowing in IVS and boliland and 4 weeks after sowing in mangrove swamp, and transplant them immediately. When uprooting, treat the seedlings with care. Pick only a few seedlings at a time so that soils can be removed from them easily. Try not to damage the stem bases by hitting the seedlings against a foot, hand, or any hard object when removing the soils. Put the uprooted seedlings in a bowl with water.

Photo. 2.5-7 Recommended Handling of Uprooted Seedlings

Transplant 2-3 seedlings per hill about 3 cm (or 1 inch) deep. Pay attention not to plant them too deep or fold the stem bases when using a planting fork.

Photo 2.5-8 Example of Transplanting 2-3 Seedlings per Hill (Left)and Subsequent Growth (Right)

(9) Water management

Drain water periodically to avoid growth stagnant.

Photo. 2.5-9 Stagnant Growth of Rice under Poor Drainage Condition

(10) Weeding

See Sub-section 2.5.1 (6).

(11) Bird scaring

See Sub-section 2.5.1 (8).

(12) Harvest

See Sub-section 2.5.1 (9).

Checklist for lowland rice cultivation:

When selecting new rice field, collect the following information:

- ☐ **Flood record (frequency, duration, flood depth, water current, etc.)**
- ☐ **Past land use**
- ☐ **Present vegetation (dominant weed)**
- ☐ **Water availability (perennial or seasonal)**

When procure seed rice, collect the following (the same as upland rice):

- ☐ **Name of Variety**
- ☐ **Growth duration (how many months from sowing to harvest)**
- ☐ **Seed source (from which seeds were obtained)**
- ☐ **Germination rate**
- ☐ **1,000 grain weight**
- ☐ **Resistance to diseases and pests**
- ☐ **Plant height**

When preparing a farming calendar, try to obtain the following information:

- ☐ **Growth duration of rice grown**
- ☐ **Tidal calendar (for mangrove swamp)**

When preparing land, the following should be kept in mind:

- ☐ **Plow before nursery preparation (for IVS and boliland)**
- ☐ **Plowing should be completed well before nursery preparation starts (for mangrove swamp only)**
- ☐ **Construct bunds for water control (for IVS and boliland where applicable)**

When selecting the nursery site, check the following:

- ☐ **Free from submergence**
- ☐ **Not too much gravel**
- ☐ **Accessible to water sources**
- ☐ **Not on steep slope**
- ☐ **Not far from the main field**

When sowing in the nursery, pay attention to the following:

- ☐ **Uniform sowing**
- ☐ **Shallow harrowing to mix seeds with soil**
- ☐ **Cover the soil with mulch**
- ☐ **Watering during drought**

When turning over and puddling in the main field, pay attention to the following:

- ☐ **Puddle until the soil turns muddy.**
- ☐ **Soil surface is level.**

When uprooting and transplanting, check the following:

- ☐ **Nursery period (3 weeks for IVS/boliland and 4 weeks for mangrove swamp)**
- ☐ **Handle seedlings with care when uprooting (not to damage stem bases).**
- ☐ **Do not dry the roots of uprooted seedlings for a long time.**
- ☐ **Do not waste seedlings by transplanting too many seedlings per hill.**
- ☐ **Try shallow planting (preferably 1 inch deep).**
- ☐ **Proper spacing (25 hills per m^2).**
- ☐ **Do not fold stems when a planting fork is used.**

Respect the farming calendar always!

Reference

Tatsushi Tsuboi; Guide for Upland Rice Experiments (Draft), presentation material for JICA/AICAD Technical Seminar on Rice Cooperation in East and Southern Africa (12-15 Dec., 2005), December 2005.

Chapter 3 Manual for Post Harvest Handling of Rice

Chapter 3 Manual for Post Harvest Handling of Rice

3.1 Introduction

The manual consists of the following two parts:

(1) Technique to reduce post-harvest handling loss

Reduction of post-harvest loss is the accumulated result of loss reduction in each post-harvesting task. Therefore, farmers must always pay attention to each post-harvest task to reduce the losses, even if each loss is small.

The FEWs can explain the techniques while showing the farmer the photographs and drawings in this manual. As all these techniques can be seen in the Kambia district, it is not very difficult for the farmer to introduce and share them.

(2) Operation and maintenance of pedal thresher, manual winnower, and motorized rice huller

The Project introduces the pedal thresher, manual winnower, and motorized rice huller, which are quite new to most rural farmers, but the operators have already been trained in operation and maintenance methods.

When any of the machines develops problems, the FEWs and operators should review and confirm the training items in this manual.

3.2 Post-harvest Handling of Rice

(1) Binding

Photo 3.2-1 Bundle (right) and Bunch (left) Binded with the Cut Stems of Harvested Rice Plants.

This causes handling loss. use of tree bark, grass, and young, torn palm leaves is recommended (Photo 3.2-2).


Photo 3.2-2 Binding Materials, Bark of Tree (left) and Grass (right)

(2) Transporting

Loss during transport occurs easily by shattering when rice plants are well dried (Photo 3.2-3). Along the way, grains continue to shatter because of the trembling action while the carrier (often a woman) walks, leaving a trail of fallen grains. To minimize handling losses, it is important to handle the crop with care when transporting. Use of a large pan, basket, or wrapping with cloths or a tarpaulin are recommended, to reduce handling loss (Photo 3.2-4).


Photo 3.2-3 Transporting Rice after Cutting


Photo 3.2-4 Use of Basket (left) and Wrapping with Tarpaulin (right)

(3) Field drying

In most cases in Kambia, field drying is carried out on ground that has been leveled and hardened a little (Photo 3.2-5). Grains shatter when a bundle is lifted and dumped. Use of a tarpaulin is recommended. If a tarpaulin is not available, woven bamboo or palm leaf mats are recommended, for easy collection of grains and for avoiding foreign materials.



Photo 3.2-5 Field Drying on the Ground (left and middle), and Tarpaulin (right)

(4) Threshing

Threshing in Kambia District is carried out by beating against a hard object such as a mortar, or a steel oil drum on the ground (Photo 3.2-6). As in the case of field drying, use of a tarpaulin is recommended for easy collection of grains and for avoiding foreign materials. If a tarpaulin is not available, woven bamboo or palm leaf mats are recommended.

Photo 3.2-6 Threshing on the Ground (left), and on a Tarpaulin (right)

(5) Cleaning

Cleaning of rough rice is carried out, just after threshing, at the same site. The rough rice may contain various foreign materials such as bits of straw, unfilled grains, sand, stones, bits of plastic and charcoal, and even metal and plastic particles. Lighter materials such as unfilled grains, chaff, weed seeds, and straw can be removed from the grain by wind. Because stones and other hard objects which remain with grains may break the sieve in the rice huller, these materials should be removed carefully to the greatest possible extent. Use of a tarpaulin or woven bamboo or palm leaf mats for cleaning is recommended to avoid mixing of foreign materials.

Photo 3.2-7 Cleaning of Rough Rice (left), and Foreign Materials Remaining (right)

Note: the coin shows the size of foreign materials

(6) Drying

After cleaning rough rice or parboiling, rice grains are dried on the following surfaces near a building (Photo 3.2-8). During this drying, grains may be further contaminated with sand, soil, stones, and bits of plastic, even if drying in the drying facilities. As in the case of threshing, cleaning is important.

Photo 3.2-8 Drying Facilities: Drying Floor Made of Hard-packed Floor (upper), Drying Floor Made of Concrete (lower left), and Tarpaulin (lower right)

(7) Storage

Storage period of rice in Sierra Leone during the dry season

Rough rice or parboiled rice used to be packed into used rice sacks (50 kg) and stored directly on the floor in the farmer's house (Photo 3.2-9). This storage condition has a problem of ventilation for grains. Use of a pallet is recommended for avoiding the possibility of absorbing moisture from the floor.

Photo 3.2-9 Example of Storage: Sacks Stored Directly on the Floor

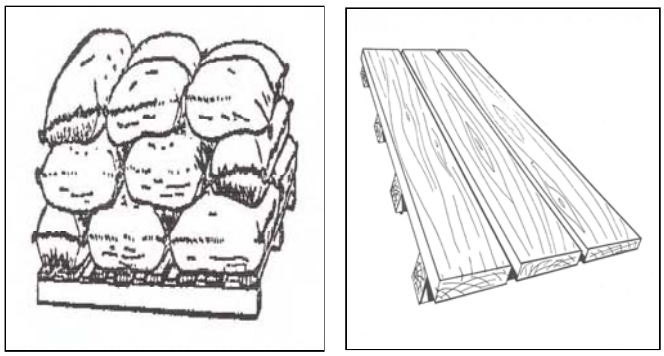


Figure 3.2-1 Storage of Sacks on a Pallet (Left) and Pallet Made of Wood (Right)

3.3 Post-harvest Machinery

3.3.1 Pedal thresher

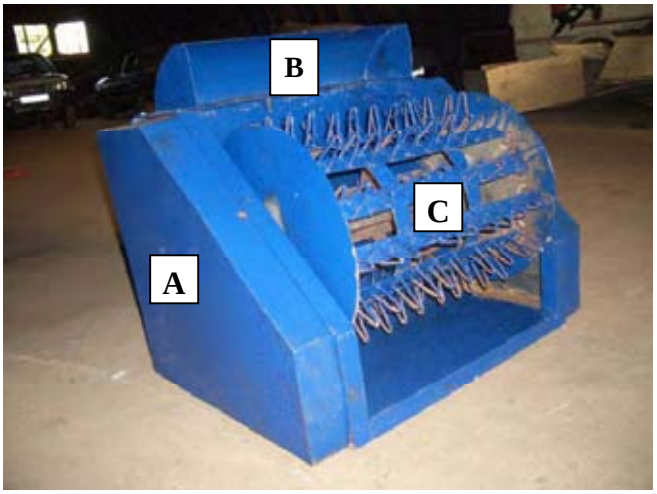


Photo 3.3-1 Pedal Thresher

(1) Names of main components and their functions

A: The side cover serves to cover the chain and sprocket mechanism of the machine.

B: The shroud serves to prevent the rice grains from hitting the operator, by deflecting them forward away from him/her.

C: The thresher rotor with spikes revolves by pedal and hits the rice to separate the grains from the straw.

Photo 3.3-2 Pedal Thresher with Cover that Prevents Scattering of Rough Rice (left). Threshing by Pedal Thresher on a Tarpaulin (right)

(2) Operation of the pedal thresher

a) Set the machine on a tarpaulin, or woven bamboo or palm leaf mats spread out on the flat ground (Photo 3.3-2).

b) Cover the machine with a tarpaulin to trap the grains of rice that are flung by the rotor spikes.

c) Put your foot on the pedal and turn the thresher rotor (C) fast with the palm of your hand by pushing it forward

d) At the moment your foot is taken upward, depress the pedal downward while still assisting the rotation with the palm of your hand.

e) At this point, the rotor will start rotating faster. Take your hand off it immediately and continue pedaling.

f) Take the rice by the stalk in reasonable bits and allow the grains to come in contact with the revolving rotor until you accept that no grains remain on the stalk.

(3) Maintenance

a) Before operation, tighten all accessible bolts and nuts, and grease the chain.

b) At the end of each day's operation, especially at the end of the harvest season, clean the machine thoroughly by freeing it from all rice chaff, grains, and stalks, and tighten all accessible bolts and nuts.

