Extension Guidelines
for
Livelihood Improvement of Villagers
in
Central Highland Areas

For Extension Staff

September 2008

Project on the Villager Support for Sustainable Forest Management in Central Highland

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Introduction

The Project on the Villager Support for Sustainable Forest Management in Central Highland (hereinafter referred to as "the Project") has been implemented for three years and three months from June 2005 under auspices of Japan International Cooperation Agency (JICA). In order to achieve the project purpose, "Agriculture, forestry, animal husbandry and agroforestry activities are improved in model villages.", the Project implemented the Livelihood Improvement Plan that is mainly intended for villagers of the model villages and the Capacity Building Plan that is intended for administrative personnel as its core components. During the implementation period, the Project carried out various activities under this framework. The Extension Guidelines have been prepared, compiling the outcomes of these activities the Project carried out and what the Project learned through experience of implementing of the Project.

The Extension Guidelines consist of "I. Technical Section" and "II. Management Section". The Technical Section is further divided into 4 parts: A. Crop Production; B. Tree Planning; C. Animal Husbandry; D. Other Activities. Technical Section of the guidelines can be used by administrative personnel as well as villagers. For the administrative personnel, the technical section can be used as guidance while he or she assists villagers solve technical problems of farming activities. The technical section also includes "Additional Information for Extension Staff" for some activities, which describes points for the extension staff to take into consideration while assisting villagers practice the activities. For the villagers, it can be used as technical guidance while the villagers practice the farming activities and/or the villagers consider taking up new activities. It can also be used as trouble shooting to technical problems and/or difficulties that the villagers have to cope with in course of practicing the activities. In principle, the technical section was prepared based on the contents of the technical trainings including handouts of the trainings, which were provided by the Project, and more information collected from reference books listed at the end of each chapter. In addition, the Project included as many illustrations and/or photographs as possible so that the users of the guidelines can understand the contents easily.

Management Section of the guidelines is solely intended for the administrative personnel that include officers of the district and province levels as well as extension staff of the commune level. The Management Section of the guidelines can be used as guidance on how to prepare and implement livelihood improvement plans and how to facilitate villagers to be involved in these processes. It can also be used for extending the activities practiced by the JICA Project to other areas. The Project hopes the users find the guidelines useful to apply for livelihood improvement activities and the Vietnamese side (the governmental sector in particular) concerned to the Project will also contribute its experiences of implementing the livelihood improvement activities to making revisions to the guidelines on its own.

I. Technical Section

A. Technical Guidelines on Crop Production Activities

A-1 Technical Guideline on Vegetable Home Gardening

1. Basic skills

(1) Applying lime

Most vegetables do not like acid soil but like the soil close to neutral acidity (pH 6-7) *. In some places in Kon Tum province, soil is acid. If your place is acid soil, you should apply lime before sowing or transplanting to have better growth. Lime also work to kill some fungus in the soil. You should remember that:

- Normal application is 50 – 100g (one handful) per $1m^2$, and you do apply lime at least about 1 week before sowing/planting.
- You do not over-use lime. If you use too much lime at once, important elements in the soil such as Mg and Fe are not absorbed (used) by vegetables.

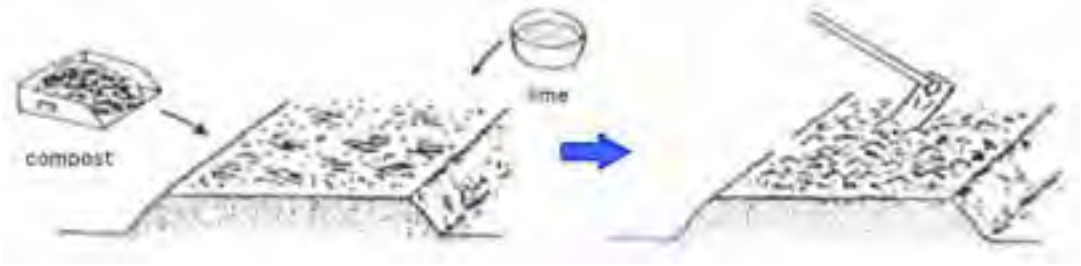
(2) Applying compost as basal fertilizer

Along with applying lime, you apply compost (or decomposed cattle dung) before sowing/planting vegetables. There are three ways of application: a) Apply to surface of bed; whole area, b) Apply to surface of bed; in rows and c) Apply to deep layer. You select one of 3 ways depending on the kind of vegetable.

a) Apply to surface of bed; whole area:

Spread compost and lime over the surface of bed, and mix them into soil to have even distribution in the bed.

- For leafy vegetables such as Pak-choi, Water spinach, Leaf mustard, Garland, Cabbage, etc.



Spread compost and lime Mix them with soil and make a bed

b) Apply to surface of bed; in rows:

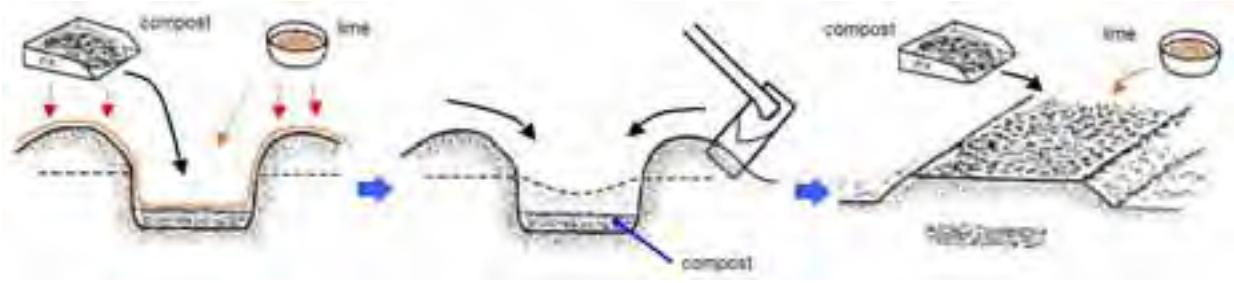
Make shallow trench in the bed, and apply compost and lime in the trench.

- For Cucumber, Beans, Egg plant, etc.

c) Apply to deep layer:

Make trench (or hole) with depth 20-30cm. Apply the compost and lime in the trench (or hole) and make bed above the trench. Apply some more compost and lime over the bed and mix them into soil.

- For fruit vegetables which have long cultivating period such as Egg plant, Tomato, Green pepper, etc.



Apply the compost and lime in the trench (or hole)

Make a bed above the trench/hole

Spread compost and lime, mix them with soil

(3) Bed making

You make a planting bed of 1.2 m wide and 15 cm high. This size (width) of bed can be used to grow different kind of vegetable continuously in the same bed.

Each time when you make a bed, firstly you pull out weeds, turn up the soil and then dry the soil under the sunlight for 7-10 days to kill pests and roots of weed.

(4) Applying additional fertilizer (topdressing)

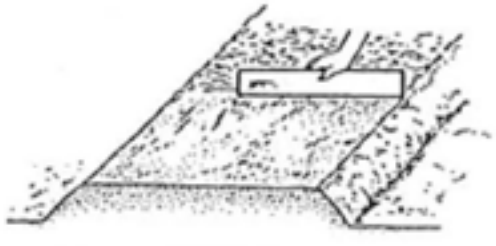
You have to give additional nutrients (fertilizer or compost) as vegetables grow to have a good harvest. In general, 1st-time of application is 1 to 2 weeks after the transplanting or germinating. 2nd-time of application is 15 to 20 days after the 1st application. Apply repeatedly afterwards at interval of every 15-20 days.

Apply fertilizer near the plants in the 1st-time, and apply at a bit outside in the 2nd-time. Move to outside a bit by bit afterwards. At each time when you apply the fertilizer, till the surface of soil between plants and do earthing-up (adding some soil on the bed / around the plants).

Urea fertilizer is often used for topdressing. You can use finely crashed dried cattle dung instead of urea.

(5) Seeding

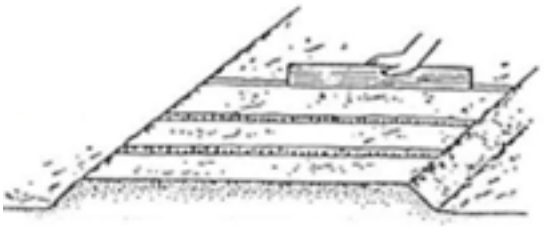
There are three seeding methods: a) spot seeding, b) stripe seeding and c) broadcast seeding. Smoothen the surface of bed with a piece of board before sowing, especially when you do the broadcast seeding.



Smoothen the surface of bed with a piece of board before sowing

a) Spot seeding	:	Sow 2 to 5 seeds at each spot (Beans, Cabbage/Chinese cabbage which forms a ball)
b) Stripe seeding	:	Sow seeds in lines or in narrow band (Water spinach, Ceylon spinach, etc.)
c) Broadcast seeding	:	Sow seeds all over the bed (Pak-choi, other leafy vegetables)

Spot seeding: Use a empty can or bottle for



Stripe seeding: Make shallow trenches with a piece of board or stick

(6) Covering the seeds with soil

Seeds should be covered with soil after sowing; usual thickness is 3 to 5 times of seed size. If soil is heavy clay soil, make the covering a little less.

Cover with soil of 3 - 5 times thickness of seeds size

After covering seeds with soil, you have to depress the soil lightly with your hands. In case of broadcasting, you can use a wood plate to depress. After depressing, mulch and water.

(7) Watering

Vegetables absorb water and soluble nutrients from roots to grow. After seeding and transplanting the seedlings, you have to give water. Under the hot climate, watering is done in the early evening, since it can cool down the soil temperature.

(8) Mulching

Watering and rain splash the soil (dirt) and it makes the lower leaves of vegetables dirty with dirt, and then risk of disease infection increases. Mulching prevent the splash of dirt by watering/rain, also it can keep the moisture in the soil.

(9) Fencing around the garden

Make a fence all around your garden with available materials to protect vegetables from domestic animals and poultry.


2. How to grow leafy vegetables

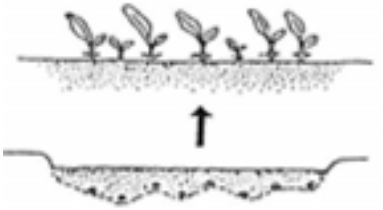
(1) Pak-choi (Cai ngot)

Land preparation

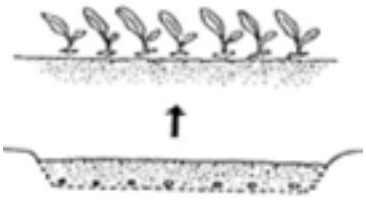
- Weed and take away the grasses from the field. Turn up the soil and dry the soil under the sunlight for 7-10 days to kill pests and roots of weed.
- Make a mounding and spread compost (or decomposed animal dung) and lime powder (50-100g per $1m^2$) over it. Mix compost and lime into soil, and make a bed (about 1.2 m wide, 15 cm high). Sow seeds after 5-7 days.


Sowing seeds

- Make surface of the bed smooth and flat with a rake and a piece of board. Size of leafy vegetable seeds is very small, so that the soil in the surface of bed should be broken up to small/fine particles and flattened. Otherwise, germinations are not all at once.



[Bad] Seeds are not in the same depth in the soil, so that the growth of plants are not uniform.

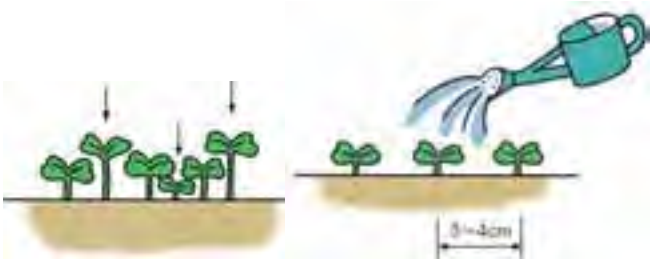


[Good] Seeds are in the same depth, and the growth of plants is uniform.

- Broadcast the seeds. Try to make a minimum distances between seeds are 1 cm. Press the seeds with a piece of board or with your hand lightly, and then cover the seeds with soil lightly. Mulch the bed with rice straw, rice husk or rice husk charcoal, and then give water.

Field management and Harvesting

- Watering: Give water twice a day.
- Thinning and harvesting:



After all germinate, remove small ones and too tall ones to make the spacing about 3-4cm

Give water after thinning to settle the survivors.

Keep on thinning (harvesting) until reach to about 10-15 cm distances with others.

Harvest by up-rooting 30-35 days after sowing.

- Topdressing: At the time of 3-4 leaves, apply urea fertilizer. Resolve 5 g (about 2 tea-spoonful) of urea with 1 liter of water and apply it by watering can, and then give water again.
  10 days after the 1st-time of urea application, give the 2nd-time of urea. No need to resolve urea with water for the 2nd-time. Apply 10-15 g per $1m^2$ directly onto the soil by your hand. Then give water.
  You can use finely crashed dried cattle dung instead of urea.
- You may plant lemon grass around the field to keep the pests (insects) away from your crops.

