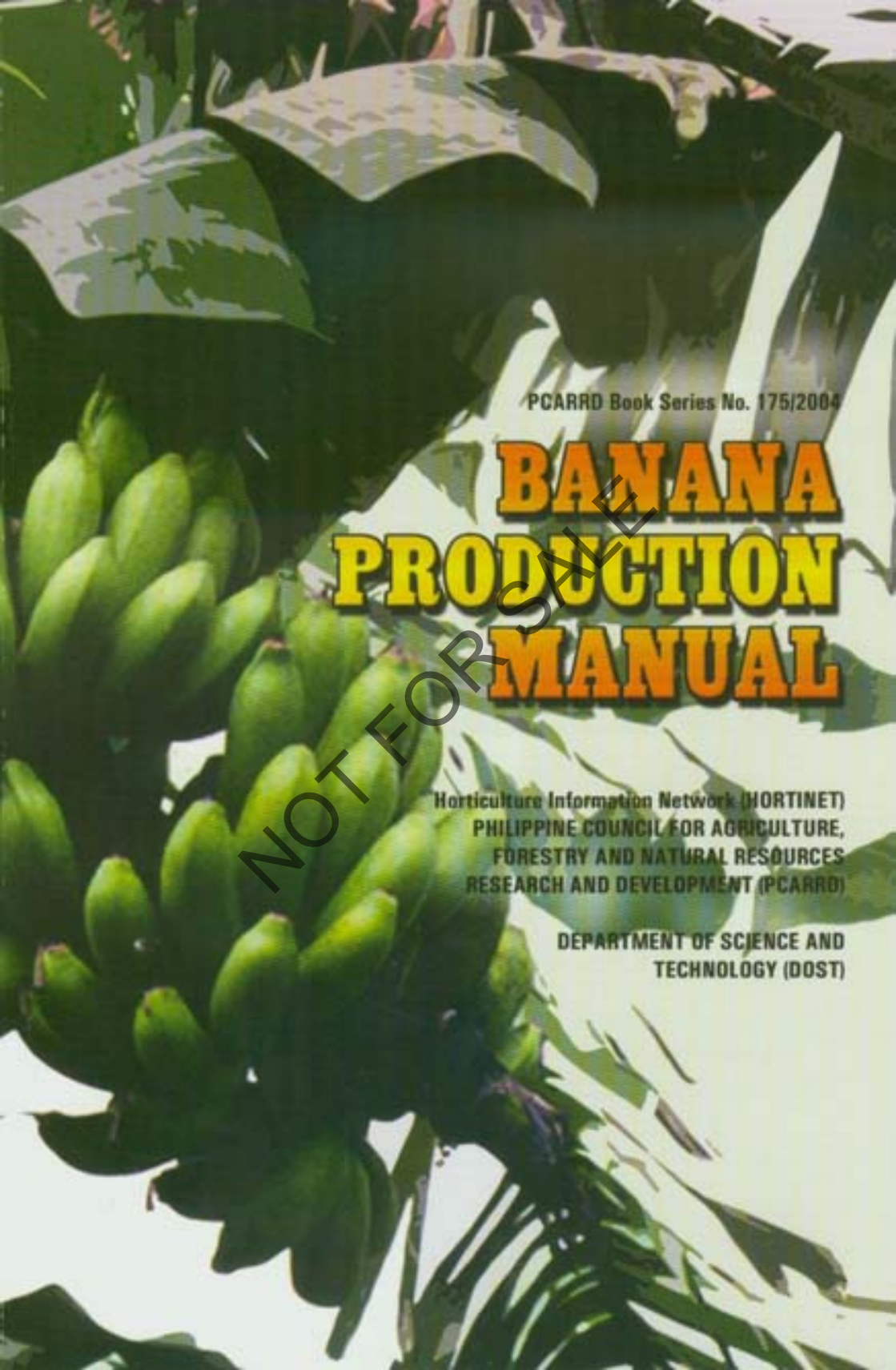

PCARRD Book Series No. 175/2004

BANANA PRODUCTION MANUAL

Horticulture Information Network (HORTINET)
PHILIPPINE COUNCIL FOR AGRICULTURE, FORESTRY AND NATURAL RESOURCES RESEARCH AND DEVELOPMENT (PCARRD)