3.3.2 Manual winnower

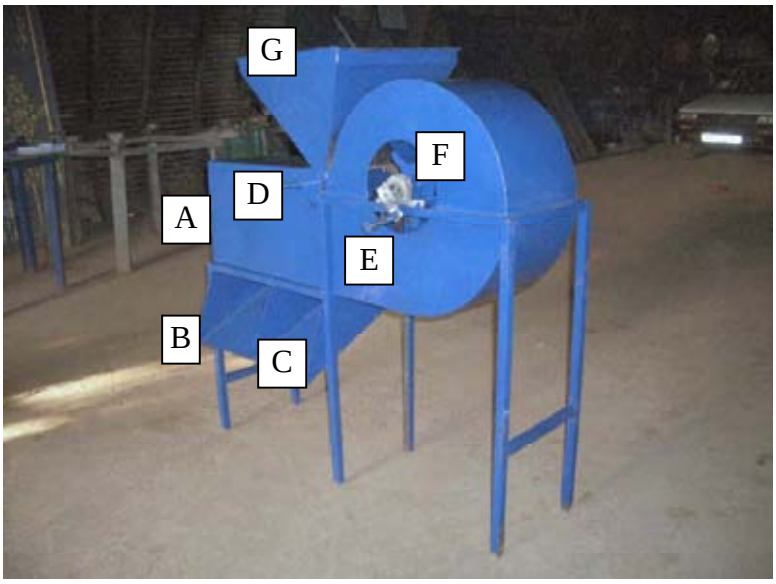


Photo 3.3-3 Manual Winnower

(1) Names of parts and their functions

A: Chaff blown out by the fan is directed out of the machine through this chute.

B: Chute collects and directs heavier chaff to a container.

C: Chute collects and directs the winnowed rice to a container.

D: Feed valve handle serves to open and close feed valve.

E: Handle enables the operator to turn the fan.

F: Fan generates air in the machine.

G: Hopper holds rice to be winnowed

Photo 3.3-4 Operation of Winnower

(2) Operation

Before operating the machine, make sure that you are familiar with the following procedures.

a) Position the machine on level ground

b) Close the feed valve by loosening the feed valve handle (D) and pushing it upward. When it is at its uppermost travel, the feed valve is closed. Tighten it.

c) Fill the hopper (F) to the brim with rice

d) Put containers to receive the gains under chutes (B) and (C)

e) Start to turn the handle (E) at a fast rate

f) Loosen the feed valve handle with your left hand and push it downward slightly. At this moment, rice will start falling from the hopper to the winnowing chamber. The degree of opening of the feed valve determines the rate at which the rice flows into the machine. The wider the opening, the more rice flows. The wider you open the feed valve, the faster you should turn the fan. If this is not done, the rice will come out without winnowing.

Note: As husk and bran are removed easily, the winnower eases women's work load

(3) Maintenance

a) Before operation, grease the bearing.

b) At the end of each day's operation, clean the machine.

3.3.3 Motorized rice huller

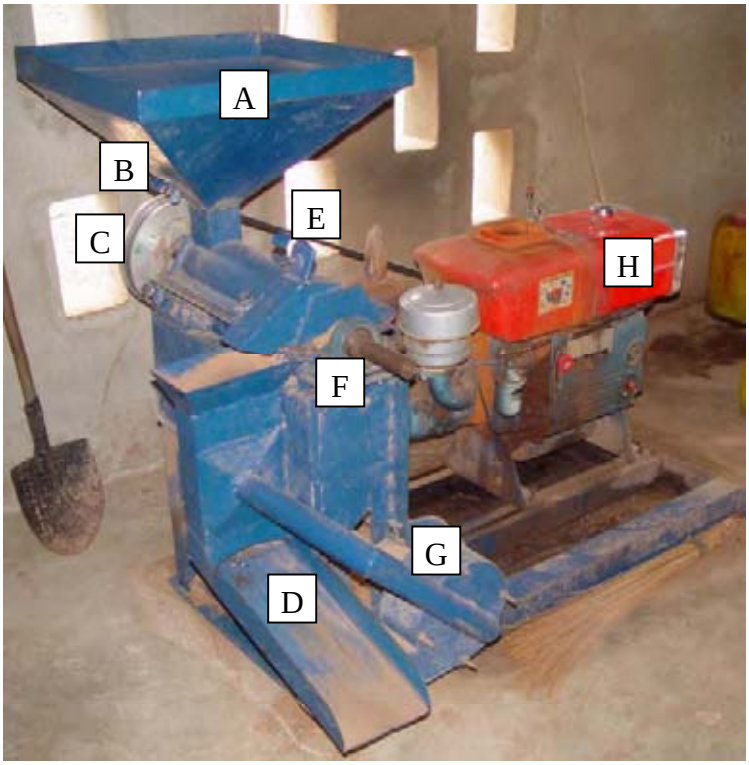


Photo 3.3-5 Main Components of Rice Hulling Machine

(1) Names of Parts and Their Functions

A: The hopper contains the rice while it is been hulled.

B: The feed Valve controls the rice with husk as it moves from the hopper (a) to the hulling chamber.

C: The pulley has the function to transfer the turning force (torque) of the engine to the hulling machine.

D: Outlet of the hulled rice.

E: The bearing keeps the hulling auger centered in the hulling chamber and at the same time allows an easy rolling motion.

F: The discharge valve regulates the quantity of rice coming out from the hulling chamber.

G: The blower removes the heavier chaff from the rice during the hulling process. Some models do not have it.

H: The engine is the source of power to operate the rice huller.

(2) Operation of the Machine

a) Start the engine and allow it to run at low speed for about 2 minutes. This is to allow the lubricating oil to fully circulate in the engine before putting the machine into full operation.

b) Push and close the Feeder (B) and Discharge (F) valves.

c) Fill the hopper with rice to the brim and put a container under Chute (D). It is recommended that you have two containers (one large and the other small). The small one serves to reintroduce unmilled rice back into the hopper.

d) After the engine runs for about 2 minutes, push the acceleration lever of the engine to the three-quarter throttle position.

e) Open the feeder valve (B) slightly. At that slight opening, rice will start to flow from the hopper to the hulling chamber. Listen for a change in the engine sound.

f) At the moment the sound changes, open the discharge valve (F) slightly. Some hulled rice will start to come out and there will be a noticeable ease of strain on the engine. There is a time lag (about 30 seconds) between opening of the valve (B) and the change in the sound of the engine, due to the hulling chamber filling.

Note: It is important to note that the wider the feeder valve is opened, the more rice will be admitted into the hulling chamber and the more strain will be imposed on the engine. Opening feeder valve (B) too wide will make the engine stop, or the belts will spin around the pulley, causing them to burn.

If the discharge valve (F) is opened too wide, most rice will escape un-hulled.

It is also important to note that at the moment the hulling starts, the quantity of rice fed into the machine should be only slightly greater than the quantity leaving it through the discharge valve (F). If the rice leaves the machine at a faster rate than it is fed into it, little or no hulling will be done. On the other hand, if the amount fed into the machine far exceeds the amount leaving, it will impose strain on the engine, which might cause it to stop.

g) As the rice starts coming out, observe the quality of the milled rice and continue to

adjust the valves until you get the best result. The rice that comes out first can be reintroduced in to the hopper for further hulling.

h) When hulling the last batch, mix the rice with some husk to a quantity that will be sufficient to fill the hulling chamber, and pour it into the hopper the moment the last batch of rice is about to disappear.

Note: There are cases where farmers might want to hull the rice once by changing the retention period of rough rice in the chamber while adjusting opening and shutting of the feeder valve (B) and the discharge valve (F). This is only advisable if the rice is parboiled. For non-parboiled rice, hulling twice to prolong the life of the engine is recommended.

(3) Maintenance of the machine

The following items should be checked before operating.

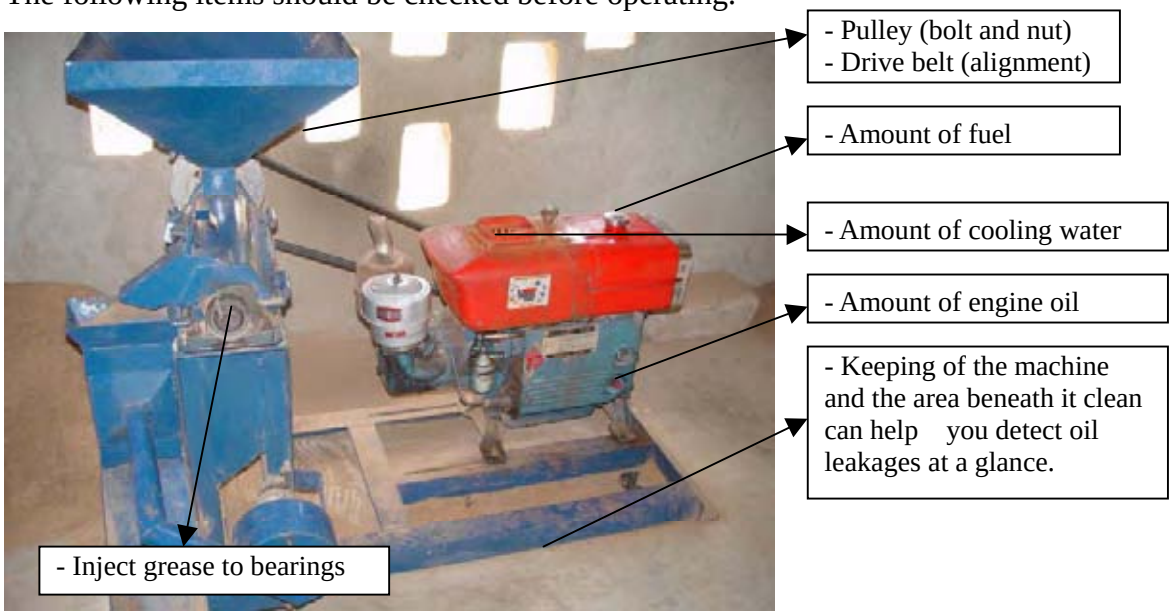


Photo 3.3-6 Parts for Daily Check

Photo 3.3-7 Inject Grease to Bearings with a Syringe (left), and Change Engine Oil Periodically (right)

(4) Troubleshooting

1) Troubleshooting of the engine

A. Engine is not aligned properly with the milling machine	
Causes	Remedy
a) Bolts holding machine to frame and engine are loose	a) Retighten
b) Milling machine pulley not in the correct position	b) Reposition
B. The engine emits too much black Smoke	
a) Engine overloaded	a) Reduce the quantity of rice entering the machine by reducing the opening of the feed valve
b) Piston rings worn out	b) Replace
c) Air cleaner blocked by either dirt or over tightening of cover	c) Clean air cleaner and ensure that the cover is not tightened to a point where it completely closes the air passage
d) Engine main bearings worn out and seizing the crankshaft	d) Replace
e) Fuel filter stuck with dirt	e) Clean fuel filter
f) Injector nozzle worn out	f) Replace
C. Engine consumes engine oil	
a) Piston rings worn out	a) Replace
b) Sleeve worn out	b) Replace
c) Leakage	c) Detect and remedy
D. Engine does not start	
a) Air in the fuel system (Air lock)	a) Bleed the fuel system
b) Filter is dirty	b) Clean fuel filter or replace
c) Water in the fuel system	c) Change governor
d) Engine governor faulty	d) Clean injector
e) Injector clogged with carbon	e) Change rings and sleeve
f) Engine lacks compression	f) Change rings and sleeve
g) Fuel tap closed	g) Open fuel tap
E. Engine is sluggish while milling	
a) Fuel finishing in the tank	a) Replenish the tank
b) Fuel filter clogged with dirt	b) Clean fuel filter or replace
c) Water in the fuel	c) Change fuel
d) Piston rings worn out	d) Replace
e) Sleeve worn out	e) Replace
f) Fuel tap not fully opened	f) Open fully