If you do the transplanting

Broadcast the seeds in a small nursery bed. Transplant the young plants at about 10 days after sowing. Plant at 15 cm distances (interval) with others.

Transplanting should be carried out in the afternoon after getting little cool. The taproot of the

seedlings shall be cut short to increase rootlet (small-white roots), and put wood ash before planting. Give water after transplanting.


5 days after the transplanting, till the surface of soil with a stick (bamboo, steel) and apply urea fertilizer (resolve 5 g (about 2 tea-spoonful) of urea with 1 liter of water and apply it by watering-can) and then water again.

10 days after the 1st-time, apply the 2nd-time of urea (10-15g per $1m^2$ directly onto the soil by your hand). Then give water.

You can apply a small amount of finely crashed dried cattle dung instead of urea.

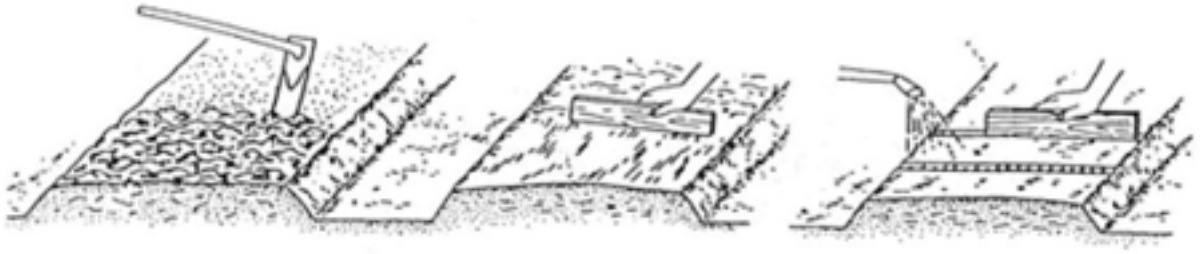
(2) Water spinach (Rau muong)

Land preparation

Apply the same method with pak-choi (read the above).

Sowing seeds

Use the “stripe seeding” method. Smooth the surface of bed, and then make trenches (1cm deep) at intervals of 15cm with a piece of board. Sow seeds in line at 3-5cm interval. Mulch and give water.



Field management and Harvesting

Cut at 4-5cm above the ground to harvest. After the harvest, till the surface of soil between the plants with a stick (bamboo, steel) and apply compost. You can harvest after 20-25 days again.

3. How to grow beans and fruit vegetable

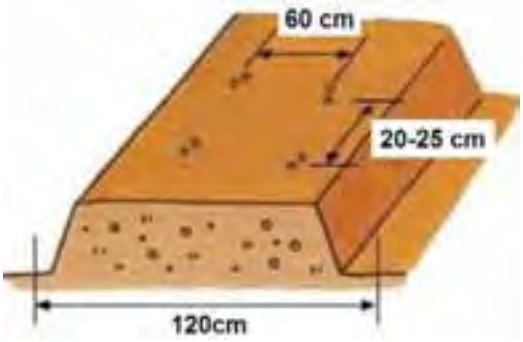
(1) Long bean (Dau dua)

Land preparation

- Weed and take away the grass from the field. Turn up the soil and dry the soil under the sunlight for 7-10 days to kill pests and roots of weed.
- Make a bed (about 1.2m wide) without applying compost and lime. Make two (2) trenches in the bed at about 60cm distance. Trench is 10cm deep and 10cm wide.
  Apply compost (or decomposed cattle dung) in 2 cm thick and lime (50g per $1m^2$) in the trench, and mix them with some soil.
  * If you can afford, you additionally apply TSP (30g per $1m^2$) in the trench.
- Do not completely fill up the trenches with soil (keep the trenches to catch water). 3 - 5 days after preparing the bed, sow seeds.

Sowing seeds

Use the “spot seeding” method. Distance between each spot is 20-25 cm. Sow 2 seeds at each spot.



** Do not soak seeds before sowing.*

Cover the seeds with soil of about 2cm thick (3-times of seeds size)

If the cover soil is not thick enough:
(left) root may be exposed.
(right) seed coat may not be removed.

Field management

- Thinning : No need to practice.
- Topdressing: 20 days after the sowing, apply compost in line at 10cm from the plants; along the plants, and then mix it into the soil.
  * If you can afford, apply NPK 3 days after giving compost at the rate of 40-50g per $1m^2$.
  15 to 20 days after the 1st topdressing, apply urea (35-40g per $1m^2$); directly onto the soil by your hand, then give water.
  * If you can afford, add Potassium (kalium) at the rate of 10-15g per $1m^2$.

- Setting the supports :


(2) Cucumber (Dua leo)

Land preparation

Apply the same method with long bean, but make only one (1) trench in the bed.

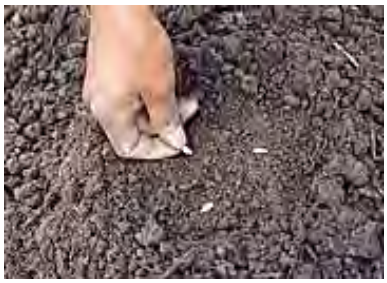
* Soil treatment with sunlight should be conducted well, since many diseases are expectable.

Pre-treating seeds

Soak the seeds in water for 2 hours. Take the seeds out of water, and wrap the seeds with wet cloth. Keep it for 2 days, and then sow the seeds.

Sowing seeds

Use the “spot seeding” method. Distance between each spot is 30 cm. Sow 2 seeds at each spot.


Sow 2-3 seeds at each spot.


Lightly depress by hand, and cover with soil.


Mulch and give water.

Field management

- Thinning : At the stage of 3rd/4th true leaf, reduce the number of plants to one (1) per spot. Select only one plant and remove others by cutting. Do not pull out; pulling out can damage the roots of good one. After thinning, do mulching and give water.
- Topdressing : Apply the same method with long bean.
- Setting the supports : Apply the same method with long bean.

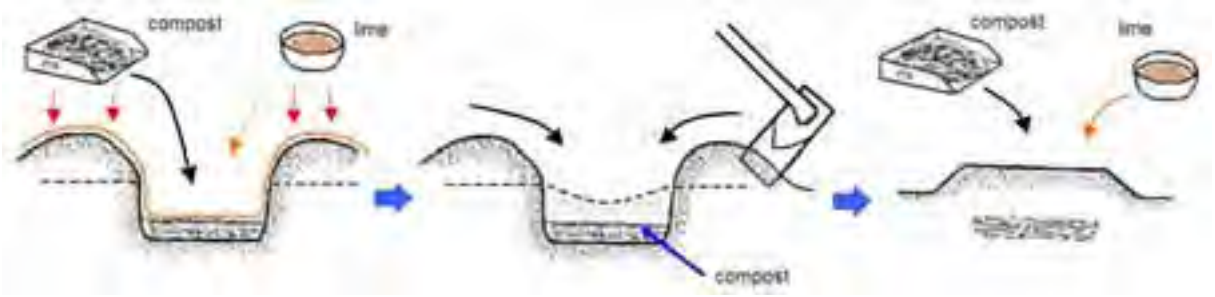
(3) Egg plant (Ca tim)

Normally people make seedlings and then transplant them in the field to reduce the risks of failure in the field before baring fruits. But if you plant only a few eggplants for home consumption, you can sow seeds directly in the field.

a) If you plant only a few eggplants = direct sowing + planting holes:

Land preparation

- Same with other kinds of vegetables, weed and turn up the soil to dry the soil under the sunlight for 7-10 days to kill pests and roots of weed.
- Dig holes (one hole per plant) with 30cm wide and 20cm deep. Apply compost (or decomposed cattle dung) in 2-3 cm thick and lime (50g per $1m^2$) in the hole, and make a mound above the hole (15cm high). Spread some compost and lime over the mound and mix them with soil.



Dig hole, apply compost and lime | Fill the hole | Make a mound, apply some compost and lime and mix into the soil.

Pre-treating seeds

Egg plant seed usually requires the relatively long period (7-10 days) for germination. You can shorten the period and have a uniform germination by pre-treating seeds before sowing.

Soak the seeds in water about 4-5 hours. Discard the floating seeds and use the ones sink to the bottom.

Take the sunk seeds out of water and wrap them with cotton-cloth. Keep the seeds under shadow and keep the seeds moist by watering sometimes. You sow the seeds after confirming the germination (seeds must start germinating in 3 days).

Direct sowing

Use the "spot seeding" method. Sow the 2-3 germinated seeds per spot (mound); keep 6-7 cm distances between seeds. Cover the seed lightly with soil and mulch with rice straw, and then give water.

Field management

- Thinning: Select one good plant and cut others when the seedlings reach about 10cm in height.
- Topdressing: 10-15 days after the germination, apply urea fertilizer. Resolve 8g (about 3 tea-spoonful) of urea with 1 liter of water, and give it with water can. Give water again after applying urea solution.

  20-25 days after the 1st topdressing, till the surface of soil and apply compost (or decomposed cattle dung). After 3 days, do earthing-up (add some soil on a bed / around the plants).

  Apply compost repeatedly afterwards at interval of every 20-25 days.

  * If you can afford, add NPK (15-15-15) at the rate of 40-50g per $1m^2$.
- Pruning and Setting the supports: Remove weak branches periodically. Select strong branches (2 to 3 branches) and attach the supports to let the selected branches grow upward.
- Harvesting: If you care well, harvest starts 75 days after transplanting, and can be harvested in 3-9 months period. For bitter egg plant (local eggplant) harvesting can last in 1-3 years.

b) If you plant many eggplants = make seedling + planting bed:

Land preparation

Apply the same method with long bean, but make only one (1) trench in the bed and make it 10 cm deep and 30 cm wide.

Pre-treating seeds

Same as the above.

Making seedlings

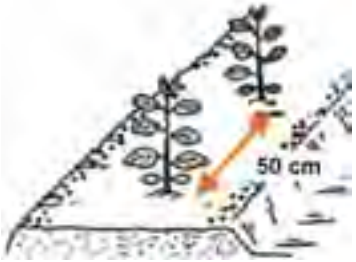
- Prepare a small area of nursery bed: weed and turn up the soil to dry under the sunlight for 7-10 days to kill pests and roots of weed; spread lime and compost over the soil and make a small bed. Prepare the nursery bed 3-5 days before sowing the seeds.
- Sow the germinated seeds in line at distances 4-5 cm. Cover the seed lightly with light soil and mulch with rice straw, and then give water.
- 10-15 days after the germination, apply urea fertilizer (resolve 8g (about 3 tea-spoonful) of urea with 1 liter of water, and give it with water can). Do not forget to give water again after applying urea solution.
- You can transplant the seedlings in the field when they reach about 10cm height (25-30 days after germination).

Field management

- Transplanting: You have to finish the land preparation about 3-5 days before the transplanting.

  Up-root seedlings from the nursery bed and transplant them immediately. Up-rooted and transplanting should be made in the evening.

  Cut the taproot a little before transplanting, and the coat (dust) the roots with wood ashes before transplanting. Plant the seedlings at 50



cm interval. Mulch and give water after transplanting.

- 15-20 days after the transplanting, till the surface of soil and apply compost (or decomposed cattle dung) and NPK (15-15-15) at the rate of 40-50g per $1m^2$. After 3 days, do earthing-up (add some soil on a bed / around the plants). Apply compost and NPK repeatedly afterwards at interval of every 20-25 days.

4. How to grow ginger

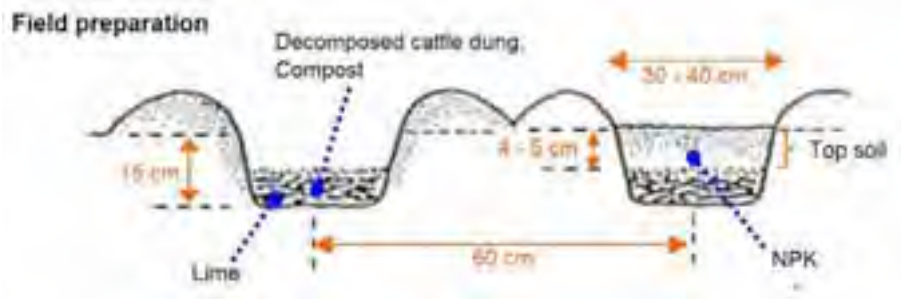
(1) Preparing the field

[Step 1] : <u>3 to 4 weeks before planting:</u>

Make trench of about 15cm depth. Spread lime (or wood ash) in and around the trench at a rate of 100g per $1m^2$. Put old (decomposed) cattle dung at the bottom about 3-4cm thick. Cover dung with little bit of soil.

[Step2] : <u>Just before or at the time of planting:</u>

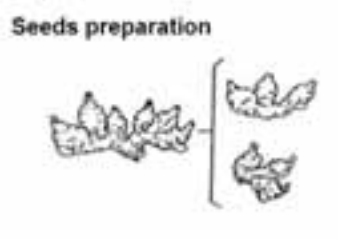
Spread fertilizer (NPK 10-10-10) on soil at a rate of 50 g per $1m^2$. Fill the trench with topsoil. Put marks showing the planting positions.