DEPARTMENT OF SCIENCE AND TECHNOLOGY (DOST)

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OFFICE OF THE EXECUTIVE DIRECTOR

Dear Reader:

This ***Banana Production Manual***, presented in an easy-to-read format, is a package of technology for banana from production to processing. It is an updated version of *The Philippines Recommends for Banana*, first published by PCARRD in 1988. Some of the information on harvesting, postharvest handling and storage, and processing, among other things, were retained for their relevance in the present situation.

The publication, except for the tissue culture laboratory and nursery operation, is specifically for smallholders with less than 20-ha banana farms.

We hope that this manual will guide our banana farmers in improving their farm productivity and help sustain our efforts to further develop the banana production in the country.

You will be assured to receive our future publications if you return the attached acknowledgment receipt. You may also acknowledge the receipt of this publication through e-mail at publications@pcarrd.dost.gov.ph.

Sincerely yours,

PATRICIO S. FAYLON
Executive Director

PCARRD Book Series No. 175/2004

Banana Production Manual

Horticulture Information Network (HORTINET)
PHILIPPINE COUNCIL FOR AGRICULTURE, FORESTRY AND NATURAL RESOURCES RESEARCH AND DEVELOPMENT (PCARRD)

DEPARTMENT OF SCIENCE AND TECHNOLOGY (DOST)

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Foreword

Banana is still the most important fruit crop in the Philippines. It contributes about US$200 million annually, mainly through fresh exports of the fruit. Processed bananas such as chips, crackers, and catsup have also started to contribute dollar earnings.

Eighty distinct banana cultivars are grown in the country. However, aside from the export cultivar 'Cavendish,' only a few cultivars such as 'Lakatan,' 'Latundan,' Buñgulan,' 'Saba,' and 'Señorita' are being cultivated.

In 2001, the country's banana output reached 5 million tons from a total area of 386,782 ha. Many workers are employed in the banana industry, both in the farms and in the processing plants. The commercial farms, which mostly grow 'Cavendish' cultivars, are concentrated in the Mindanao area. Elsewhere in the country are numerous backyard farms, whose produce is mainly destined for the local markets.

PCARRD has long recognized the importance of disseminating generated technologies to banana stakeholders. This *Banana Production Manual* is one of the strategies to inform and guide banana growers in improving their productivity. The information contained in this manual is specifically for growing the banana cultivars mentioned above.

This manual presents the technology package on banana from production up to processing. It follows the style of the sought-after *Mango Production Manual* published by PCARRD's Mango Information Network (MIN) in 1999. This manual came out as part of the expansion of the MIN to a Horticulture Information Network (HORTINET) (http://www.hortinet.pcarrd.dost.gov.ph), starting with banana.

May this manual provide insights and directions for those interested in improving their banana production.

PATRICIO S. FAYLON
Executive Director, PCARRD

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Introduction

Growing Conditions

Banana grows in many soil types and land classifications. However, it is most productive when grown in deep soil with loam, clay loam, or silty clay-loam textures and in flat to undulating terrains. It can thrive at an elevation of 1.5–1,000 m a.s.l. (meters above sea level). It produces sweeter fruits at 600 m and above.

It tolerates a wide range of soil pH, from a strong acidity of pH 3.4 to a medium alkalinity of pH 7.8. However, the ideal soil pH for banana is pH 6.5. Also, banana requires a high soil organic matter content of not less than 2.5%, moderate amount of soil phosphorus of about 24 ppm (parts per million), and large amounts of potassium of about 400–600 ppm. Calcium and magnesium are also critical for a balanced nutrition. Micronutrients such as zinc and boron are deficient in most banana plantations; thus, they should also be closely monitored.