2) Troubleshooting of rice huller

A. Roller does not discharge the rice at normal speed	
Causes	Remedy
a) Auger welded on roller worn out due to sustained use.	a) Replace
b) Cylindrical Roller burst due to wear	b) Replace
c) Belt slipping due to slackness	c) Adjust belt tension
d) Pulley spinning around the shaft due to broken key or key way	d) Replace key
e) Rice Discharge valve not appropriately opened	e) Open valve accordingly
f) Paper or plastic stuck in the neck of the hopper	f) Remove
g) Rice leaking along the protrusion of the roller shaft	g) Fit cloth/ sponge around the shaft.
B. Rice escapes from sieve	
a) Sieve burst due to stone/metal in rice	a) Screen rice before milling
b) Wear due to sustained use	b) Replace
c) Sieve not properly seated on its seat	c) Reposition the sieve
d) Wrong size of sieve fitted	d) Replace
C. Rice comes out without being milled properly	
a) Milling blade worn out	a) Replace
b) Milling blade wrongly adjusted, making gap between auger and blade too big	b) Readjust
c) Auger worn out	c) Replace
d) Discharge and feed valves not opened correctly	d) Open accordingly
e) Rice does not fully fill the milling chamber	e) Ensure the milling chamber is filled with rice before opening discharge valve
D. Too much rice broken while milling	
a) Rice too dry	a) Avoid the extreme
b) Rice too soaked/wet	b) Avoid the extreme
c) Adjustable milling blade too close to milling auger	c) Adjust the blade to have a gap of about 4 mm
E. Rice too difficult to mill	
a) Rice is rubberlike due to high moisture content, particularly for parboiled rice	a) Dry the rice properly
F. Unusual noise is heard from the milling chamber during milling	
a) A piece of metal or stone is in the milling chamber	a) Remove the foreign matter
b) Milling auger too close to the milling blade which makes the two to rub and cause noise	b) Readjust the milling blade
c) Rice sieves not properly sited	c) Reposition the sieves
d) Milling machine bearings worn out	d) Replace the bearings

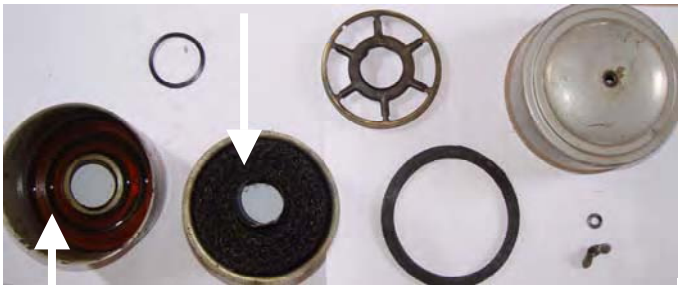
3) Items to be repaired by the operators

The following maintenance may be performed by the operators after the diagnosis

a) Cleaning of air filter
b) Bleeding the fuel system
c) Cleaning of oil filter
d) Replacement or readjustment of milling blade

a) Cleaning of air filter

Wash filter with kerosene and dampen the filter with used oil.



Proper quantity of oil is poured into the container.

Bottom ←----------→ Top

Photo 3.3-8 Parts Arrangement of the Air Filter

b) Bleeding the fuel system

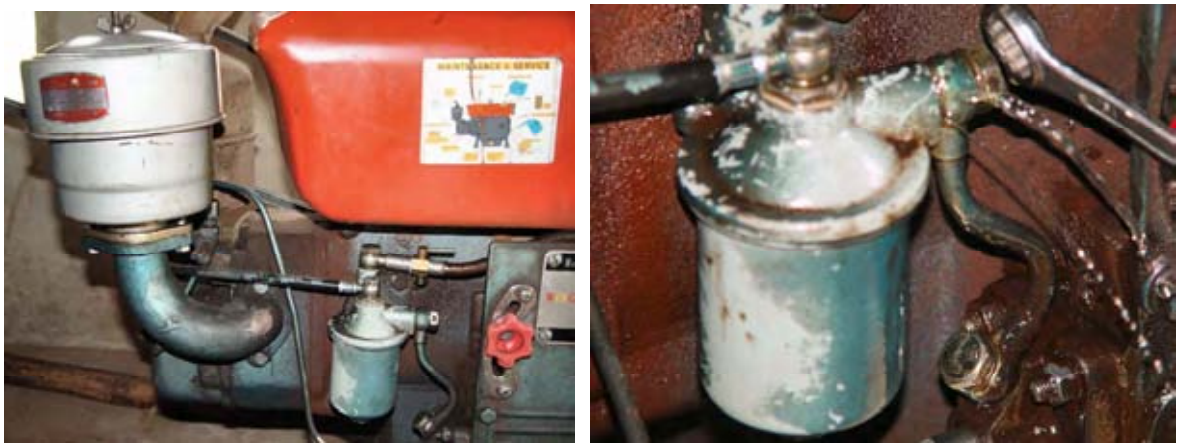


Photo 3.3-9 Bleed the Fuel System (left) and Fuel Overflow (right)

Note: Loosens nuts (inside white frame) and overflow fuel for a little (Diesel), then tighten the nuts.

c) Cleaning of oil filter

Clean air cleaner

Bottom ←----------→ Top

Photo 3.3-10 Parts Arrangement of the Oil Cleaner

d) Replacement or readjustment of milling blade

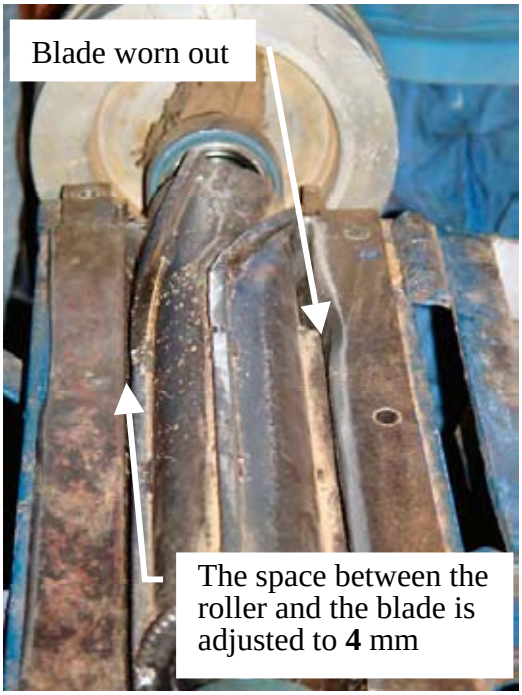


Photo 3.3-11 Roller and Blade

Contact Address for Repair and Maintenance:

Consult the manufacturer (FINIC) and MAFFS-K to repair the machine in cases other than the problems mentioned above, after performing diagnosis by troubleshooting.

a. Spare parts: FINIC: No. 3F Baibureh Road, Ferry Junction, Freetown, 076-601-956

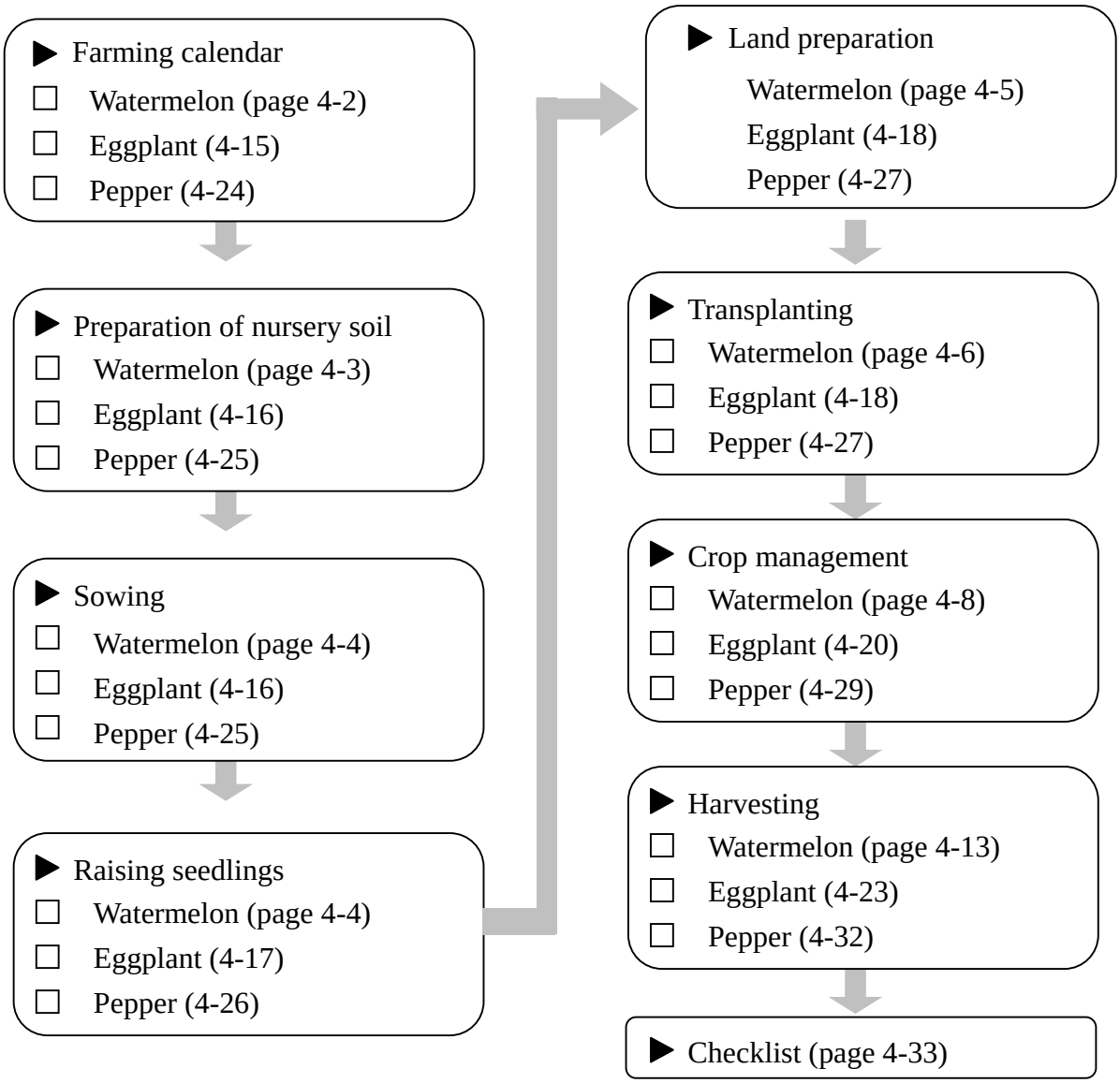
b. Engine trouble: MAFFS-K Tel: 076-882-076

Chapter 4 Vegetable Cultivation Manual

Chapter 4 Vegetable Cultivation Manual

4.1 Instructions for use

This vegetable cultivation manual is an extension material mainly used by the FEWs to give technical guidance directly to women's groups who are mainly engaged in vegetable cultivation in lowland areas during the dry season. It focuses on 3 vegetables: watermelon, eggplant, and pepper, although the basic techniques presented here can be applied to other vegetables as well. This manual contains a substantial amount of illustrations and pictures to help farmers understand visually. At the end, a checklist is presented to make sure farmers are following the correct procedures.