[Step 1] **[Step2]**

- Roots should not directly touch the fertilizer when you plant the roots. Carefully prepare the land.
- The preparation of [Step 1] should be done about 3 to 4 weeks before the planting, because of using cattle dung. If you use matured compost, 2 weeks before must be OK.

(2) Preparing the seeds



Select good roots: large/thick and no disease. Divide them into pieces. Each piece shall have 3 buds, and weight of 60-70g. Disinfect the cut-parts with ash before planting.

(3) Planting

Place seeds at 30 cm interval. Buds should be upward. Cover seeds with soil; depth should be about 5 – 6 cm. Do not plant too deep.

* Necessary amount of ginger roots = 350 kg for 1000m^2.

(4) Applying fertilizer

15-20 days after the planting, apply fertilizer (NPK 15:15:30). Spread it on the edge of mound at a rate of 50 g per 1m^2, and then pile some soil over the fertilizer.

1 month after the previous application, apply fertilizer (NPK) again.

* You can use some old (decomposed) cattle dung to reduce NPK in the second time.

(5) Mulching

Dry condition (dried soil) is no good for ginger plants. So, to keep the soil in moist condition, cover the surface of soil with rice straws or cut grass or other materials available.

* Covering soil surface is very important if your ginger plants receive direct sunshine long hours in a day or if the climate is very sunny and dry.

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A-2 Technical Guideline on Fruit Tree Planting

1. Introduction

This manual describes the general method of fruit tree planting in your home garden. It covers the works of planting hole preparation, planting and initial cares. Please note that methods of propagation, managements such as pruning, pest control, harvesting, etc. are not covered in this manual. Please read the already published guidelines/manuals on specific fruit.

2. Place for planting and planting space

Most kinds of fruit trees prefer the place (soil) of good drainage. Therefore, the gently sloping filed is a good place to plant fruit trees; especially if your place has a long period of wet season like in Hieu commune. Never plant fruit trees at spots where are flooded during rainy season or where are high in underground water table or where are always very wet. Another important points are sunshine and wind. To have good growth of trees and better quality of fruits, you have to plant fruit trees at spots where have good sunshine and well protected from the strong winds.

Planting space varies by kinds of fruit. It also varies by soil fertility and climate condition at each planting place, way of management, etc. Kind (type) of rootstock also greatly alter the vigor (size) of trees in case of grafted seedling. Popular planting spaces are as follows.

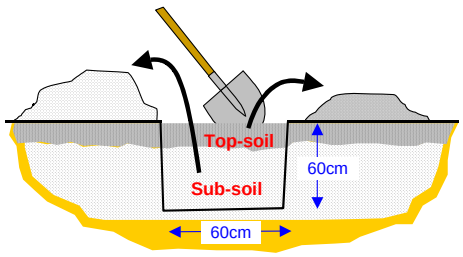
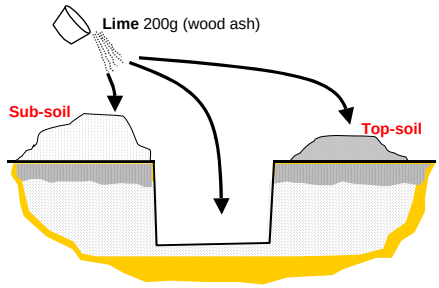
Kind of fruit	Planting space (m)
Orange, Tangerine, Lime	4 – 6 x 4 – 6
Pomelo	5 – 6 x 5 – 6
Mango	8 – 12 x 8 – 12
Longan	5 – 6 x 5 – 6
Rambutan	7 x 10, 8 x 12
Star apple	7 – 8 x 7 – 8
Guava	4 – 6 x 4 – 6
Jackfruit	10 – 12 x 10 – 12
Durian	7 x 12, 10 x 10

Since you plant only limited number of trees around your house, you may not plant trees in grid. Even though you plant trees in random order, you should keep enough distance between tree and tree. Remember that wider space is better since each tree can have more sunlight and ventilation.

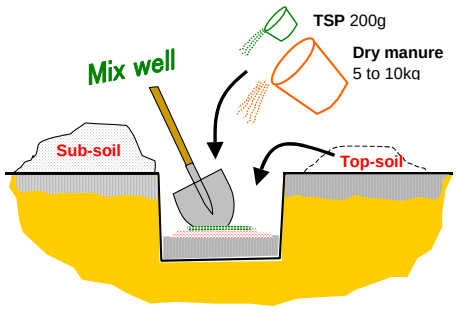
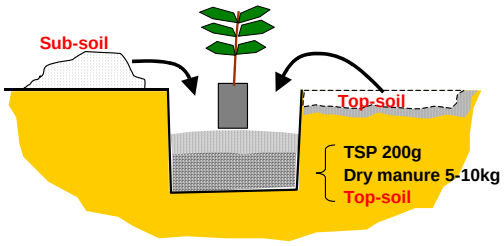
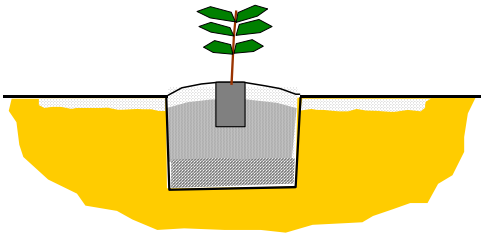
3. Prepare the planting holes

Planting should be carried out during wet season. Prepare the planting holes in dry season well in advance (at least 2 to 3 weeks before) of the planting, so that you can clear away insects, worms and

termite. In addition, aerating the soil improve the physical property and chemistry of dug soil. Size of planting hole is 60 x 60 x 60 cm for most kinds of fruits.

	Pile topsoil to one side of the hole, subsoil to other side of hole
	Spread about 200g of lime over the topsoil and subsoil, and over the soil in the planting hole. If lime is not available, use wood ash. Leave the hole until the time of planting.

4. Plant the seedlings

	Return the topsoil into the hole. Then, put 5 to 10 kg of dry manure (decomposed animal dung). If you can afford, apply about 200g of Triple Superphosphate (TSP) onto the topsoil in the hole. Mix dry manure and TSP with the topsoil in the hole.
	Fill the hole with the topsoil about 50% to 70% (depending on the size of seedling). Place the seedling upright in the hole. Make sure the position is OK (center of the hole, not too deep or too shallow). Cover the root ball with soil, and then gently pressing the soil into contact with the root ball.
	Finish filling the hole with soil. Gently press soil down with your feet. Do not stomp as this may damage the roots. Give water, do mulch and make a simple guard around the tree for protection.

Remember the following important points:

- Before planting, thoroughly water the seedlings in the bags.
- If seedlings have been in the bags for an extended time, roots may grow around in a circle inside the bag. It is important that such roots are gently teased out by hand; otherwise roots will continue to grow in a circular manner after planting. Carefully straighten large roots and prune off badly twisted roots.
- Do not let roots touch the manure (decomposed animal dung) directly.
- Never cover the grafted section with soil (keep the grafted section above ground).
- Keep the final soil level slightly heaped above the surrounding, as the soil will settle down after planting. Do not plant fruit trees in large depression, as this will cause the water-logged condition in wet season.
- Give water if no rains.

5. Field management for young trees

After the seedlings take root, you have to carry out the following works periodically to achieve good growth.

Weeding:

Applying manure:

Apply manure (decomposed animal dung) and wood ash at least two (2) times in a year:

- in dry season; to promote the good growth in wet season,
- after fruiting season (or after harvesting; in appreciation for the fruits).

Pruning:

- For citrus trees, when a main stem reaches about 1m high, it is topped to induce branching. The lower branches are removed and 4 to 6 branches higher up are allowed to develop the future frame of the tree.
- For Mango, Jackfruit, Durian, Star apple, etc., pruning for forming tree-shape is not usually done. But you can apply same method as citrus trees on most kinds of fruit trees.
- For all kinds of fruit tree, you prune off dead or diseased branches and weak branches periodically.
- For grafted seedlings, you prune away all branches come out from the rootstock. This should be done while branches are still young and soft.

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References

- Technical guideline on some animals and fruit trees, 2005, Extension Center, DARD of Kon Tum Province
- Technical guideline on Mango planting, Southern Fruit Research Institute, MARD
- Technical guideline on Longan planting, Southern Fruit Research Institute, MARD

A-3 Technical Guideline on Basic Bamboo Plantation & Management

1. Introduction

This chapter descirbes the techniques on bamboo plantation & management for the species of *Phyllostachys pubescens*. *Phyllostachys pubescens* is a good material, even the best for producing bamboo mat (includes mat and chessman mat), and also a good material for producing handicraft and fine arts, etc. The second important value of *Phyllostachys pubescens* is good bamboo shoot with high yield, and also harvest in winter so it is very expensive. The bamboo shoot is very plump, the average weight of it is from 1.5 to 2.5 kg/one. *Phyllostachys pubescens* forest can have yearly average output of bamboo shoot from 7.5 to 11.5 ton/ha. Therefore, management way of taking bamboo shoot is also included in this guideline.

Seven-year *Phyllostachys pubescens* forest in Zhejiang-China

2. Planting Techniques

(1) Land Preparation for the planting

1) Planting density

In areas that land is rather flat and the slope angle is under 20^0 then we plant with the space of 4x4 m, corresponds to 625 trees/ ha. In areas which has the slope angle of over 20^0, we plant with the space of 4x5 m – corresponds to 500 trees/ha.

In areas which has high slope angle (over 30^0) we must work the soil according to planting hole, it means that in each place of planting *Phyllostachys pubescens*, we must flatten a floor at about 4 m^2 (2x2 m) then dig planting hole in the middle.

2) Digging hole

Phyllostachys pubescens is grown by rhizomes so the planting hole of *Phyllostachys pubescens* is usually in rectangle which has the long curve in parallel with the following contour and size: from 40 to 50 cm in length, from 40 to 50 cm in width, from 40 to 50 cm in depth.

Surface soil layer is divided separately to mix from 5 to 10 kg decomposition farm manure and refill soil in the hole until half of depth of hole, in other words, until 20 to 25 cm from the top of hole cm, and then compact soil.

Regarding techniques on digging hole, please refer the chapter 3 (1) Prepare the planting holes in the "A-4 Technical Guideline on Coffee Tree Management". Since the difference of methods for digging hole between bamboo and coffee is application way of fertilizer/manure and refilling soil, please use

the ways for the bamboo mentioned above.

(2) Planting method

In general, seedling is bred one year after when the bamboo has from 3 to 8 aerial trunks with the height of from 50 to 150 cm and the diameter of rhizomes is from 0.4 to 1.0 cm can meet the standard of planting them in the field (See the right side picture).

Two-year old seedling of *Phyllostachys pubescens*

We should make use of cool and rainy season to plant bamboo seedlings to reach the high survival rate.

Place the seedlings into dug hole with refilled soil and make rhizomes spread freely according to inclined direction of the hole then fill up by soil which is broken in small pieces. Then tightly compact the soil of the covered layers of 20 to 25cm. We should pay attention to cram soil slightly to prevent hurting gemma of bamboo shoot on rhizomes.

Create edge to keep humidity, cover the seedlings with a layer of dry glass, straw into foot of tree and irrigate if soil is dry.

Covering the bamboo seedling with grass in a layer and surrounding the seedlings with pole fence for preventing animal attack.

Watering the seedling just after planting and covered with grass for avoiding drying.

3. Tending Techniques

(1) First year tending

Have measures of preventing the bamboo seedlings from ravage of livestock, poultry if necessary. For the way of prevention, please refer the chapter 2.7 Tending in the “B-1. Basic Tree Plantation Techniques” and see above picture.

Weed up grass and turn up root 2 times in February, March and May, June.

Fertilize 2 times at the first year: one in May and June and one in September and October, fertilize from 50 to 150 g NPK/ per time per hole.

(2) Trimming

According to experience, bamboo shoots in the first year should not be basically kept for growing, in case of keeping bamboo shoots in the first years, just keep only a small amount. From the second year, only 1-2 healthy/good bamboo shoots which are far form the mothers' root can be kept for growing as new mother trees, namely other bamboo shoots should be trimmed.

We should follow the following principles:

- keep the bamboo shoot which is far from its mother's root for growing and cut the bamboo shoot which is near from the its' mother's root.
- keep the good bamboo shoot cut the bad one.
- keep bamboo spacious and cut when bamboo shoots are too crowded.

If we can maintain this principle, the *Phyllostachys pubescens* forest will grow rapidly, give high yield.

(3) Fertilization

According to analysis, to create 50 kg bamboo shoot of *Phyllostachys pubescens*, we need to take from soil 250 to 300 g of nitrogen, 50 to 75 g of phosphate, and 100-125 g of kali. If we harvest 15,000 kg bamboo shoot/each hectare per year, we must fertilize 75-105 kg nitrogen, 15-22.5 kg phosphate, and 30-37.5 kg kali (rate of N:P:K is 5:1:2).