Banana can grow in a wide range of climatic conditions, from Type 1 to Type 4. However, it grows best in areas with a rainfall of 7 mm per day in most nights and with full sunshine during the day, year round, to produce maximum yields with the least production inputs.

Banana is sensitive to waterlogged conditions. It needs a good surface and an internal drainage. The water table must be 100–125-cm deep from the soil surface, with more than 100 cm of sand or gravel layer. It must have a distance of more than 75 cm to a permeable or soft limestone; more than 100 cm to a hard, impermeable rock; and more than 100 cm to a hardpan. It cannot thrive in flooded areas.

Wind speed is critical in banana production. A wind velocity of 95 km/hour can blow down an entire fruit-laden banana plant in a few seconds because of the plant's soft pseudostem (trunk) and heavy bunch. The ideal wind speed is 10–14 km/hour. A 35-km/hour wind speed is tolerable but it may inflict leaf shredding.

Banana Cultivars

The major banana cultivars with selected botanical characteristics in the Philippines (Valmayor et al. 2002) are shown in Table 1.

Table 1. Botanical characteristics of major banana cultivars in the Philippines.

Name	Planting to Harvest	Pseudostem Height (m)	Weight (kg) of Bunch	No. of Hands	Weight (kg) of Hand	No. of Fingers/ Hand	Length/ Diameter of Finger (cm)	Peel Color
'Buñgulan'	12 mo[a] 6 days	2.8–3.2	14–16	8–10	1.7–2.7	14–22	14–16/ 3.4–3.3	Yellow-green when ripe
'Cavendish'								
- 'Grand Naine'	11–13 mo	1.6–2.3	16–60	6–16	2.2–4.0	16–30	13.5–16.0/ 3.5–4.5	Green-yellow when degreened
- 'Giant Cavendish'	11–13 mo	4.5–5.0	17–60	6–18	2.2–4.0	16–30	13.5–6.0/ 3.5–4.5	Green-yellow when degreened
'Lakatan'	12–13 mo 21 days	2.7–2.8	13–15	7–8	1.3–1.8	12–16	13–14/ 3.5–4.0	Orange-yellow when ripe
'Latundan'	12 mo 4 days	2.7–2.9	11–12	7–8	1.2–1.6	12–16	10–12/ 3.4–4.0	Straw yellow when ripe
'Saba'	21 mo 14 days	4.5–5.0	26–28	9–11	2.1–3.2	15–22	12.5–13.0/ 4.2–4.4	Yellow when ripe
'Señorita'	15 mo	2.1–2.9	4.6–5.0	5–6	1.0–1.4	14–20	16.0–16.2/ 3.2–3.3	Yellow-orange when ripe

[a]Month.

Propagating the Planting Materials

Farmers can produce their own planting materials or they can buy from reliable banana nurseries. For those who may wish to produce their own planting materials, they can grow bananas by the conventional method (e.g., corms, suckers, seed pieces, and ball heads) (Fig. 1) or by tissue culture.