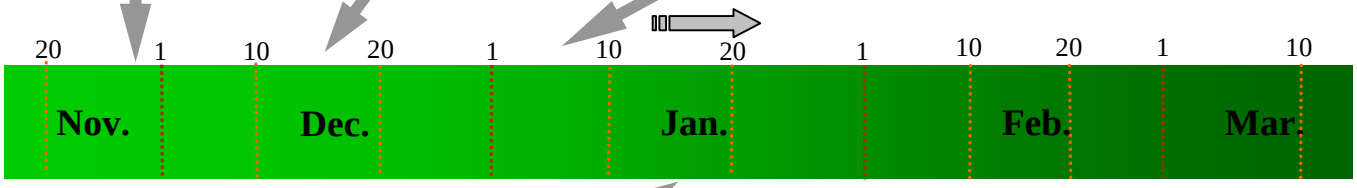
4.2 Watermelon

Farming Calendar

Sowing to pot

Transplanting

Top Dressing



Thinning out

Disease and insect control

Harvest

1. Preparation of nursery soil

a) Sieve and mix fertilizer

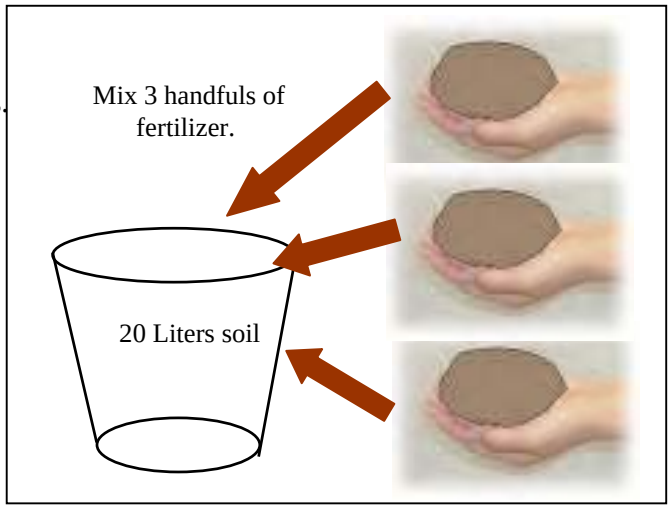
Find a sunny and flat place for putting nursing pots.

Sieve topsoil and a little organic manure with a fishing net or screen net.

Mix a certain amount of fertilizer in the soil.

Example for nursing 100 pots

fertilizer type: NPK 15-15-15, quantity of soil: 20L (1 bucket) → put 200g (3 handfuls or 3 tomato tins) of fertilizer.



b) Prepare plastic cups

Prepare 100 plastic cups and make 3 holes at the bottom of each to drain water. Use a heated nail head.

c) Plug up with soil

Till to a depth of 15 cm and mix well.

Plug up the cups with soil and place them uniformly. Water plentifully and wait until water is drained.

2. Sowing

a) Sow

Prepare 100 seeds and sow 1 seed per 1 cup. Softly poke soil with the fingers and put in a seed.

Cover with 1 mm soil to hide seed.

b) Cover

After watering gently, thinly cover soil with palm leaves for promoting germination and preventing dryness.

3. Raising seedlings

a) Remove

Remove palm leaves from cups when seed leaves appear. Watering is preferably done every morning.

b) Control insects and disease

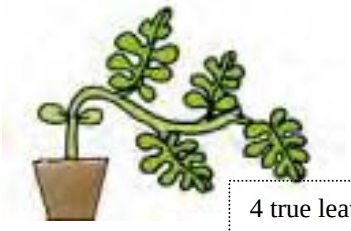
To protect from pests and disease, spray furadan, endosulfan malathion or cyflane diluted 2000-3000 times. Use a sprayer, or a broom made from rice straw.

If not applicable, put rice bran surrounding the cups or spray neem extract liquid to plants.

c) Optimal time

Check for optimal time to transplant.

Optimal time is when 3-4 true leaves appear, about 14-21days from sowing date.



4 true leaves

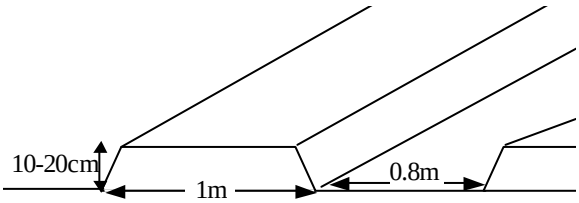
4. Land preparation

a) Make ridge

Till soil to a depth of 20 cm from surface and use a hoe to make a ridge of a height of 10-20 cm and a width of 1 m (about 2 steps). Open a space between ridges about 0.8 m (wide enough to walk).

<u>Example for transplanting 70 plants</u>

Prepare a plot of 20m*10m (66*33 feet).



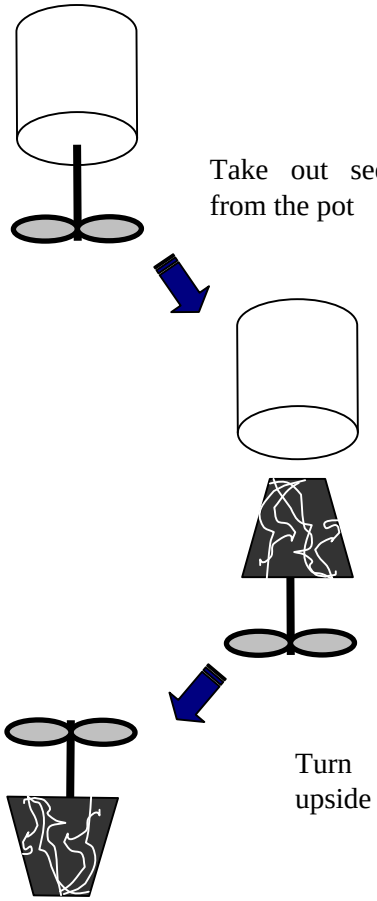
5. Transplanting

a) Water

Before transplanting, harden seedlings 2-3 days by reducing watering. However, water substantially just before transplanting.

b) Uproot

Transplanting should be done in early morning or evening hours. Take out seedlings carefully with soil block by turning the pot upside down.

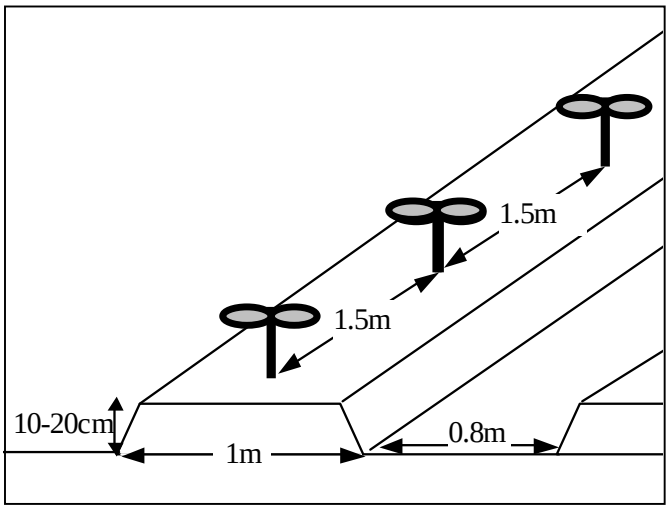


Take out seedling from the pot

Turn the pot upside down.

c) Planting system

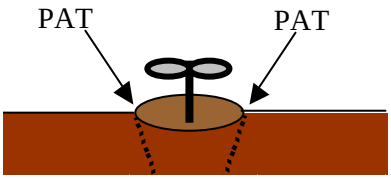
Plant in 1 row. Set intrarow space to 1.5 m (about 3 steps).



d) Transplanting

Dig planting hole and put seedling with soil block in the hole.

Softly pat the adjacent area of soil and root ball by hand.



e) Fertilizer application

Apply fertilizer around the plants 3-5 days after transplanting. Apply 1 handful or 1 tomato tin per 1 plant. Then cover with the nearby soil.

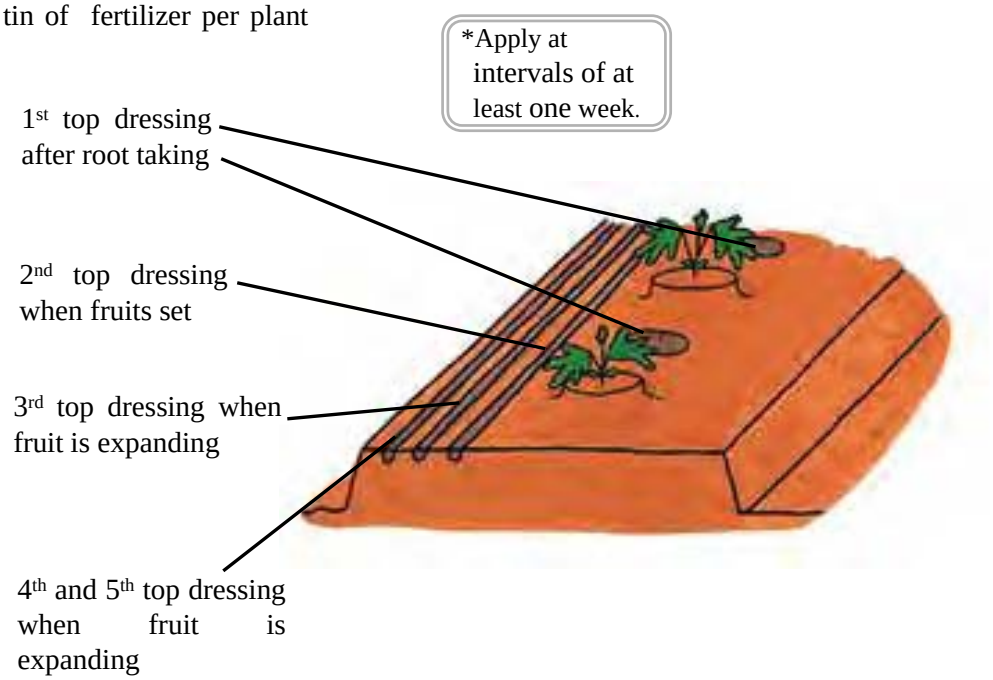
6. Crop management

a) Mulch with rice straw

Cover soil with rice straw to retain water and to prevent weed growth. Water sufficiently every day.