According to experience, we have to fertilize 4 times/per year at the year starting harvest bamboo shoot (maybe forth or fifth year after planting the seedlings), and mix inorganic fertilizer and farm manure to the meet the requirement for growth of *Phyllostachys pubescens.*

1st time: fertilize 35 % of NPK/year, immediately after harvesting bamboo shoot (from April and June) with the combination of stir soil hoe.

2nd time: fertilize from July to September, with the 15 % of NPK/year. At this time we should mix fertilizers into water to fertilize or fertilize in rainy time.

3rd time: fertilize 40 % of NPK/year into November and December, with 1,000 to 3,000 kg farm manure to each hectare according to kind of soil, apply less on good conditions and more on bad conditions.

4th time: fertilize 10 % remainders of fertilizers with 380 kg nitrogenous fertilizer/each hectare and fertilize in February and March.

4. Felling and cutting, taking bamboo shoot

For the harvesting bamboo shoot or trunk which is the main purpose of planting bamboo, the density should be kelp suitably. In other hand, we must pay attention to above principle of trimming mentioned in the chapter 2 (2). Bamboo at the age of 3-4 years old can produce good bamboo shoot so they should be kept for creating next generation. Bamboo at the age of 6 to 7 is old trees so we should fell off to make spacious. Bamboo, is polled or attacked by pest and they don't have the commercial value any more, should be cut down. The work of cutting and trimming should carry out in winter. The optimization density is from 2500 to 2700 trees/ha, in which tree in the age of 1 to 2 account for 30 % (750 to 810 trees/ha), 3 to 4 accounts for 37 % (925 to 1000 trees/ha), 5 to 6 account for 30 % (750 to 810 trees/ha), 7 - 8 account for 3 % (75 to 80 trees/ha).

Winter and spring bamboo shoot of *Phyllostachys pubescens*

Harvesting bamboo shoot with a proper method (way) will help the bamboo improving in quality and quantity. Bad or not good bamboo shoot should be harvested (cut), the good bamboo shoot should be kept for regenerating.

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References

- Bao Huy, Tay Nguyen University, 2008, Techniques of Planting Phillostachys pubescens forest, Vietnam

Additional information on Bamboo Plantation & Management for extension staff

1. Distribution of climate and cultivated land

South of China is the homeland of hug *Phyllostachys pubescens*, natural distribution 24 to 32^0 northern latitude, and 102 to 122^0 east longitude

Phyllostachys pubescens can grow in areas which have annual temperature from 12 to 22°C, the annual average rainfall is from 1200 to 2000mm.

Annual optimal average temperature of *Phyllostachys pubescens* is from 15 to 19°C, the rainfall is from 1400 to 2000 mm and regular distribution.

When ***weekly average*** air temperature is up to 10°C, *Phyllostachys pubescens* starts growing.
When ***weekly average*** air temperature is up to 15 - 25°C, photosynthetic coefficient reaches the highest value.
When ***weekly average*** air temperature exceeds 35^0C, *Phyllostachys pubescens* stops growing.
According to the principle if there in an decline in the south to 1 latitude, elevation must be pushed up to 100m then northern mountainous areas in Vietnam ($21\text{-}22^0$ latitude) the low limit that can plan *Phyllostachys pubescens* must be from over 500 to 600m, in mountainous area of Nghe an ($19\text{-}20^0$ northern latitude) the low limit of planting *Phyllostachys pubescens* must be over 700 to 800m.

We should choose soil which has the depth layer of over 0,5m, the best choice is soil which has depth layer of 1.0m and is the distribution limit of rhizomes. pH from 4.5 to 7.0, foot of limestone mountain, or valley of limestone mountain, alluvial soil from riparian land reaction on the neutral side are suitable with *Phyllostachys pubescens*.

2. Keeping bamboo shoot

When bamboo shoot is still under the ground, it has lightly yellow color and is very delicious food, after emerging from the ground, bamboo shoot turns into yellow brown color and tastes less delicious. The fresh bamboo shoot can be restored in room temperature of 10 to 15 days, but if it is tinned. Therefore, we should process as soon as possible immediately after harvest.

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References

- Bao Huy, Tay Nguyen University, 2008, Techniques of Planting Phillostachys pubescens forest, Vietnam

A-4 Technical Guideline on Coffee Tree Management

"How to start Arabica coffee farming"



1. Introduction

This guideline describes the practical methods of coffee trees management for the small-scale farmer, especially those who has just started or is going to start growing Arabica coffee for income generation. It covers the works of land preparation, planting and cares of young trees. Please note that seedling production, harvesting and post-harvest processing are not covered in this manual.

What is the differences between Arabica coffee and Robusta coffee

Arabica coffee is a higher value coffee (better taste and aroma) normally grown in cooler, elevated areas of the tropics and sub-tropics at 1000 m or more above sea level.

Robusta coffee is a lower quality coffee and prices are normally about 30 to 40% less than Arabica. Robusta is normally grown in warmer areas at lower elevations unsuited to Arabica. Compared with Arabica, Robusta is generally more vigorous, more productive and less vulnerable to coffee rust disease.

Good place to grow Arabica coffee

To produce good quality Arabica coffee, planting sites should meet the following factors;

Elevation : Elevation greater than 1000 m above sea level is required. In low elevation, Arabica coffee does not possess the quality required by the world markets.

Temperature : Ideal temperature is between 20 to 24°C. Mean temperatures of less than 15°C limit plant growth and are considered sub-optimal. At higher temperatures, the risk of pests infection increases, and quality sinks.

Rainfall and water supply : Ideal rainfall is between 1500 and 1900mm per year. Coffee plants need a dry period with little or no rain to induce a uniform flowering. Without a dry period, flowering may extend over many months making harvesting more difficult. Therefore, the rainfall should be uniformly distributed throughout the rest of 7 to 9 months of the year.

Soil type : Coffee can be grown on many different soil types but it is not tolerate water-logging. For successful production, well-drained soil with a minimum depth of one meter is required. Avoid heavy clay or poor-draining soils. Coffee prefers a soil with pH of 5 to 6. Applications of lime can alter and improve the soil pH.

Topography : Eastern or southern facing field with a slope less than 15% is preferable. Strong winds should be avoided or windbreaks established before planting the coffee trees.

2. Preparing the field

There are five (5) important works to be made.

(1) Clear the land

Coffee is a half-shade plants and shade trees are important for sustainable production*[1].

Clear the land and remove existing trees and their roots. Do not leave old timbers lying around as this attracts pests. Then plant shade trees <u>one year before planting coffee</u>. If you cannot to do it, you must leave some existing trees uncut for shade trees. If there are many clouds, it is not always necessary to provide shade. Then all the trees can be cut down.

(2) Mark the positions of planting holes

Coffee is planted in rows 2 m apart with plants 1.5 m apart within the row.

When land is greater than 15% slope (go up 1.5m while move 10m in horizontal direction), contour planting must be undertaken. To mark the planting holes at this spacing on sloping land, follow the steps below.

<u>Marking the planting holes on contour lines</u>

1. Make a simple wooden A-frame of 1.5 m high with legs 1.5 m apart. The horizontal support cross-piece is marked at the central point.
   A string with a weight (stone) is attached at the apex of the ‘A' and allowed to hang freely.
2. Starting at the bottom of the slope, 'walk' the A-frame across the slope. Place a marker at each point on the ground where the string comes to the centre mark on the A-Frame cross-piece. This marker shows the planting hole for each plant on that row/contour. Continue for the desired length of the contour line.
3. Locate the next contour line 2 m up hill from the first row. Follow the same marking procedure.

Using an A-frame to mark the planting holes on contours

(3) Plant windbreaks

If the site is exposed to strong winds, permanently planted windbreaks are necessary. Windbreaks should be well established before planting out the coffee trees. If the site is surrounded by natural forest, supplemental planting of windbreaks may be undertaken. Windbreaks are usually located

[1] Modern technique of growing coffee without shade (so called “sun coffee”) can result the higher yields than growing with shade. But it requires much higher levels of external inputs: irrigation, more fungicide for coffee leaf rust and more fertilizers. And productive life of the trees of “sun coffee” is much shorter. Therefore, this manual recommends using shade trees.

along boundaries of the coffee area.

(4) Establish the shade trees

Shade protects young coffee plants from drought stress and over exposure to sun, which causes yellowing and death of leaves, tree overbearing and/or dieback in older trees. Shade also promotes a better balance between flowering and growth resulting in better berry production. [2]

Shade trees should be established before coffee trees are planted out. As stated the above, clear the land and remove existing trees and their roots, then plant shade trees one year before planting coffee. Plant shade trees within the coffee rows. Remove lower branches from young shade trees as they grow.

Many tree species can be used as shade trees. Legume species are recommended since they provide organic matter and nutrients from leaf fall and pruning, and fix nitrogen from the air to restore soil fertility. Following is the preferred ones.

• *Erythrina subumbrans* (December tree) (Vông hạt đá / Cây gạo). A fast growing and easily propagate by cutting. • *Gliricidia sepium* (Đậu Anh Đào). Fixes nitrogen from the air.	4.5 x 4 m (555 trees/ha)
• *Melia azedarach* (Neem) (Cây Xoan). A good timber tree that may provide some insect control. Seed extracts are used as the insecticide. • *Paulownia tomentosa* (Empress Tree, Princess Tree) (Cây Hông). A quick growing, timber tree.	6 x 6 m (277 trees/ha)

Erythrina shade trees

Melia (neem) shade trees

[2] No figures can be offered for the optimum shadow density, as this depends on the local site conditions and the state of the plantation. A rule of thumb says that the shade should be around 50%. In some regions there are many clouds, so that it is not always necessary to provide shade.

Instead of trees, you may use crops such as sorghum, pigeon pea, maize and banana, by intercropping, to provide temporary shade cover for young plants. In this case, such crops should be planted between the coffee rows.

(5) Establish the ground cover

If you leave the soil bare, the rain will spoil the soil and destroy its good structure. Water washes away the mineral salts, and the sun very quickly decomposes humus, and then the soil becomes poorer and does not feed the coffee trees well enough. Therefore you must cover the soil to protect it against erosion.

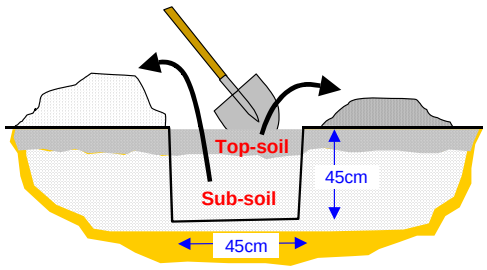
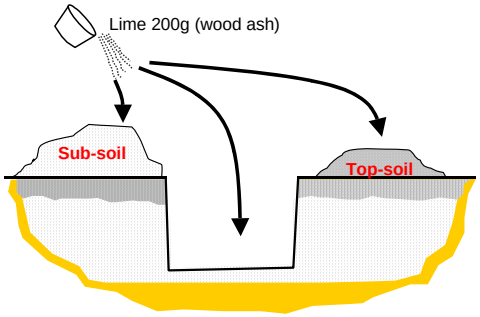
Legume ground covers of pinto peanut (Arachis pintoi) or green leaf desmodium (Desmodium intortum), will greatly assist with weed control in young coffee. Ground covers add nitrogen to the soil and provide mulch for the shade trees.

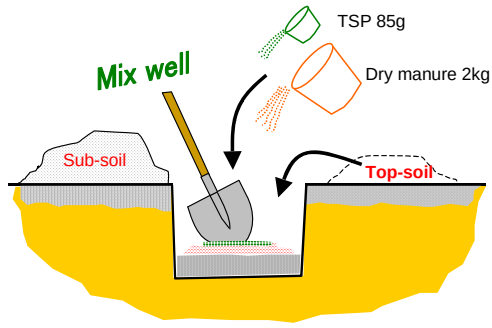
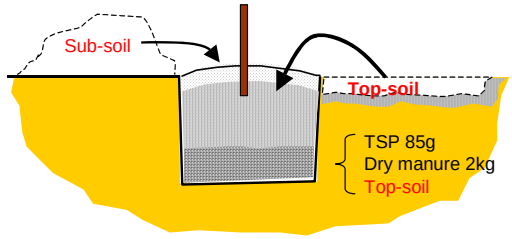
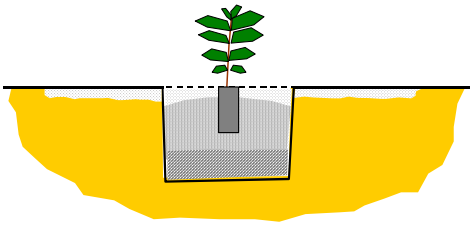
3. Planting the coffee trees

Prepare the holes one month before planting. Planting can begin when the coffee seedlings have a minimum of six to eight leaf pairs. Planting should be done during the wet season.

(1) Prepare the planting holes

Prepare the holes (45 x 45 x 45 cm) one month before planting. Planting holes should be dug after it has rained prior to planting. As the soils would still be moist, digging is made easier.