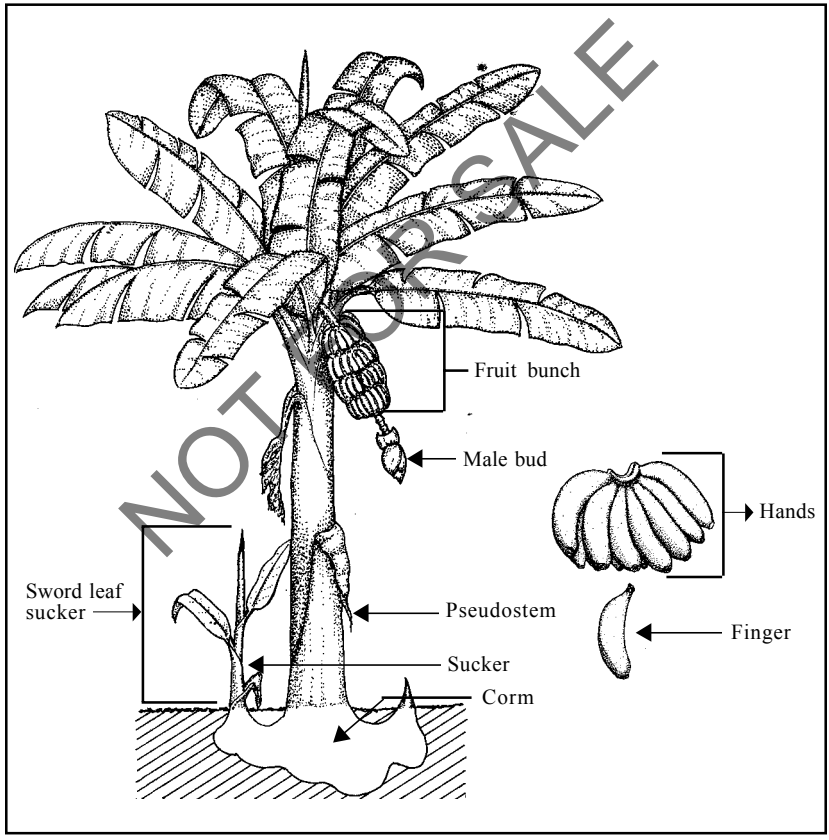

Fig. 1. The banana plant (Valmayor et al. 2002).

Conventional Method

Corm Digging or Desuckering

Sucker extraction and corm digging must be strictly supervised to minimize the loss of planting materials and avoid unnecessary injury to the mother plant and to the other suckers within the mat. Fertilization must immediately follow.

Technology

For suckers

- Select only the sword leaf suckers—those with narrow leaves, big corms, and are about 60-cm tall.
- Detach the sucker from the mother plant using a desuckering bar, then remove all the roots.

For whole corms

- Select plants with corms that are at least 2 kg.
- Dig the corms with a desuckering bar and remove the roots. Leave about 20 cm of the pseudostem from the base of the corm.

For seed pieces

- Cut the corm into pieces, with each piece/bit bearing at least one good bud.

For ball heads

- Follow the same procedure for corms. However, leave about 1.5 m of the pseudostem from the base of the corm.

In preparing all these materials, cover the hole with soil to prevent the mother plant from tipping over or leaning. Haul the corms to the roadsides for pickup and bring them to a shaded place for treatment.

Requirements (Based on 2002 Prices)

Materials and Equipment

Quantity	Item	Unit Price (₱)	Cost (₱)
1 pc	Shovel	145	145
1 pc	Desuckering bar	250	250
2,005 pc	Suckers/corms/seed pieces or ball heads[a]	5	10,025
1 unit	Tractor-drawn trailer[b]	50,000	50,000
	Total		**60,420**

[a]The 2,000 plantlets are good for 1 ha at a planting distance of 2.5 x 2.0 m. The extra five plantlets are intended for replanting.
[b]Could be used for other operations.

Labor

Activity	Corms/ Man-day (MD)[a]	MD[b]	Cost (₱) /ha
Corm digging	600	3.3	528
Covering holes	1,200	1.67	267
Cleaning and hauling	600	3.3	528
Total			**1,323**

[a]Good for 1 ha.
[b]At 160/MD.

Total cost of corm digging or desuckering operation

Item	Amount (₱)
Materials and equipment[a]	60,420
Labor[b]	1,323
Total	**61,743**

[a]Breakdown of cost of materials and equipment is indicated above.
[b]Breakdown of cost of labor is indicated above.

Treatment of Planting Materials

Planting materials should be treated with certain chemicals to protect them from pests and to ensure their good growth and development.

Technology

The procedure is good for 2,000 corms.