b) How to top dress

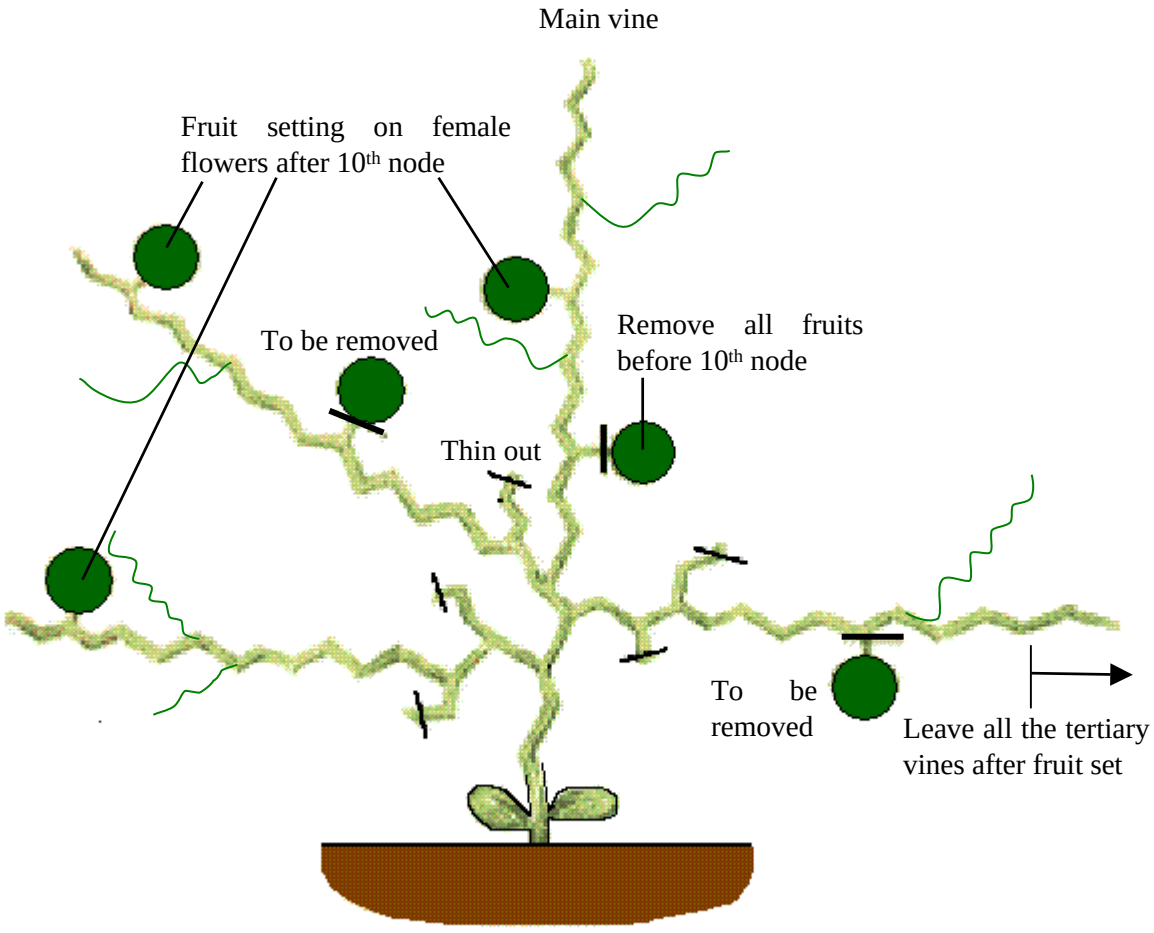
Top dress beyond the tip of vine. Apply 1 handful or 1 tomato tin of fertilizer per plant and cover soil.



c) How to thin out

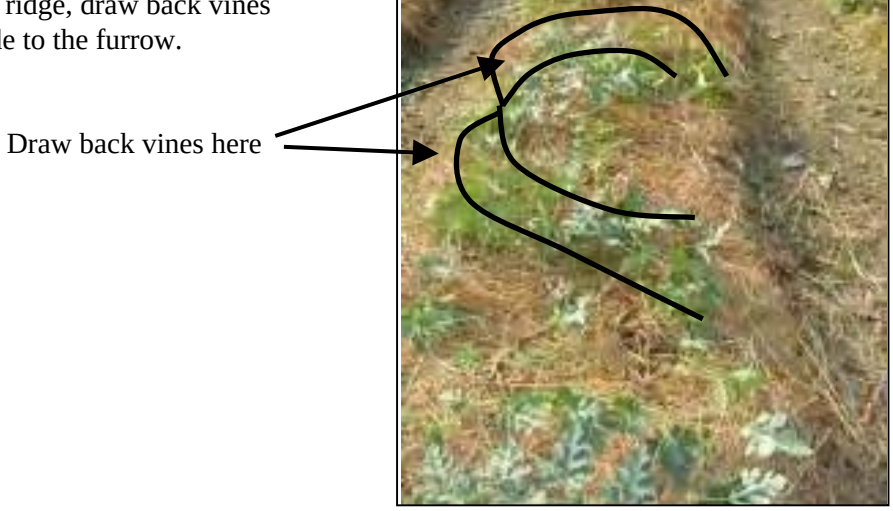
Select the best 4 vigorous vines, including 1 main vine and 3 secondary vines. Thin off all tertiary vines below the 10th node.

Remove all female flowers or fruits before the 10th node. Set fruits after 10th node on each vine. Total number of fruits on each plant should be limited to only 2 or 3.



e) How to train vines

Train vines to the same direction. When vines extend to the edge of the ridge, draw back vines so that they do not intrude to the furrow.



f) How to control disease and insects

To protect from disease and insects, brush neem water to back and surface of leaves or to fruits once a week. Neem powder is preferably applied during the rainy season.

If uncontrollable, brush furadan, endosulfan malathion, or cyflane to surface of fruits after diluting to 2000-3000 times.

How to make neem pesticide

Seed Extract (3 Liters)

i) Prepare 3 butter cups of dried neem seeds and remove pulp and husk.*
ii) Grind kernel into powder (neem powder**).
iii) Add 2 big bottles of lukewarm water into the paste.
iv) Keep in the shade more than 24 hours.
v) Filtrate extract to fine cloth.
vi) Add small amount of mashed soap as dispersing agent.
vii) Spray or brush to plants once a week during evening hours.

Neem seeds

* Ground pulp and husk are useful for sprinkling over plants.

** Neem powder is also suitable for sprinkling over plants.

Neem powder

Seed extract is more effective than leaf extract because seed contains high active element.

Leaf Extract (3Liters)

i) Prepare 1.5 kg of dried neem leaves and 0.5 kg of dried pepper (10-17 fruits).
ii) Add 3 Liters water.
iii) Follow the same process as for seed extract.

Neem leaves

g) How to pollinate

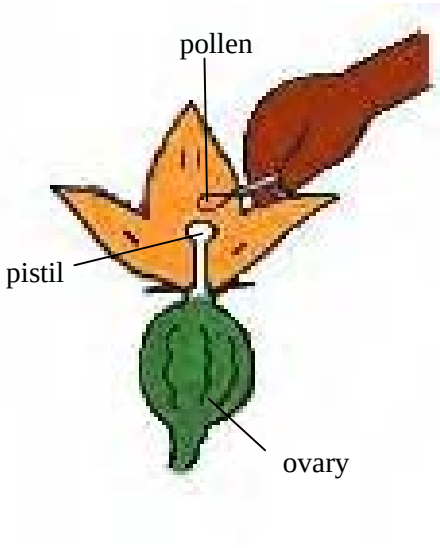
Pollinate by hand if rain falls intermittently.

Evenly rub pollen of stamen flowered on the day to tip of pistil flowered on the day.

Pollination probability is high when done in early morning.

Stamen (left) and pistil (right)

Be careful not to injure hair of fruit surface.



Rubbing pollen to pistil

h) Fruit turning

When watermelon has grown to the size of a fist, turn yellow side upward to achieve uniform coloring.

Disease and insects

Disease and insects should be controlled thoroughly in the nursery to avoid wide propagation to the field.

However, melonfly attack and water-soaked fruit are difficult to avoid, especially during the rainy season. Early countermeasure by chemicals or organic pesticide is recommended.

Fruit damaged by melonfly

Fruit damaged by water soaking

7. Harvesting

a) How to harvest

Harvest by knife when the fruits have matured.

Harvest 40 to 45 days after flowering or 10 to 14 days after disappearance of stripes on the fruit surface.

Stripe is recognizable

Indication of harvest

1. Fruit color is dark green for 10 to 14 days.

2. Fruit is about the size of a human head.

3. Knocking produces a deep sound.

4. Tendrils wither and become brownish

b) How to produce and preserve seeds

Keep seeds after eating the fruits. Wash well and eliminate runny liquid. Preserve only seeds that sink in water.

Preserve seeds in sealed paper bag in a cool place.

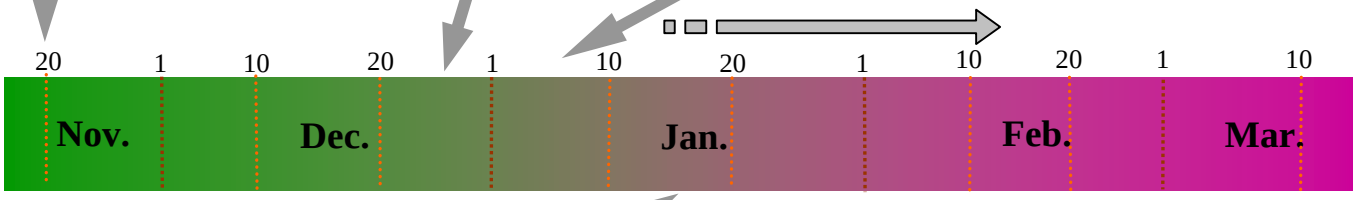
4.3 Eggplant

Farming Calendar

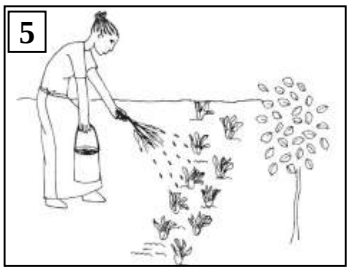
Sowing to nursery

Transplanting

Top Dressing



Thinning out



Disease and insect control

Harvest

1. Preparation of nursery soil

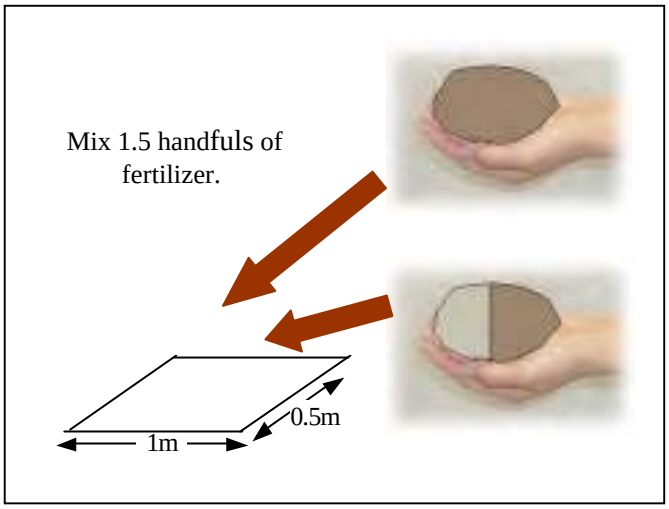
a) Mix fertilizer

Find a sunny and flat place for nursery.