	1. Pile topsoil to one side of the hole, subsoil to other side of hole
	2. Spread about 200 g of lime over the topsoil and subsoil, and over the soil in the planting hole.

	3. Return the topsoil into the hole. Then, put 2 kg of dry manure (decomposed cattle dung) and about 85 g of Triple Superphosphate (TSP) onto the topsoil in the hole. Mix dry manure and TSP with the topsoil in the hole.
	4. Fill the hole with topsoil and subsoil. Re-mark the centre of the hole with a stick. 

(2) When to plant

Ideal size of seedling for transplanting

Field planting can begin when the coffee seedlings have a minimum of six to eight leaf pairs.

Planting should be made during the wet season - after some rainfall and adequate moisture in the soil. It is recommend do the planting on cloudy days; avoid windy or hot day.

(3) Choose the seedlings

Seedlings should be strong and healthy with no sign of pests or disease.

Good seedlings are:

- ✓ healthy, with dark green, well-formed foliage and a minimum of 6 to 8 leaves.
- ✓ have no stem damage.
- ✓ have been hardened to full sun before planting.

(4) Planting procedure

Unsuitable plant with a twisted taproot

1. Before planting, thoroughly water the trees in the bags.
2. Remove plants from plastic bags by cutting the bags.
3. Discard plants with J-roots or bent roots.
4. If seedlings have been in the bags for an extended time, roots may grow around in a circle inside the bag. It is important that such roots are gently teased out by hand; otherwise roots will continue to grow in a circular manner after planting. Carefully straighten large roots and prune off badly twisted roots.
5. Place the seedling upright in the hole - do not plant at an angle. Half-fill

the hole with soil, and then gently pressing the soil into contact with the root ball. Fill hole with water. This helps to bring the soil into close contact with the roots. Allow water to drain, and then finish filling the hole with soil.

6. Firmly press soil down with your feet. Do not stomp on the soil as this may damage the young roots. Keep the final soil level slightly heaped above the surrounding, as the soil will settle down after planting. Do not plant coffee in large depressions, as these will trap water. Coffee does not like wet soil and plants can die.
7. Water the seedlings well, with 1 to 2 liters of water per seedling.
8. To maintain soil moisture and control weeds, mulch the trees with rice straw or other suitable materials. Keep mulch away from the base of the seedling to reduce the risk of disease.

4. Field management of young coffee trees

To achieve good yields of quality coffee, good field management practices are essential. Poorly managed coffee will take longer time to produce a good crop and will suffer from dieback. There are four key works to be made.

- Control weeds
- Mulch plants
- Water plants
- Replace seedlings that have not grown well

(1) Control weeds

Coffee trees are shallow-rooted, which means that most feeder roots are near the surface. Weeds compete for both nutrients and water, so it is essential to keep the area under the canopy of the trees weed-free. When weeding, be careful not to damage roots of the coffee plant with knife or hoe. In the wet season, two or three weeding may be needed.

(2) Mulch plants

Coffee plants should be mulched with rice straw or other material especially at the end of the wet season. Dead or dry weeds can be used as mulch. Be sure to keep mulch materials 5 to 10 cm away from the trunk of tree. Mulching will reduce the amount of weeding required.

(3) Water plants

Do not allow the plant root ball to dry out after planting. If no rain after planting, irrigate (hand water) two to three times per week for the first few weeks.

(4) Replace seedlings that have not grown well

During the months after planting, you must look often to see whether the coffee trees are growing well. If you see diseased or dead coffee trees, pull them out and burn them, and then plant other coffee seedlings.

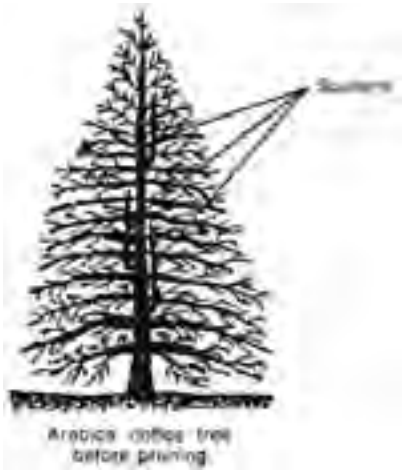
5. Pruning

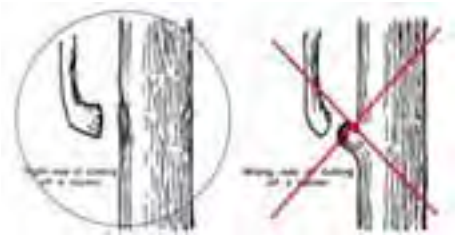
Pruning is an essential work for managing the coffee trees. It basically involves "thinning of branches" and "removal of old/dead stems". Pruning has purposes, such as:

- It gives the good shape and height of the tree.
- It maximizes the good stems and branches for the next season's crop.
- It prevents over-bearing and results in bigger berries of higher quality, then reduce biennial bearing.
- It helps prevent some pest and disease problems by improving sunlight penetration and air circulation.

Arabica coffee should be grown as a **single stem system** (only one main stem). Works are as below:

1st year	• Cut away suckers to maintain a single stem system. * Remove all fruit as they appear.
2nd year	• Cut away suckers to maintain a single stem system. • Remove the branches at the bottom of the main stem. • Remove all the small branches that grow on the main stem. • Cut back drooping primary branches that touch the ground to nearest secondary branch. • Remove secondary branches within 20 cm of the main stem. * Remove all fruit as they appear.
3rd year	• Cut away suckers to maintain a single stem system. • Cut off the top of the tree so that the coffee tree is not taller than 1.5 to 2 meters. • Cut back drooping primary branches that touch the ground to nearest secondary branch. • Remove secondary branches within 20 cm of the main stem. • Maintain a maximum number of well-spaced secondary branches on each primary branch. • Cut away all the dead and dry branches, and all diseased branches. * Trees should be allowed to crop in the 3rd year





Suckers must be cut off close to the trunk

Properly pruned
(leaf and cherry is balanced)

Not properly pruned
(leaf and cherry is not balanced)

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References

- Better farming series, FAO Economic and Social Development Series – Coffee, FAO
- Arabica coffee manual for Lao-PDR, FAO
- Introduction to Coffee Management through Discovery Learning, CABI Bioscience, Africa Regional Center
- Production guidelines for organic Coffee, Cocoa and Tea, OSEC (Switzerland)

B. Technical Guidelines on Tree Planting Activities

B-1 Technical Guideline on Basic Tree Plantation

1. Introduction

This chapter is for the techniques on tree plantation consisting of the nursery techniques and the planting techniques. The techniques for three species of Boi Loi, *Leucaena leucocephala* and *Acacia auriculiformis* are mentioned in this chapter. However, the techniques can be applied for other tree plantation because it is basic techniques. In addition, some parts such as pre-treatment of seeds which special techniques are needed in each species are separately mentioned for the three species.

Main purposes of the three species are in the following table.

	Boi Loi	*Leucaena leucocephala*	*Acacia auriculiformis*
Main purpose	Wood can be used for making home-products and paper. Bark can be used for producing medicine, glue, incense. Leave is used as browse.	Mainly used for fodder of livestock such as cattle and goat. In addition, used as green manure. wood can be used for fuel wood.	Wood can be used for house-building, furniture, carriage-making, and paper pulp.

2. Nursery Techniques

2.1 Nursery establishment

(1) Conditions when establishing nursery

When establishing a nursery, you have to pay attention to the following things:

1) Choose a flat or gentle slope area in order to take care of seedlings conveniently. It also helps to prevent from water-logging.
2) The nursery should be located in a ventilated place, less bushes and big trees because bushes are the shelters of insects and shading of big trees will cause water-logging and shortage of sunshine that makes seedlings grow slowly.
3) Water is available throughout the duration of raising seedlings for the watering of seedlings. In addition, the water source has to be cleaned/has not to be mixed with impurities. Diseases will be transmitted to seedlings directly from dirty water.

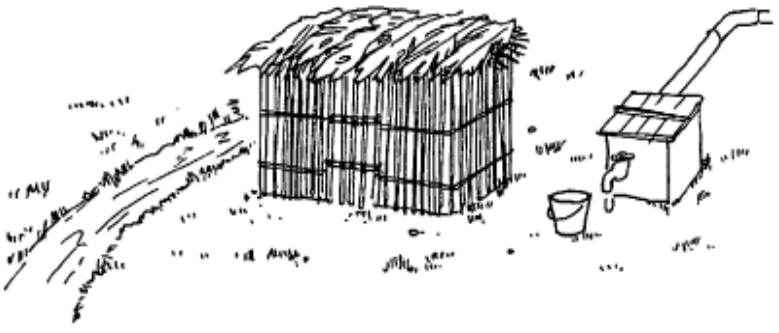

Figure-1 **Good example** as condition of nursery establishment

See the figure-1 and figure-2 for good and bad example of condition of nursery respectively.

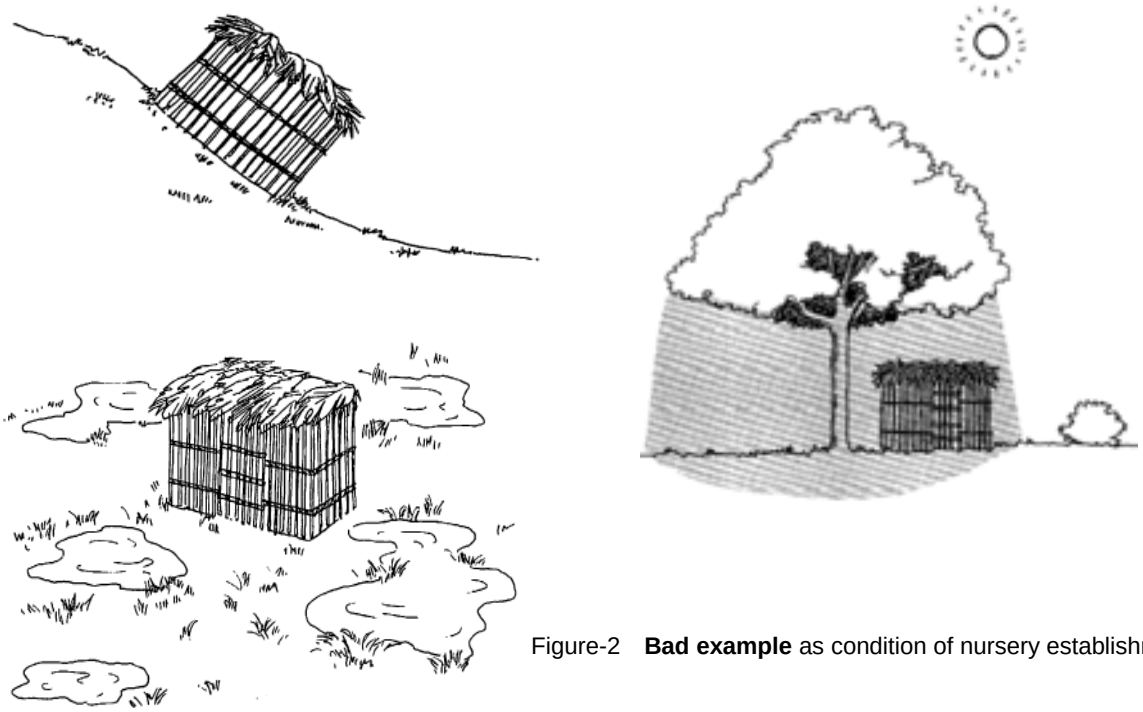

Figure-2 **Bad example** as condition of nursery establishment

(2) Making frame for the nursery

You have to make a high and dry frame. It's normally 10-20cm higher than human being's head. It's helpful for tending seedlings and watering daily. For a good growing condition of seedlings, you should put shading net on the frame of the nursery (leaves are also used but they should be dried because there are many kinds of harmful insects among fresh and wet leaves). The nursery should be fenced with some materials such as bamboo sticks and plastic sheet to prevent from damaged by animals etc. Regarding the materials, local materials are better. See figure-3.

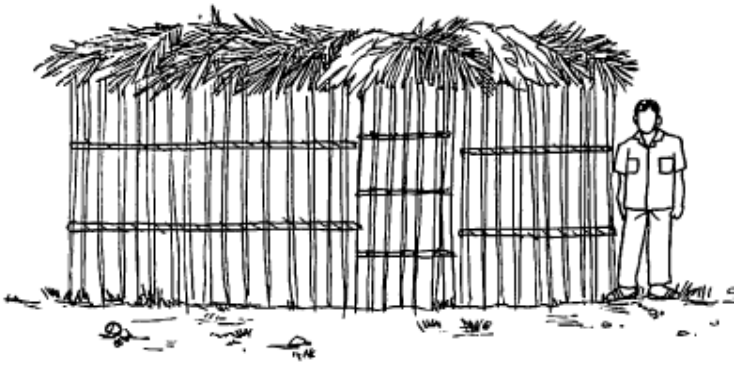

Figure-3 Nursery frame and size

(3) Time of start of nursery establishment

Nursery establishment should be started in proper time considering duration of raising seedling in the nursery and time of transplanting the seedlings in the field which is usually early stage of rainy season. The following the regular duration of raising seedlings in the nursery.