- Cut back the corms to about 6–8 cm long from the tip. However, if the corms are to be transported over long distances or if planting is to be delayed by more than 48 hours, allow an extra 4 cm to be trimmed prior to planting.
- Combine 2.5 kg of fungicide and 276 mL of insecticide with 900 L of water in the treatment tank.
- Fill up the treatment tank to its capacity. Soak the corms in the tank for five minutes; remove and place them in the baskets. Use rubber gloves when treating, mixing, soaking, or retrieving.
- Restore the quantity of chemical solution in the tank by adding water and one-third of the original chemical proportion to maintain the desired potency of the treatment.

Requirements (Based on 2002 Prices)

Materials

Quantity	Item	Unit Price (₱)	Cost (₱)
1 pc	Bolo	140	140
1 unit	Treatment shed (temporary-coconut leaves/bamboo)	200	200
1 unit	Treatment tank (1,200 L capacity)	600	600
4 pc	Baskets	50	200
2 pairs	Rubber gloves	150	300
	Chemicals per 900 L water:		
2.5 kg	Fungicide (Dithane M-45)	110	275
276 mL	Insecticides (Sumithion 50 EC)	240(/L)	67
	Total		**1,782**

Labor

Activity	Corms/MD[a]	MD/ha[b]	Cost (₱)/ha
Cleaning/paring/soaking of corms	600	3.3	462
Retrieving from treatment tanks	1,000	2.0	280
Total			**742**

[a]Good for 1 ha.
[b]At P140/MD.

Total cost of chemical treatment for planting materials

Item	Amount (₱)
Materials[a]	1,782
Labor[b]	742
Total	**2,524**

[a]Breakdown of cost of materials is indicated on page 6.
[b]Breakdown of cost of labor is indicated above.

Total cost of the conventional method of propagation

Item	Amount (₱)
Corm digging or desuckering[a]	61,743
Chemical treatment for planting materials[b]	2,524
Total	**64,267**

[a]Breakdown of cost for corm digging or desuckering is indicated on page 5.
[b]Breakdown of cost for chemical treatment is indicated above.

Tissue Culture Method

The banana shoot-tip culture technique is a rapid clonal micropropagation that produces disease-free plantlets at optimum cost. One banana sucker can produce a maximum of 1,500 plantlets or meristems in eight months. It is a reliable means of mass-producing planting materials for commercial banana farms.

Compared with suckers or corm seed pieces, tissue-cultured plantlets have a higher survival rate at field establishment; more

uniform growth and fruiting; earlier flowering; and relatively higher production.

Technology

The five stages in commercially micropropagating banana plantlets by shoot-tip culture are 1) initiating aseptic culture; 2) multiplying the shoots/buds; 3) rooting; 4) acclimatizing or hardening; and 5) potting out in the nursery. The first three stages are done in the laboratory while the rest are done in the nursery.

Aseptic culture initiation

All the activities on preparing the culture media/explants and sterilizing should be done in the preparation room or laboratory.

Preparing the culture media

- Use the Murashige and Skoog (MS) mineral salt mixture (Table 2) to prepare the culture media. For example, to prepare a 1-L stock of Macro 1 medium, mix the following: 1) 95 g KNO_3; b) 82.5 g NH_4NO_3; and c) 22 g $CaCl_2.2H_2O$. For a 1-L proliferation media, mix 20 mL Macro 1 medium, 20 mL Macro 2, 20 mL Macro 3, 5 mL Micro, 5 mL Fe stock, 5 mL vitamins and amino acid, 2 mL indole acetic acid (IAA), 2.25 mL Benzyl Adenine (BA), 30 g sugar, and 7 g gulaman bars.
- Adjust the pH of the culture media to pH 5.7 by using 1 N NaOH or 1 N HCL. If the pH is low, add a drop of 1 N NaOH while constantly stirring the media. Test the pH. Do it until the desired pH is reached. If the pH is high, add 1 N HCL.