Mix a certain amount of fertilizer in nursery soil.

Example for cultivating 200 plants

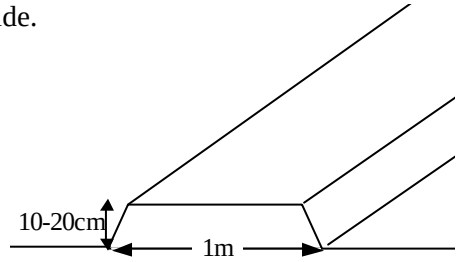
fertilizer type: NPK 15-15-15, nursery area: 1m * 0.5m (3.3* 1.6 feet) → put 100g (1.5 handfuls or 1.5 tomato tins) of fertilizer.



b) Make bed

Till soil to a depth of 15 cm.Water plentifully and wait for 1 day.

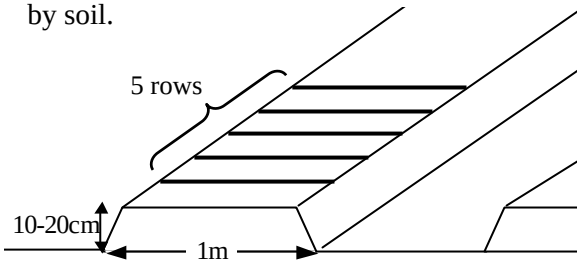
Use a hoe to make a flat bed for nursery about 10 – 20 cm high and 100 cm (about 2 steps) wide.



2. Sowing

a) Sow

Prepare 8 cc (half a spoon) of seeds. Sow seeds by stripe of 6 cm intervals with 5 planting rows. It should be done in early evening.
Cover with 0.5 cm of soil, slightly hidden by soil.



b) Cover

After watering gently, thinly cover soil with palm leaves for promoting germination and preventing dryness.

3. Raising seedlings

a) Remove

Remove the leaves from soil when seed leaves appear. Watering is preferably done every morning.

b) Control insects and disease

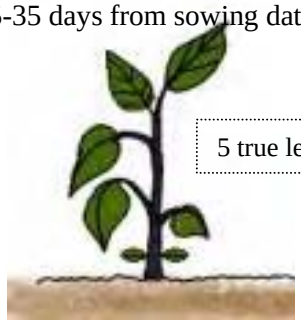
To protect from insects and disease, spray endosulfan, malathion, or cyflane diluted to 2000-3000 times. Use sprayer, or broom made from rice straw.

If not applicable, put rice bran in interrow space or spray neem extract liquid to plants.

c) Optimal time

Check optimal time to transplant.

Optimal time is when 4-5 true leaves appear, about 25-35 days from sowing date.



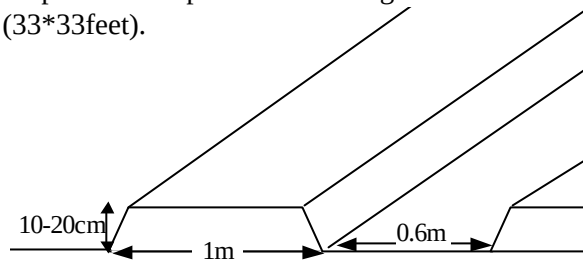
4. Land preparation

a) Make ridges

Till soil to a depth of 20 cm from the surface, and use a hoe to make a ridge having a height of 10-20 cm and a width of 1m (about 2 steps). Open a space of a about 0.6m between ridges.

Example for transplanting 200 plants

Prepare a plot measuring 10m*10m (33*33feet).



5. Transplanting

a) Cut interrow space

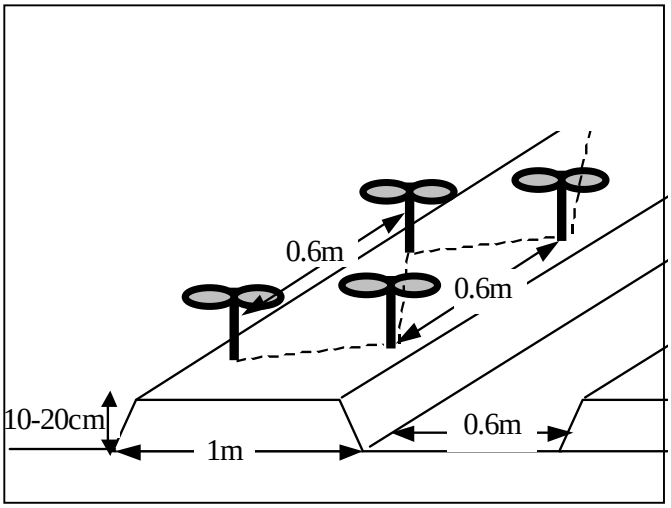
Cut interrow space by knife every two days starting a week before transplanting, to stimulate new root growth.

b) Uproot

After watering substantially, soften surrounding soil by shovel to facilitate uprooting. Then, uproot from the bottom of the root by hand. Be careful not to injure roots.

c) Planting system

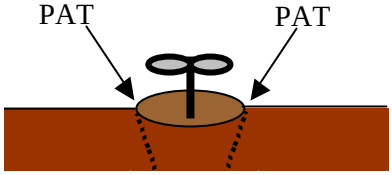
Plant in staggered row. Set intrarow spacing to 0.6m (about one stride)



d) Transplanting

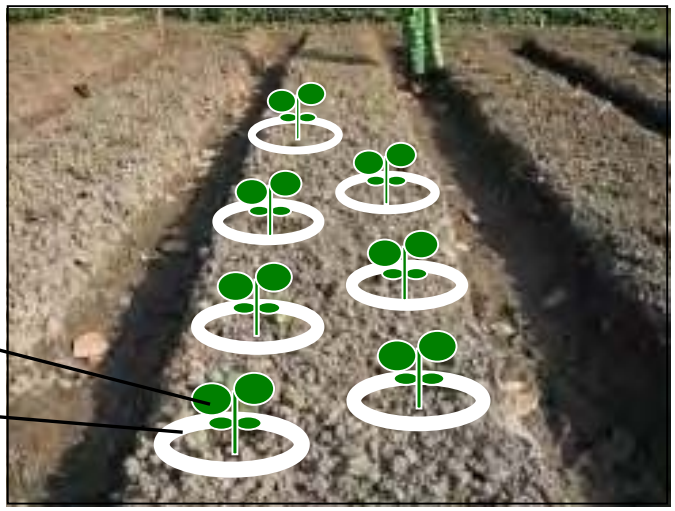
Dig planting hole and put seedling in the hole.

Softly pat the adjacent area of soil and root ball by hand.



e) Fertilizer application

Apply fertilizer around the plants 7-10 days after transplanting. Apply 1 handful or 1 tomato tin per plant. Then cover with the surrounding soil.



6. Crop management

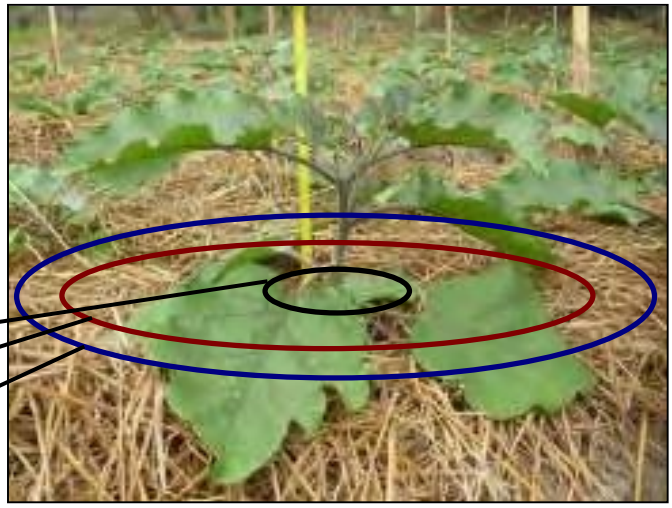
a) Mulch with rice straw

Cover soil with rice straw to retain water and to prevent weed growth. Water sufficiently every day.

b) How to top dress

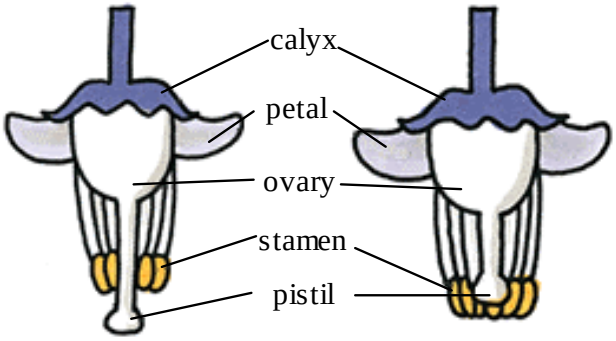
Top dress around or between plants every 2 weeks after first fruit set. Apply 1 handful or 1tomato tin of fertilizer per plant and cover soil.

Apply to a different spot each time.



Method of nutrient diagnosis

Refer to diagnosis when top dressing.



○ **Good!**

Pistil is longer than stamen.

= enough nutrients

⇩

No need to top dress immediately.

× **Bad**

Pistil is shorter than stamen.

= lack of nutrients

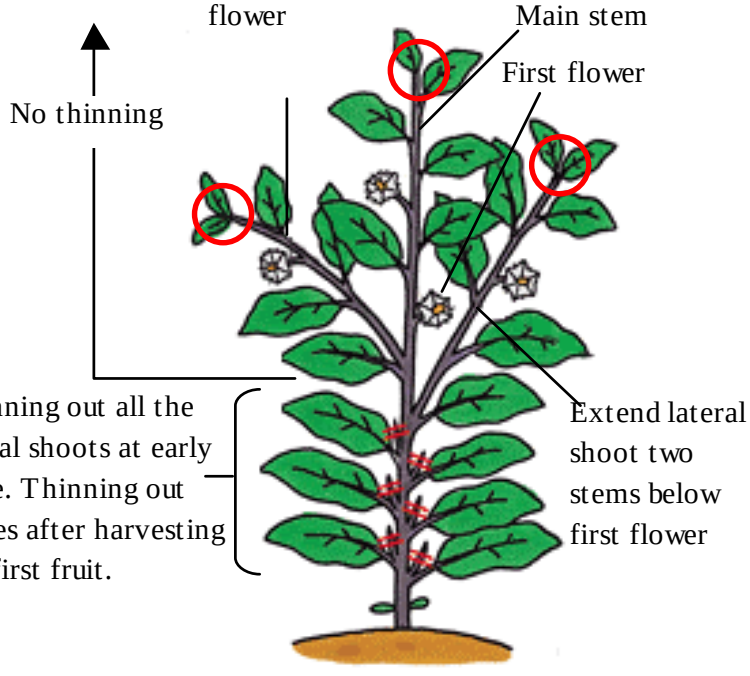
⇩

Top dress immediately.

c) How to thin out

Thin out stems except main stem and 2 of the vigorous lateral shoots.

This activity encourages growth and increases fruit set ratio.



d) How to control disease and insects

To protect from disease and insects, spray or brush neem water to back and surface of leaves once a week. Neem powder is preferable during the rainy season.

If uncontrollable, spray endosulfan, malathion or cyflane diluted to 2000-3000 times.

Ladybug feeding on fruits and leaves

Disease and insects

Disease and insects should be controlled thoroughly in the nursery to avoid wide propagation to the field. However, little damage occurs after transplanting.