Boi Loi	: about 7 to 8 months
Leucaena leucocephala	: about 4 to 5 months.
Acacia auriculiformis	: about 4 to 5 months.

Therefore, for example, in case of Boi Loi in the area where rainy season start from August when the transplanting is done in the field, actual nursery work which is pre-treatment of seeds should start from January. Then as the actual nursery work can be started in January, the nursery has to be established.

2.2 Seed collection

The origin of the seeds must be the natural distribution area. The breeding trees must be a well growing one, truck straight, good canopy, not infected with disease/insect, and had over two time of fruiting, more than 10 years of age in the natural forest or planted forest. See figure-4.

Figure - 4

In case of buying seeds from dealer, it is necessary to have profile of the seeds and technical information attached.

2.3 Pre-treatment of seeds

In natural condition, seeds of many tree species need a long period to germinate or have very low germination percentage. Pre-treatment of seeds is then practiced to hasten the germination time and to get good germination percentage. In this Chapter, methods of pretreatment of seeds of Boi Loi, *Leucaena leucocephala* and *Acacia auriculiformis* are mentioned.

(1) Seeds of Boi Loi

1) Before pre-treatment of seeds, good seeds should be selected. For this sake, Boi Loi seeds have to be soaked in the water, wash and then take out the bad seeds over-floating on the surface of the water (period for this stage is 15 minutes).
2) Fish out the washed seeds and put in the basket for drying (period of this stage is 5 minutes), then put the seeds in warm water (3 portions of boiled water, 2 portions of cool water) of which the level has to be always 3 cm higher than the seed. See figure 5.


Figure-5 Portion of boiled and cool water for pre-treatment

3) Soaking the seeds in the warm water mentioned above 2) in 8 hours (temperature of the warm water is naturally decreasing), then take them out, let them dry in 5 to 10 minutes, put them in a textile fiber bag (cotton bag), and keep them inside house with temperature from 25 – 30 degrees, but the temperature is not more than 30 degrees because the seeds are rotten and can not be germinated.
4) Wash the seed daily by putting the seed in warm water (4 portions of boiling water mix with 2 portions of cool water), then put them back into the bag. The purpose of washing the seed is to clean the gums around the seed so that the seed can absorb water easier.
5) After covering the seeds for 9-12 days, we can see the seed get germinating.

(2) Seeds of *Leucaena leucocephala*

1) Put seeds in almost boiled water (90-100°C) in 4-5 minutes, the volume of water is double compare to the volume of the seed. After putting the seeds in the water, the temperature of water is decreasing and stable from 70-75°C.
2) Pour the hot water out, then put cold water again and soak the seeds in 6-10 hours. Then pour water out and keep the seed dry, then take the seed for sowing.

(3) Seeds of *Acacia auriculiformis*

1) Boil the water in a tank
2) Put the seed in a textile fiber bag (cotton bag). Each bag should keep 200g of seed for each time of treating to ensure that seed is soaked in water evenly. Size of the bag should be suitable for amount of the seeds mentioned above (not so big and not so small).
3) Put the bug with seeds in boiling water for 1 minute and then immediately bring the bag out.
4) The bag should be covered by another thicker textile fiber bag to keep the seed warmer.
5) The seed must be washed by cold water one time per day until the seed is germinated. This is a first stage of germination which means that the seed is broken. It is very easy to find out the broken seed. On the top of the broken seed, colour of the seed will become white colour. Normally, the seed will be broken after 1 week.

2.4 Preparation of potting

(1) Soil mixing

Forest soil, manure and phosphate are usually mixed for potting as follows,.

a: 88 % soil under forest canopy (the soil should be broken and slightly dried by sunlight, and sterilized by fungicide if available)

b: 10 % decomposed manure which is better than dung without decomposition, if available

c: 2 % Super phosphate

(2) Potting

After mixing three materials, plastic bags are filled with such mixed soil. Size of pot to be recommended: 7 to 9cm in width x 11 to 13cm in length.

Put the mixed soil into pot with 1/3 size of the pot, compact to have the hard bottom, then continue to put mixed soil into the pot use finger to compact evenly. On the pot, 3 –5 holes must be made for irrigation. See figure 6.

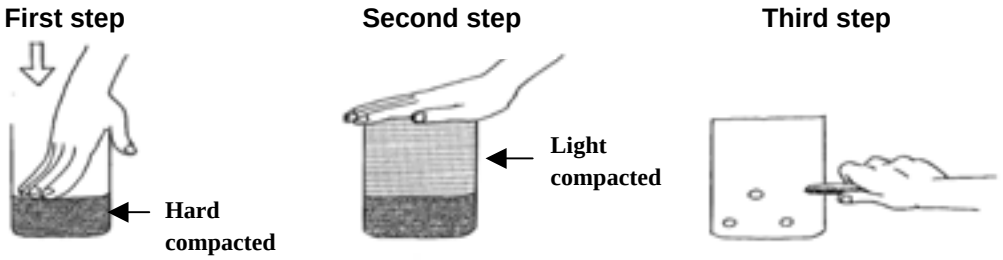

Figure-6 Process of potting

2.5 Sowing of seeds

Sow the seeds into plastic pots after finishing the pre-treatment. Make sure that seeds shouldn't be sowed too deep because it will be difficult to germinate. Seeds should be 1 to 2cm form the surface of soil pot. Sow two or three seeds in a pot.

Boi Loi: After covering the seeds for 9-12 days, we can see the seed get germinating. Then such seeds can be sown in the pot.

Leucaena leucocephala: After the pretreatment, immediately the seeds should be sown in the pot.

Acacia auriculiformis: The broken seed with white spot must be instantly transferred in the pot. Direction of transplantation of the broken seed must be correct. White colored top of the broken seed must be turned to the bottom of the pot. See the figure 7.

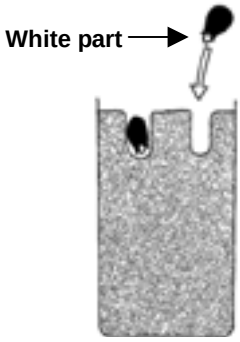

Figure-7 Way of sowing of Acacia

2.6 Arrangement of pots

It is recommended to make fixed number pots a unit such as 100 pots (10 x 10) and 200 pots (10 x 20) to ease the management work and counting. See figure 8.

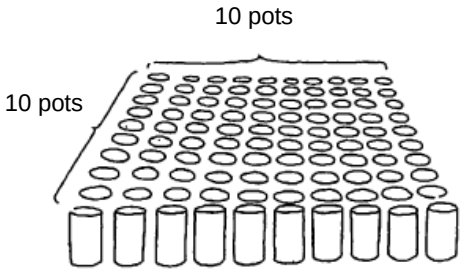

Figure – 8 Arrangement of pots

2.7 Tending

(1) Shadowing

It is not necessary to make stable roof for tree nursery.

Time and rate of shadowing: in the first 20 days, seedling needs covered 70-80% then reduce shadowing to 30% gradually by 30 to 45 days before the transplanting.

(2) Watering

Water seedlings one time/day with 3 to 5 liters/m^2. However, the volume of water depends on the weather condition but always enough to keep the pot humid. Not to water too much to avoid waterlogged or fungus. In the winter if the weather is too cold, water in the morning.

(3) Thinning

In case that more than two seeds in a pot are germinated, seedling(s) which does not relatively grow well compared with another should be removed from the pot after ether one seedling reach 3 to 4 cm, so that only one good seedling remain in a pot. See figure 9. Please note that time of thinning should not be missed especially too late thinning is not good. However, if you miss the time, do not remove a seedling with the root from the pot and do cut the seedling on the surface of soil in the pot by a knife because the removing may damage a remaining seedling in the pot. See figure 10.

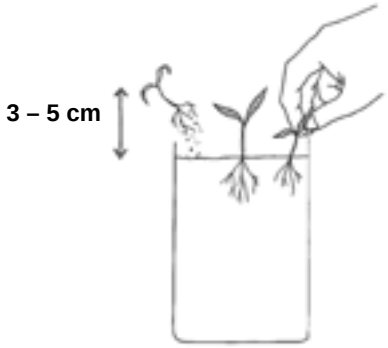

Figure-9 Way of thinning in good timing

Figure-10 Way of thinning in too late timing

(4) Weeding

Weeding in and around the pot, arranging the seedling and turn up the soil up to 0.5 cm depth with small stick if available. Be careful of damage the seedling, periodically 1 time/15-20 days.

(5) Top-dressing

Usually top-dressing is not necessary. However, for especially Boi Loi seedling, top-dressing is necessary based on the following condition and way.

Keep on monitoring the growing status of seedling, especially in the first stage so that to have suitable intervention. Top-dressing when young seedling grow not well. In a moth, put one time with NPK (5:10:3) concentration 1% (0.1 kg /10 liters of water), apply 3 liters/1m^2. Do not apply fertilizer in harsh sunny day, better to apply fertilizer in cloudy day or in drizzly weather, in the morning or evening. Note do not use urea for top-dressing.

(6) Hardening

Hardening is to expose the seedlings to harsh conditions to make them strong so that they will be able to survive under natural climate condition in the field after planted out.

1) Remove the roof

   Remove the roof before transplanting the seedling in the field 30 to 45 days in advance. Start removing the roof when it is rainy or cloudy, do not remove the roof when it is sunny because the heat will burn the young leave and make the seedling death or they can not grow well.

2) Rearrange the seedlings before transplanting

   Rearranging the pots will help them grow evenly, seedlings can absorb energy from the sun, water, nutrient in the soil more evenly.

   Selecting the good one and put in a separated area for planting first. The remaining will be kept for further tending and for later transplanting.

3) Reducing and stopping watering

   Reduce the quantity or frequency of watering to insure the plant against the drought, then lastly stop watering. This action should be started from 20-30 days before transplanting.

2.8 Standard of seedling for transplanting

Basic standard of seedling of the three species for transplanting in the field is as follows,

Boi Loi	: 30 to 40 cm
Leucaena leucocephala	: 40 to 50 cm
Acacia auriculiformis	: 40 cm

3. Planting techniques

3.1 Site preparation

The site where the trees are to be planted should be prepared before planting. Planting hoes must be ready in time waiting for the rain.

If there are bushes or grasses around your planting site, clear them before in order not to disturb the digging process and also prevent the competition between seedlings to be planted on moisture and sunshine after plating.

Bushes and grasses should be cut at the base. In case that there are many bushes, not only cut them but also remove and pile the branches in an orderly manner. Where the vegetation is thick, clear the one line parallel with the contour, clear-line 2m in wide, leave-line 1m in wide. On the line for planting tree, vegetation is cut clear, move the cut-vegetation into the leave-line, regenerating-tree are left alone.

3.2 Digging

Planting hoes should be dug before plantation of seedlings at least two weeks in advance. The purpose of the digging is to soften the soil so that the roots of trees can easily penetrate into deep, and the soil can catch and contain more moisture. The size of hole depends on the natural condition but usually 40 cm x 40 cm x 40 cm or 30 cm x 30 cm x 30 cm are applicable. The bigger hole should be applicable in the place with heavier weather and soil condition. When digging the hole, keep the topsoil separated for the re-filling the hole mentioned in the below chapter 2.3.

Standard of interval of the species between the holes are as follows,

Boi Loi	: from 3 m x 2 m to 3 m x 4 m
Leucaena leucocephala	: It depends on the purpose. In case of making hedgerow, 50 cm to 1m between seedlings in one line and interval between two lines is also 50 cm to 1 m. In case of usual planting for fodder making, 3 m x 2 m or 3 m x 3 m
Acacia auriculiformis:	: 3 m x 2 m or 3 m x 3 m

3.3 Re-filling of the holes

Put the topsoil into the bottom of the hole with decomposed organic compost or animal dung if available. In case of animal dung, put it at least two (2) weeks in advance before planting. If the top spoil around hole also is available, you can use it for cover above (See figure 11), but even the poor soil can be used for cover above in case of only poor soil available, then pile up like the cone shape.

Figure-11 Re-filling soils in the hole

3.4 Transporting seedling

Water seedlings one night before transporting to the planting site, then avoid to break the pot or the seedling. Seedling are living things and very fragile so they must be handled carefully. Don't pile them up each other when transporting. Using boxes or bags are recommendable especially when the planting site is far. Seedlings must be transported to the planting place within the day, if seedlings are not planted immediately so the seedlings must be kept under shadow and watered

3.5 Planting

Planting should be carried out in the cloudy time or showering time and the soil must be enough humid. Delivering seedlings to holes before planting, seedlings delivered to holes must be planted in the day.

Common planting process is:

(1) Make a hole which should be deeper than the height of the pot by 1-2 cm by using hoe or spade or stick. See figure 12.