Sterilizing

- Put 20 mL of the culture media into the packet jar. Cover the jar with an autoclavable plastic, securing it with a rubber band. Cover the entire jar with a clean paper, securing it with a rubber band.
- Sterilize the jars in the pressure cooker at 15 pounds per square inch (psi) for 20 minutes. Take out the jars and put in the culture room.

Table 2. Culture media requirements.

Medium	g/stock	Establishment	Regeneration	
		Proliferation	Semisolid	Liquid
		(mL/L media)	(mL/L media)	
1. Macro 1 (MSIa): (50%) – 1L stock		20	20	20
Potassium nitrate (KNO_3)	95.00			
Ammonium nitrate (NH_4NO_3)	82.50			
Calcium chloride ($CaCl_2.2H_2O$)	22.00			
2. Macro 2 (MSIb): (50%) – lL stock		20	20	20
Magnesium sulfate ($MgSO_4.7H_2O$)	28.50			
3. Macro 3 (MSIc): (50%) – 1L stock		20	20	20
Potassium phosphate Monobasic (KH_2PO_4)	8.50			
4. Micro (MSII): (100%) – 0.5 L stock		5	5	5
Manganese sulfate ($MnSO_4.4H_2O$)	2.23			
Boric Acid (H_3BO_4)	0.62			
Potassium iodide (KI)	0.08			
Zinc sulfate ($ZnSO_4.4H_2O$)	0.86			
Sodium molybdate ($Na_2MO_4.H_2O$)	0.025			
Copper sulfate ($CuSO_4.5H_2O$)	0.0025			
Cobalt chloride ($CoCl_2.6H_2O$)	0.0025			
5. Fe Stock (100%)- 0.5 L Stock		5	5	5
Ferrous sulfate ($FeSO_4.7H_2O$)	2.785			
NaEDTA.$2H_2O$	3.725			
6. Vitamins and amino acids (100% - 0.5L stock)		5	5	5
Glycine	0.2			
Thiamine HCl	0.04			
Pyridoxine HCl	0.05			
Nicotinic acid	0.05			
7. IAA:0.175 ppm (100 mL stock)	0.00875	2		
8. NAA:0.186 ppm (100 mL stock)	0.0093		2	2
9. BA:4.5 (establishment) – 100 mL stock	0.2	2.25	0.12	
:0.225 ppm (reagent) – 100 mL stock				
10. Sugar		30 g	20 g	20 g
11. Activated charcoal			0.25 g	0.25 g
12. Gulaman bars		7 g	6 g	

Preparing the explants

- Use gloves in washing the corms/suckers under tap water. Trim the roots, outer leaf sheaths, and corms, leaving about 2.5 cm^3 of the corms with the shoot tip or apex.
- Place the trimmed corms in a clean polyethylene bag (good enough for 10 corms).
- Wash the trimmed corms with soap solution. Rinse, drain, and soak in 30% commercial bleach (1.57% NaOCl) for 30 minutes. If the intention is to use 5–6 cm-sized corms, soak them in 90% commercial bleach for 30 minutes.
- Decant the bleach solution.

Establishing the initial culture

- In the culture room, cut the corms further into 1 cm^3. Make sure that the cube still contains the shoot apex.
- Cut the shoots longitudinally to produce explants containing the shoot tip and inoculate them into the culture media.
- Place three to four sections or tissues in each jar and incubate at 26°C in the culture shelves.
- Expose to artificial light for 16 hours daily for four weeks inside an air-conditioned room. Make sure to maintain the required temperature.

Multiplying the shoots/buds

- After three weeks, when the explants have already proliferated, subdivide the shoot cluster into two or four sections depending on the size.
- After another three weeks, examine the culture. Subculture again. Subculture up to eight cycles at a three-week cycle each.