Refer to 4.2 Watermelon for method of making neem pesticide.

Grasshopper feeding on leaves

Aphids on the back of a leaf

7. Harvesting

a) How to harvest

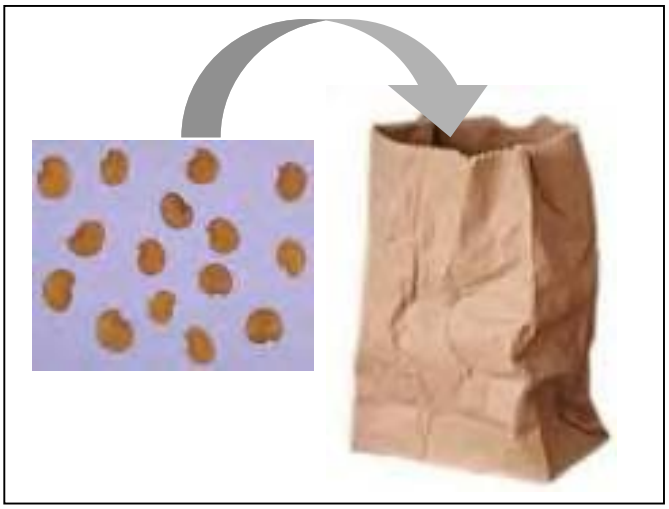
Harvest by knife when the fruits have matured. Removal of first fruit at small size is recommended, to maintain plant vigor.

b) How to produce and preserve seeds

Produce seeds from overripe fruits. Wash well and preserve only seeds that sink in water.

If the plants are of many varieties, preserve seeds by variety.

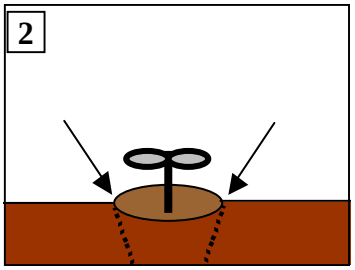
Preserve seeds in sealed paper bag in a cool place.



4.4 Pepper

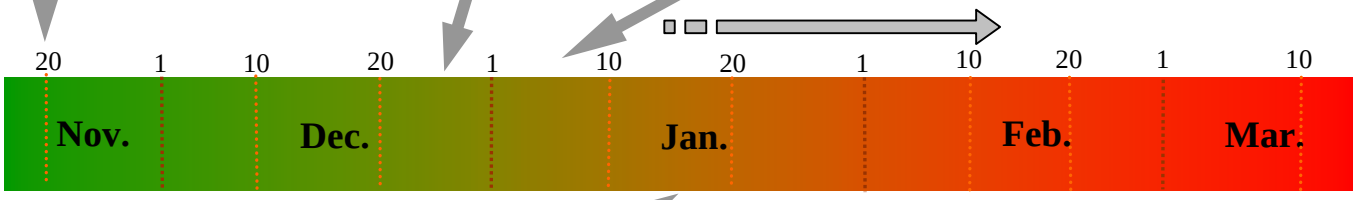
Farming Calendar

Sowing to nursery

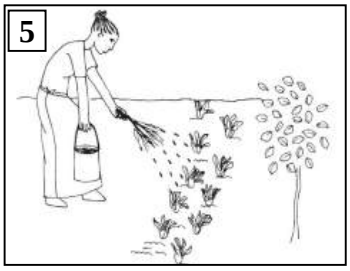


Transplanting

Top Dressing



Thinning out



Disease and insect control

Harvest

1. Preparation of nursery soil

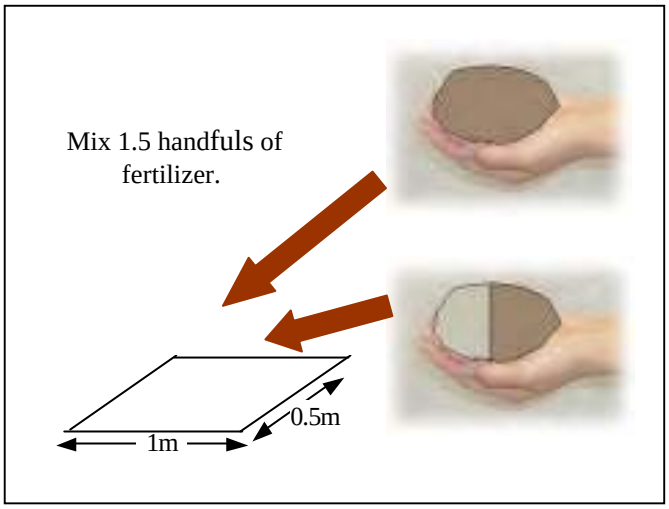
a) Mix fertilizer

Find a sunny and flat place for nursery.

Mix a certain amount of fertilizer in nursery soil.

Example for cultivating 280 plants

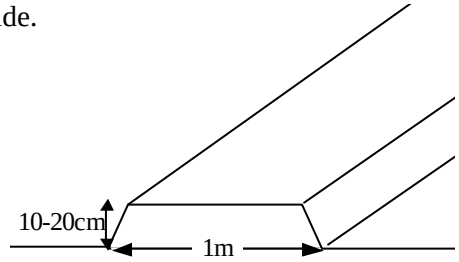
fertilizer type: NPK 15-15-15, nursery area: 1m * 0.5m (3.3*1.6 feet) → put 100g (1.5 handfuls or 1.5 tomato tin) of fertilizer.



b) Make bed

Till soil to a depth of 15cm. Water plentifully and wait for 1 day.

Use a hoe to make a flat bed for nursery about 10 – 20cm high and 100cm (about 2 steps) wide.

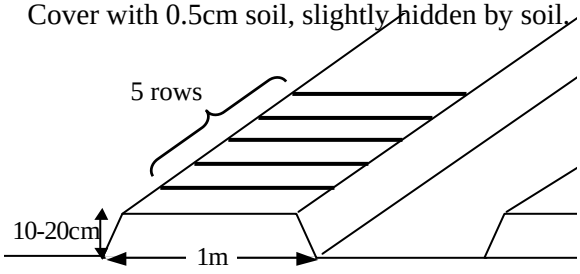


2. Sowing

a) sow

Prepare 8 cc (half a spoon) of seeds. Sow seeds in stripes of 6 cm intervals with 5 planting rows. It should be done in early evening.

Cover with 0.5cm soil, slightly hidden by soil.



b) Cover

After watering gently, thinly cover soil with palm leaves for promoting germination and preventing dryness.

3. Raising seedlings

a) Remove

Remove the leaves from soil when seed leaves appear. Watering is preferably done every morning.

b) Control insects and disease

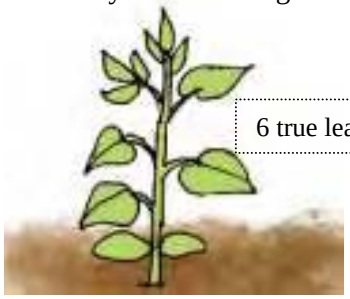
To protect from insects and disease, spray endosulfan, malathion, or cyflane diluted to 2000-3000 times. Use sprayer, or broom made from rice straw.

If not applicable, put rice bran in interrow space or spray neem extract liquid to plants.

c) Optimal time

Check optimal time to transplant.

Optimal time is when 6-7 true leaves appear, or about 25-35 days from sowing date.

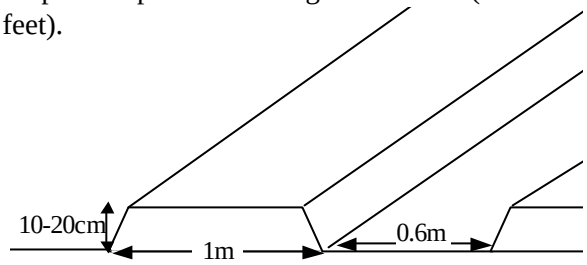


4. Land preparation

a) Make ridge

Till soil to a depth of 20 cm from surface, and use a hoe to make a ridge having a height of 10-20 cm and a width of 1m (about 2 steps). Open a space of about 0.6m between ridges.

<u>Example for transplanting 280 plants</u>
Prepare a plot measuring 10m*10m (33*33 feet).



5. Transplanting

a) Cut interrow space

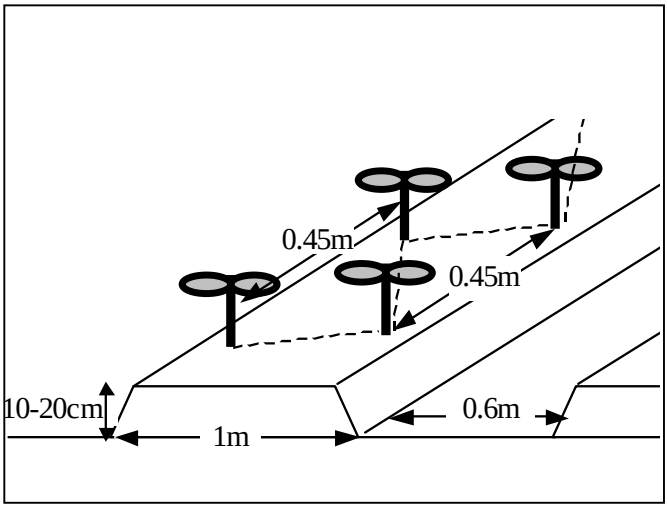
Cut interrow space by knife every two days starting a week before transplanting, to stimulate new root growth.

b) Uproot

After water substantially, soften surrounding soil by shovel to facilitate uprooting. Then, uproot from the bottom of the root by hand. Be careful not to injure roots.

c) Planting system

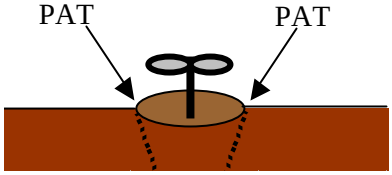
Plant in staggered row. Set intrarow spacing to 45 cm (about one step).



d) Transplanting

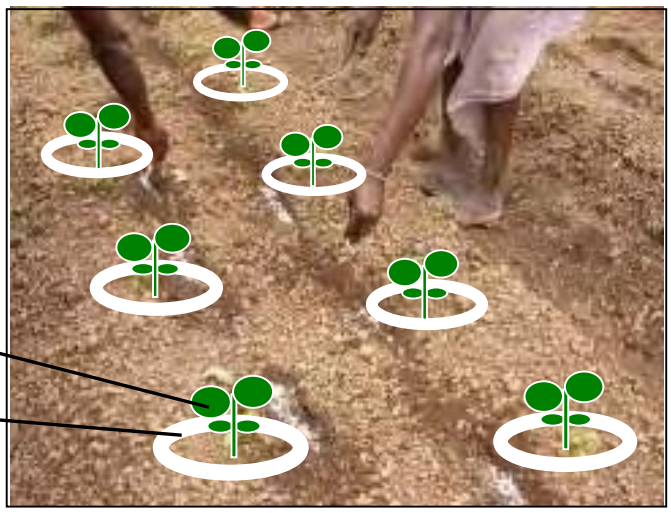
Dig planting hole and put seedling in the hole.

Softly pat the adjacent area of soil and root ball by hand.



e) Fertilizer application

Apply fertilizer around the plants 7-10 days after transplanting. Apply 1 handful or 1 tomato tin per plant. Then cover with surrounding soil.