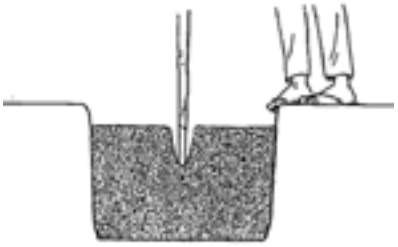

Figure-12 Making hole

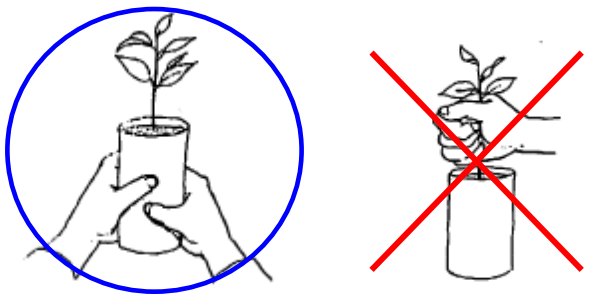

Figure-13 Good and bad way of handling of seedling

(2) Hold the pot and harden the soil by two hand. See Figure 13.

(3) Remove the pot with razor (if available) carefully. See figure 14.

(4) Plant the seedlings straight in the hole without removing the pot soil carefully. Use the top soil to fill the hole. See figure 15.

Figure-14 Removing pots

Figure-15 Planting pot in the hole

Figure-16 Pushing the soil

(5) Push the soil around the seedlings firmly by hands to avoid leaving any space between soil and roots. See figure 16.
(6) Add some more wet soil (topsoil is better).
(7) If the water is available, give it to the seedlings.

3.6 Protection

To protect seedlings from livestock and wild animal fencing is the most effective. If the number of seedlings planted is small, fencing individual trees is easier and economical. See figure 17.
For larger scale plantations, fencing all around the area to keep animals out is recommended. Branch of trees and/or bamboo etc. can be used as fencing materials which are readily available in local areas. See figure 18.

Figure-17 Fencing individual tree

Figure-18 Fencing area with trees

3.7 Tending

Main tending for first three year after plating seedlings is weeding. If grasses or bushes grow around the seedlings planted in the field, clear them to avoid the water and light conflict between seedlings and grasses or bushes.

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- Kenya/Japan Social Forestry Training Project, 1991, Social Forestry Techniques (Textbook for the training courses at Kitui Regional Training Centre), Kenya
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Additional information on Basic Tree Plantation for extension staff

1. Suitable natural condition on the three species

Suitable natural condition of the three species are mentioned in the below table.

	Boi Loi	*Leucaena leucocephala*	*Acacia auriculiformis*
1 Altitude	Lower than 600 to 700 m	Lower than 700 m	Lower than 400 m
2 Temperature	Average temperature: 18 to 25 °C Average max temperature in hottest month 25 to 27 °C Average min temperature in coldest month 10 to 20 °C	Annual mean temperature of 15 to 28°C	Annual temperature of 26 to 30°C
3 Annual Rainfall	1,500 to 2,500 mm	800 to 2,000 mm	1,000 to 2,000 mm
4. Soil	- Grow and develop well on yellow, red feralit soil, on clay schist, mica schist, but also be planted in arid area with forest-soil characteristics. - Thick of layer is more than 30 cm - pH is 4.5-5.0	- Wide soil texture from gravel to deep clay with infertile but the most rapid growth is on deep clay soils which are fertile, moist and alkaline. In addition, drainage place is better. - pH is 6.0-7.5. Bad below 5.0	- Grows in a wide range of deep and shallow soils, compacted clays, coral soils, laterites, limestone, mica schist, podzols, seasonally waterlogged soils, even sand dunes and unstable slopes.soil types and soil pH of 3.0 to 9.5. Aided in drought resistance and low-nutrient tolerance by mycorrhizal and nitrogen-fixing bacterial associations of the roots

B-2 Technical Guideline on Betel Nut Palm Planting

1. Introduction

This chapter mainly describes the method of betel nut propagation, which is considered as the best practice based on the existing guidelines as well as the lessons learned from our failures in seedling production during the project period.

You will grow betel nut trees as a cash crop. Please note that China is (will be) the only market for your betel nut fruits and no one knows about future demand. In 2007 Chinese demand slumped (no one know the reasons) and no local traders came to Ngoc Tem to purchase the fruits. So that it is not recommendable to plant a large number of betel nut trees instead of your food crops.

Betel nut palm trees in Ngoc Tem

2. Making the seedlings

Note: Please read the Technical Guideline B-1 about the “conditions when you select a nursery place” and “preparation of potting”.

(1) Why you do make the seedlings? (direct seeding vs. transplanting)

Betel nut is exclusively seed propagated. You can sow seeds directly in the field to germinate and to grow to maturity. However, the practice of direct seeding can be time consuming, and more prone to physical damage during their early growth stages. Direct seeding requires more time since you have to visit the fields for weeding and tending. Also, accidental trampling/cutting in the field maintenance and trampling by animals/other villagers can bring about greater chances for physical damage.

In general, starting out plants as seedlings for transplanting is a more efficient way of propagating betel nut trees. Seedlings grown in the nursery allows for easier watering, weeding and other maintenance. In addition, transplanted hardy seedlings have a greater chance of survival than those directly seeded.

(2) Seeds selection

Based on our failures in seedling production with dried seeds, we strongly recommend you to use

matured fresh fruits as seed source to ensure a greater chance of germination, although some say that dried seeds are OK.

Generally, fruits are matured when the husk has completely turned from green to yellow or orange.

Use the fruits come from healthy trees with a history of producing desired nuts. Select only the large and fully ripened fruits. You can select good fruits by putting them in water.

Matured fruits

Fully mature, heavy fruits that float vertically in water with the calyx end upward give a high germination rate and vigorous seedlings.

The choice of mother tree is believed important. Good mother trees are:

- regular bearing,
- bear large number of fruits,
- large number of leaves on the tree,
- short internodes in the trunk.

You should avoid mother trees that show any symptoms of bacterial or viral diseases; these can be passed on to offspring through seeds.

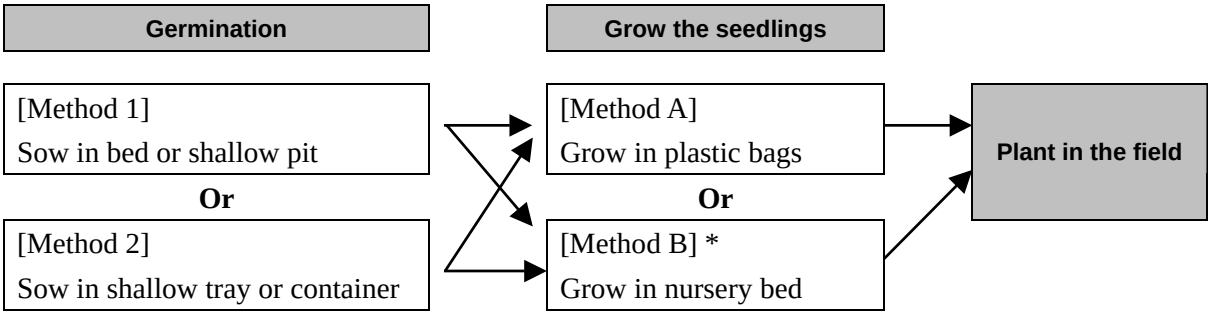
(3) Pre-planting treatments of seeds

No pre-planting treatment is required. Sow the mature fruits immediately after harvesting.
Drying fruits for 2-7 days before planting is customary practiced in some countries but it is reported that no increase in germination rate.

(4) Sowing seeds

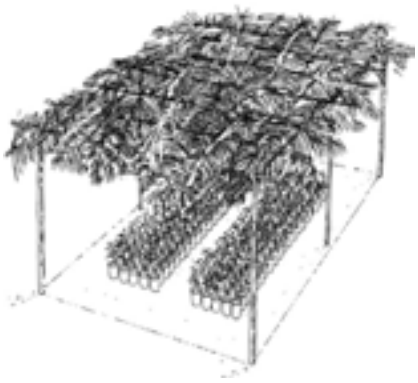
Sow the mature fruits as whole fruits with husk. Betel nut palm seed will lose viability in short period. You have to sow the seeds within 7 days after harvest. It is reported that the germination rate is usually over 90% with fresh and mature fruits.

The normal (best) method of sowing is to sow the selected seeds (1) in shaded germination areas (bed or shallow pit) or (2) in shallow tray or other tray-like container (about 5cm deep) with adequate drainage for germination. Then transplant the germinated seedlings (A) into individual plastic bags or (B) nursery bed until plating out in the field (1-2 years).



* Method A (using plastic bags) is recommended, since easier to transplant in the field. But adequate size of plastic bags are often not available in the market. If no bags available you have to practice the Method B.

- To germinate the seeds, in both methods, place fruits in a single layer; with husk; 2.5 cm apart; and cover with soil or sand.
- Be sure to maintain adequate moisture.
- Nursery area for both germination and growing the seedlings should be shaded.
- You have to take care the seedlings for a long time (1-2 years), so that select the nursery place carefully.



(5) Seedling maintenance

In general, germination can be completed about 90 days after sowing, and at this time the seedlings have one bifid (forked) leaf and five roots.

After the germination, transplant the germinated seedlings (A) into individual plastic bags or (B) nursery bed; until planting out in the field (1-2 years). In case of transplanting into individual plastic bags, use at least 14-15cm (diameter) x 20–22cm(height) = over 3 liters size plastic bags with adequate drainage.

- Seedlings require 50% or more shade to protect from sunburn.
- Regular watering and exposure to filtered sunlight are very important, especially during the first 4 months of growth.
- Do not to over water because it can contribute to root rot.
- In case you use the clay soil for potting, you can add rice husk to improve air permeability and drainage.


(6) Time of out-planting

You can plant the seedlings in the field when they have five (5) or more leaves. Growth rates vary, and it requires 12–24 months (rarely up to 4 years) before seedlings are ready to this size.

3. Planting and managing the trees

Note: Please read the Technical Guideline B-1 about the planting techniques such as “site preparation, digging planting holes, re-filling holes, transporting seedlings, planting and protection”.

Time of planting :	Transplant at the start of wet season.
Planting holes :	Prepare planting holes in advance. 40-50cm deep x 40-50cm wide is desired.
Spacing :	Spacing varies from 1.25 x 1.25 m to 3.6 x 3.6 m depending on soil depth and fertility. In general, 2.7 x 2.7m or 2.4 x 3m is desired.
Shading :	During the hot weather, young seedlings should be protected from direct sunlight. Intercropping with banana is recommended: plant young palms under bananas which provide sun protection until the palms grow taller than the bananas. Or provide the artificial shade with banana leaves, palm leaves, etc.
Manuring :	Apply cattle manure, green manure (mulch around the trees with grass and leaves), and wood ashes periodically.

Some indicators of the growth (for reference)

- One-year-old seedling has 4 or 5 leaves.
- Trunk is formed in the third year.
- Adult palm produces about six new leaves per year, carries a crown of 8-12 leaves, and drops mature leaf after the life span of about 2 years.
- The rate of growth in height is about 0.5 m per year.
- The life span of a betel nut palm is 60-100 years.

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Additional information on Betel Nut Palm Planting for extension staff

1. Summary of information for nursery planning

English name	Betel nut palm, Arecanut,
Scientific name	Areca catechu
Vietnamese	Cau
Method of prorogation	Seeding
Germination ratio	90%
Seeding method	Seeding in shaded beds/pits or in a shallow try/container, then transplant the germinated seedlings into plastic bags or into nursery bed for growing on. Germination place should be shaded.
Pre-planting seed treatment	No pre-planting treatment is needed. Drying fruits before planting is customary practiced in some country but it is reported that no increase in germination rate.
Size of pots	3.8 liter, 14–15cm (diameter) x 20–22cm(h)
Soil for pots	Good drainage
Selection of good seeds	Select fully mature fruits. Fully mature, heavy fruits that float vertically in water with the calyx end upward give high germination rate.
Time of transplant in pots	About 90 days after sowing, when the germination completed. At this time the seedling must have one forked leaf and five roots.
Care for seedlings	Young seedlings should be protected from direct sunlight during the hot weather. Shading 50%.
Other	Seed (fruit) cannot be stored long time. Plant within 7 days after harvest.
Hardening before planting	Reduce the shading gradually.
Size / age of seedling when plant in the field	Seedlings should have five (5) leaves 1 year to 2 years age (growth speeds are variable)
Planting space	1.5 x 1.5 m (minimum), 2.7 x 2.7m or 2.4 x 3m is desired.
Planting holes	Prepare planting holes in advance. 40-50cm deep x 40-50cm wide is desired.

Required soil volume

Pot size (diameter x height, cm)	Soil volume per pot (cm^3)	Soil volume per 1000 pots (m^3)
12 x 25	2826	2.8
15 x 25	4416	4.4
15 x 30	5299	5.3

Required space to place the pots * Space for aisles is not included.

Pot size (diameter, cm)	Number of pots per $1m^2$	Space for 1000 pots (m^2) *
12	65-70	15
15	40-45	25

2. Information about the sources of seeds and seedlings

There is no commercial nursery which selling betel nut seeds and seedling in Kon Tum.
A large number of seedlings are available at:

Trung tâm giống cây trồng vật nuôi (Seedling and animal stock center in Quảng Ngãi Province)
178 Hùng Vương, Thành phố Quảng Ngãi, Tỉnh Quảng Ngãi
Ông Trần Quy

Purchasing a large amount of fresh and fully matured seeds is difficult and time-consuming.
To purchase the fresh and matured seeds, you have to find farmers who grow many betel nut trees, and then you have to make a deal in advance (book the seeds). You should remember that farmers grow betel nuts for selling, and they harvest green nuts.
There are farmers growing betel nut trees in some scale in Quang Ngai, and you may be able to find one who can harvest fully matured fruits for you.

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B-3 Technical Guideline on Slope Land Agroforestry
"Introduction to Alley Farming"

1. Introduction: What is the Alley Farming?

(1) Traditional Slash/burn Fallow Systems must not viable in near future

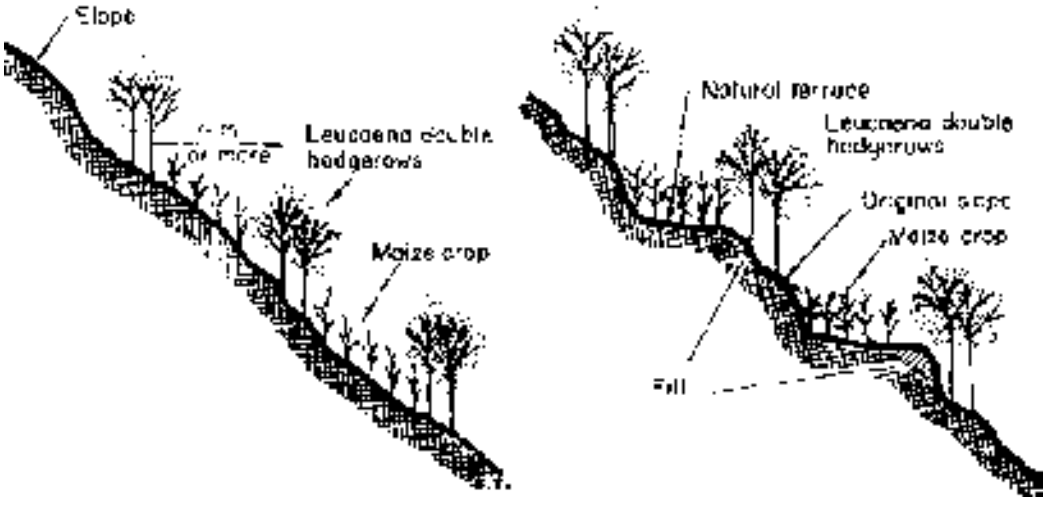
Where land is abundant, the slash/burn fallow system can be a stable method for restoring soil productivity. Food crops grow well on newly cleared land after a long rest period.

However, rapid increases in human population and the associated increases in demand for farmland have overstretched this traditional system. Long fallow periods, which in the past lasted over 10 years, have been shortened drastically. This has resulted in increasing degradation of farmland, increasing infestation by problem weeds, and declining food crop yields. Fertilizer use has not been a viable option in much of the rural area, because of its high cost and unavailability to most smallholder farmers.

(2) Characteristics of the Alley Farming

Agroforestry is the land management system which combines the production of trees and the production of crops and/or animals on the same land.

Alley farming is an agroforestry system in which food or forage crops are grown in the "alleys" between hedgerows of trees or shrubs. The trees or shrubs - preferably fast-growing, leguminous (nitrogen-fixing) species - are established in hedgerows usually spaced 4-8 meters apart. The trees are periodically pruned and managed to prevent shading the crops. The cut pieces of leaves and stems are incorporated into the soil as green manure or used as mulch. Some portion of the tree foliage can be harvested and fed to livestock.



Alley farming has various advantages over the slash/burn fallow system, but usually it requires more labor and management inputs. The hedgerows in the Alley farming can offer some or all of the following benefits:

- ✓ Provide green manure and mulch for companion crops,
- ✓ Provide biologically fixed nitrogen for companion crops,
- ✓ Improve soil conservation,

- ✓ Create favorable conditions for beneficial soil organisms,
- ✓ Provide good fodder for livestock,
- ✓ Provide staking material and/or firewood.

2. Establishment of Alley Farming System

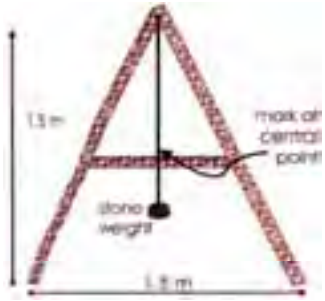
(1) 10 basic steps

Alley Farming System is a simple, effective method of farming uplands, without losing topsoil to erosion. It consists of the following 10 basic steps.

Step 1. Making the A-frame

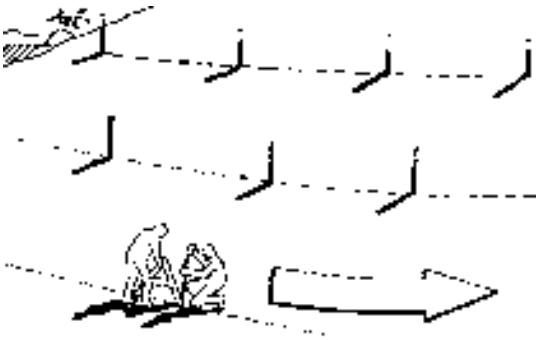
If the slope is steep, the contour lines should be determined more accurately than can be achieved by eye alone. Make and use a 'A-frame'.

A-frame is a simple tool. It is made of 3 wooden or bamboo poles tied together in the shape of a capital letter A with a base 1.0 to 1.5m wide. A string with a weight (stone) is attached at the apex of the 'A' and allowed to hang freely.



Step 2. Determining the contour lines

Put one leg of A-frame on the ground, and move (swing) another leg until the string comes to the centre mark on the A-frame cross-piece. Mark the position of the leg with a marker (wood stick). Move the A-frame, placing one leg on the marker, and repeat the process.



Step 3. Cultivating the contour lines

One meter strips along the contour lines should be plowed and harrowed to prepare for planting. The markers serve as a guide during plowing.

Step 4. Planting seeds of hedgerow plants (nitrogen fixing trees/shrubs, forage grasses, etc.)

Along each prepared contour line, in general, make two furrows and sow 2 to 3 seeds per spot. The seeds should be covered firmly with soil. When the hedgerow plants are fully grown, they hold the soil, serve as a source of fertilizer and mitigate the soil erosion.

Examples of suitable hedgerow species are *Leucaena leucocephala*, *Gliricidia sepium*, *Tephrosia candida*, etc. (see the table annexed).

Hedgerows with tephrosia and pineapple

Step 5. Cultivating the alleys

The space between the hedgerows is called 'alley', and the crops are to be planted. Plow and harrow to prepare for planting.

Cultivation on alternate alleys (alleys 2, 4, 6 and so on) may be applied. This alternate planting prevents erosion very well because the unplowed alleys are covered with grass and it will hold the soil in place.

Step 6. Planting short-term crops

Short and medium-term crops (maize, upland rice, sweet potato, peanut, mungbean, pineapple, ginger, taro, etc.) are to be planted in the alleys as a source of food or income.

Beans

Cassava

Step 7. Planting permanent crops

Permanent crops such as coffee, banana, fruit trees may be planted when the hedgerow plants are sown. Tall crops should be planted at the bottom of the field while the short ones are planted at the top.

Step 8. Trimming of hedgerow plants (trees/shrubs)

Periodically (or occasionally) the growing hedgerows are cut to a height of 0.6 m to 1.5 m from the ground. The cut leaves and branches should be piled on the soil around the crops, where they serve as an excellent organic fertilizer.

Trimmed tephrosia shrubs

Step 9. Practicing crop rotation

A good way of rotating is to plant cereals such as maize or upland rice, tubers and other crops on alleys where legumes were planted previously, and vice versa. This practice will help maintain the fertility and good condition of the soil. Other management practices in crop growing, such as weeding and pest control, should be carried out regularly.

Step 10. Building green terraces

To enrich the soil and effectively control erosion, organic materials such as straw, stalks, branches and leaves, and also rocks and stones, are piled at the base of the rows of hedgerows trees. As the years go by, strong, permanent terraces will be formed which will anchor the precious soil in its right place.

(2) Spacing of Hedgerows

The position and spacing of hedgerows and crops depend on plant species, slope and soil conditions. If the land slopes steeply (e.g., on hillsides) the hedgerows will be spaced closer together. Also, on steep slopes the contour lines should be determined accurately with A-frame.

Recommended spacing for various tilt (for erosion control)

Slope (%)		Space between hedgerows
5 - 10	very gentle slope	18 m
10 - 15	gentle slope	13 – 14 m

Slope (%)		Space between hedgerows
15 - 25	not so steep	9 m
25 - 35	steep	6 m
35 - 50	very steep	4 – 5 m
50 - 60	very very steep	3 m

* Slope 5% means that climb 5m while move 100m horizontally.
25% means that climb 1m while move 4m horizontally.

3. Management of Alley Farming Systems (hedgerow)

Once established, the hedgerows will need to be trimmed (pruned) occasionally. Trimming serves two purposes:

1. Trimming minimizes shading of the companion crop, and
2. Trimming makes leaves and branches available for mulching and firewood.

(1) Trimming techniques

There are two types of trimming methods:

Coppicing:	Trees are cut close to the ground at a height of 30 to 60 cm. New shoots will be produced from the stump.
Pollarding:	Crown of tree is cut back to the height of roughly 2 meters. Re-growth will be beyond the reach of browsing animals.

coppicing **pollarding**

For manual cutting, a sharp knife should be used. A blunt knife that splits up the stem and strips the bark may predispose the trees to disease and delay re-growth.

(2) Trimming schedules

Generally applicable principles of hedgerow trimming are:

- When the hedgerow is established, trimming should be avoided for the first 6-12 months.
- At the time of planting food crops in an established alley farm, the trees should be coppiced to provide mulch and fertilizer for the crop and also to avoid shading crop seedlings.

- Re-growth after the initial trimming may be harvested continuously for feeding livestock, or it may be cut periodically for additional mulching and to avoid shading.
- In total, the hedgerows will be trimmed 3 to 6 times per year.

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References

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- Developing Forage Technologies with Smallholder Farmers: how to select the best varieties to offer farmers in Southeast Asia (ACIAR Monographs MN62 1999)
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Annex : Selected legume tree/shrub for alley farming systems in the 5 model villages

*Selection was made based on the results of CIAT-FSP Project and plants data of TROPICAL FORAGES – FAO.

Scientific name	Vietnamese name	Cool climate	Notes	Propagation
Legumes shrub for hedgerows (not palatable)				
Tephrosia candida *	Cốt khí	Possible but not recommend	Less 2m high, Used for hedgerows in the Project. In PoE and Hieu, it survived the cool season in 2006/2007 but many died in 2007/2008. Not palatable. Chicken do not eat the seeds.	Seed
Legume tree/shrub for animal forage (ruminants)				
Leucaena leucocephala *	Keo dậu	Not OK	Need the protection against animals until tree become tall. 25-30°C for optimum growth, Cease growth at 15°C. Contain mimosine (water soluble toxic amino acid)	Seed
Gliricidia sepium *	Giả anh đào	Not OK	Stems are available in Kon Tum. Possible to make a living fence. Drought tolerant, tolerates repeated cutting Leaves abscise when night temperatures fall below 15ºC	Stem cutting, Seed
Cajanus cajan * (Pigeon pea)	Cây đậu chiều	Not OK	Annual or short-lived perennial shrub, very tolerant of hot conditions, Excellent green manure for improving soil, Not very palatable.	Seed
Flemingia congesta * (*macrophylla)*	Đậu công	Possible	0.5-2.5m high. High drought tolerant, High shade tolerance, Best for 22-28°C, Very poor quality forage for cattle (high fibre & tannin), Palatable to goats	Seed
Desmanthus virgatus	Cây điền keo	Possible	Typically to 0.7 m tall, Poor tolerance of medium to heavy shade, Very tolerant of regular cutting and grazing by ruminants. Quite drought tolerant, Seed has dormancy	Seed
Calliandra calothyrsus	Chưa có tên VN	OK	Grow well on a wide range of soil types, Growing naturally to 1800/2000m	Seed
Legume tree/shrub for animal forage (pig & ruminants)				
Stylosanthes guianensis *	Cỏ Stylo	Possible	Good for Pig, Rabbits also for Fish, 1 – 1.5m high, Best on sands and sandy loams, Good drought tolerance.	Seed
Trichanthera gigantean *		Not OK	Best at mean temperatures of approx. 30°C. Shade tolerance, Can be grown under banana.	Stem cutting

Annex : Photos of legume tree/shrub for alley farming systems

Tephrosia candida



Leucaena leucocephala


Gliricidia sepium




***Cajanus cajan* (Pigeon pea)**


***Flemingia congesta (*macrophylla)**



Stylosanthes guianensis


Trichanthera gigantea