6. Crop management

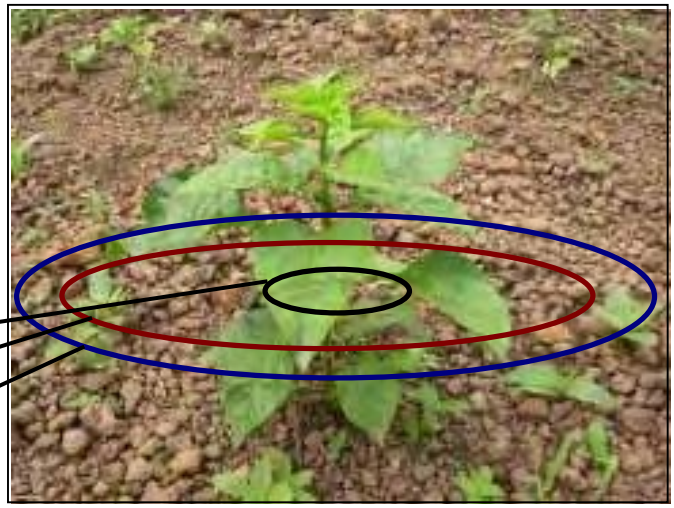
a) Mulch with rice straw

Cover soil with rice straw to retain water and to prevent weed growth. Water sufficiently every day.

b) How to top dress

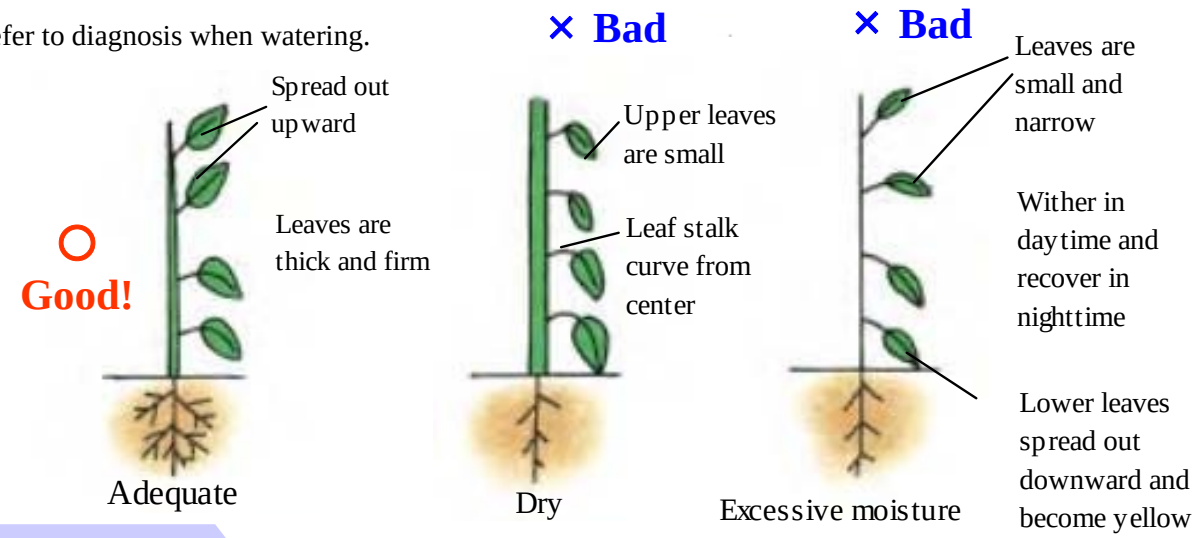
Top dress around or between plants every 2 weeks after first fruit set. Apply 1 handful or 1tomato tin of fertilizer per plant and cover with soil.

Apply to a different spot each time.



Method of soil moisture diagnosis

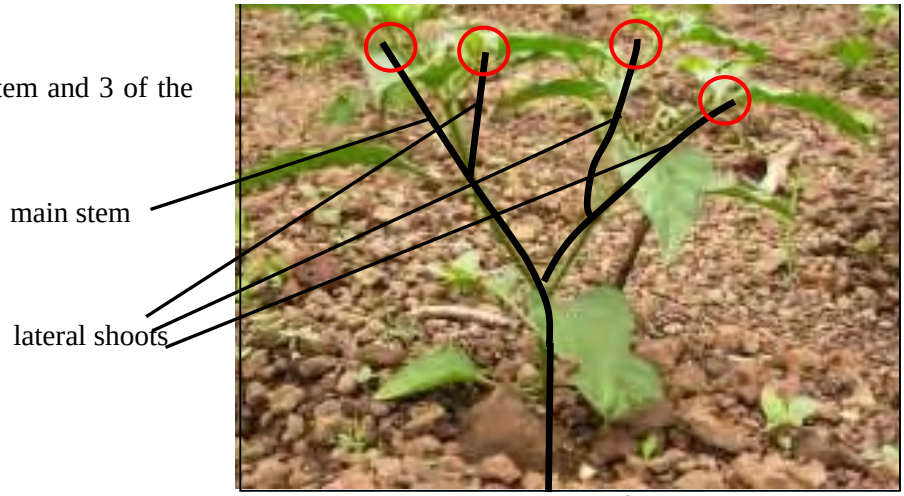
Refer to diagnosis when watering.

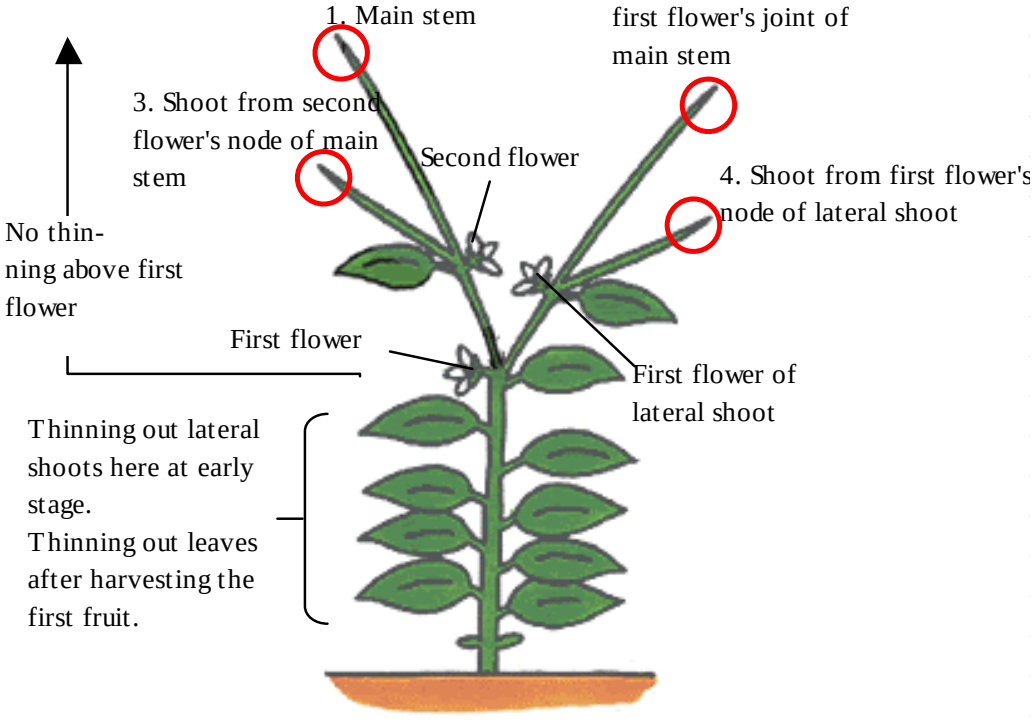


c) How to thin out

Thin out stems except main stem and 3 of the vigorous lateral shoots.

This activity encourages growth and increases fruit set ratio.





d) How to control disease and insects

To protect from disease and insects, spray or brush neem water to back and surface of leaves once a week. Applying neem powder is preferable during the rainy season.

If uncontrollable, spray endosulfan, malathion or cyflane diluted to 2000-3000 times.

Aphids on the back of the leaves

Disease and insects

Disease and insects should be controlled thoroughly in the nursery to avoid wide propagation to the field.

However, tobacco mosaic virus is a serious issue in pepper cultivation. Eradicating aphids by chemicals or neem is the practical measure to control virus infection.

Refer to 4.2 Watermelon for method of making neem pesticide.

Leaves infected by Tobacco mosaic virus

Close-up of leaves infected by virus

7. Harvesting

a) How to harvest

Harvest by hand when the fruits have matured.

b) How to produce and preserve seeds

Produce seeds from overripe fruits. Wash well and preserve only seeds that sink in water.

If the plants are of many varieties, preserve seeds by variety.

Preserve seeds in sealed paper bag in a cool place.

4.5 Checklist

Check each box below if materials are prepared or if the point is followed, e.g., ☑.

<Material to prepare before starting>

Watermelon, eggplant, and pepper	Importance	Purpose
☐ Seeds	◎	For sowing
☐ Organic manure	△	To mix with soil
☐ Fertilizer	◎	For fertilizer application
☐ Insecticide	◎	For protecting from disease and insects
☐ Neem seed or leaves	○	For protecting from disease and insects
☐ Palm leaves	◎	To cover until germination
☐ Rice straw	○	For mulching
☐ Hoe	○	For making ridges
☐ Shovel	○	For making ridges, digging seedlings
☐ Watering can	◎	For watering plants
☐ Headpan	○	For carrying materials
☐ Spoon	△	For measuring seeds and insecticide
☐ Sprayer or broom	○	For applying neem and insecticide
☐ Measuring tape	△	For measuring land
☐ Scale	△	For weighing fertilizer
Watermelon only		
☐ Plastic cup	◎	For raising seedlings
☐ Bucket	○	For making nursery soil
☐ Fishing net or screen net	○	For sieving nursery soil
☐ Fire source (candle)	○	For making holes in plastic cup
☐ Brush	○	For applying insecticide to fruit
Eggplant and pepper only		
☐ Knife	○	To cut interrow space before transplanting

◎: Most important, ○: Important, △: Less important

<Points to be checked before starting>

☐ Secure sunny and flat place of sufficient size for raising seedlings and transplanting.

☐ Secure water source near nursery and transplanting field.

☐ Be sure to secure fence if any animals disturb the nursery or transplanting field.

☐ Be sure to prepare the materials above.

<Points to be checked from sowing to raising seedling>

☐ Check if fertilizer is mixed uniformly.

☐ Check for germination every day to remove palm leaves immediately after germinating.

☐ Check back of seedling leaves carefully for any insect damage.

→ If insects are found, apply chemical to eradicate.

☐ Check for any symptoms of disease.

→ If any disease is found, apply chemical to eradicate.

<Points to be checked from transplanting to harvesting>

☐ Be sure not to transplant young or aged seedlings.

☐ Be sure to handle with care so as not to damage roots of seedling.

☐ Be aware of dryness. Prevent by watering and mulching.

☐ Do not top dress at once. Be sure to apply frequently in small amounts.

☐ Be sure to thin out carefully and properly for obtaining high yield.

☐ Be sure to protect from disease and insects constantly.

☐ Check for disease and insects at all times.

☐ For watermelon, check the presence of bees or butterflies to determine need for hand pollination.

☐ For watermelon, check optimal harvest time carefully.