Rooting

- For rooting, transfer the bigger shoots individually into milk bottles containing either a solid or liquid rooting medium. For the rooting medium, add a rooting hormone like IAA. For small clusters of shoots/buds, inoculate back into the multiplication medium until they can be transferred to a rooting medium.

- Incubate the subcultures at 26°C for 16 hours daily for two weeks.
- Control insect pests such as aphids, mites, and mealybugs by spraying with insecticides every two weeks. Prevent the spread of leaf diseases such as Sigatoka and leaf spots by sanitizing the stems and leaves, roguing the infected plants, or spraying with fungicides.
- Water the plants whenever necessary.
- Expose the plants gradually to full sunlight within four weeks before field establishment.

Requirements for the tissue culture laboratory

The operation of a tissue culture laboratory cannot be dissociated from the nursery operation. Meristems produced in the tissue culture laboratory are reared in the nursery before they can be transplanted after two or three months. Most of the personnel, fixtures, furniture, equipment, facilities and space are shared among the laboratory, the nursery, and the office. Manpower requirement is shown in Appendix 1.

Requirements (Based on 2002 Prices)

Laboratory Equipment/Apparatus

Item No.	Qty.	Unit	Item	Unit Price (₱)	Cost (₱)
1	1	set	Distilling apparatus	195,000	195,000
2	1	set	Analytical balance	166,980	166,980
3	1	set	Double laminar flow hood	150,000	150,000
4	1	set	Toploading balance	80,000	80,000
5	1	unit	pH meter	45,000	45,000
6	1	unit	Hotplate magnetic stirrer	35,000	35,000
7	4	unit	Pressure cooker	28,000	112,000
8	1	set	Computer with printer	25,000	25,000
9	4	unit	Air conditioner (2 hp)	23,000	92,000
10	1	unit	Refrigerator (20 cu ft)	12,000	12,000
11	1	unit	Mobile phone	4,000	4,000
12	1	unit	Fire extinguishers	4,000	4,000
13	5	unit	Wood box transfer chambers	3,500	17,500
14	1	unit	Land line telephone	3,000	3,000
15	3	pc	Office table	2,500	7,500
16	1	unit	Heavy duty gas stove	2,500	2,500

Item No.	Qty.	Unit	Item	Unit Price (₱)	Cost (₱)
17	2	unit	Refillable gas tank (50 kg cap)	2,500	5,000
18	1	pc	Volumetric flask (2,000 mL Pyrex)	2,100	2,100
19	1	set	Stove accessories	2,000	2,000
20	2	pc	Beakers, plastic (5,000 mL)	1,500	3,000
21	2	pc	UV lamp tube (30 watts)	1,350	2,700
22	1	pc	Volumetric flask (1,000 mL Pyrex)	1,300	1,300
23	6	pc	Adjustable propagator's chair	1,250	7,500
24	6	pc	Office chairs	1,200	7,200
25	8	pc	UV lamp tube (15 watts)	1,200	9,600
26	6	pc	Scissor forceps	1,200	7,200
27	6	pc	Stool (high chair 0.68 m)	1,000	6,000
28	6	pc	Amber bottles (3L cap)	875	5,250
29	1	pc	Magnetic stirrer retriever	750	750
30	6	pc	Coupling jar (aluminum)	600	3,600
31	1	pc	Respiratory gas mask	550	550
32	3	pc	Beakers, plastic (2,000 mL)	510	1,530
33	1	pc	Graduated cylinder, clear (1,000 mL)	507	507
34	2	pc	Casserole (30 L cap)	500	1,000
35	3	pair	Scissors	450	1,350
36	3	pc	Aluminum stirring rod (0.30 m)	350	1,050
37	6	pc	Laboratory gown	350	2,100
38	2	pc	Knife	350	700
39	3	pc	Beakers, plastic (1,000 mL)	292	876
40	1	pc	Scotch tape dispenser	250	250
41	4	pc	Chopping board	250	1,000
42	2	pc	Slashing bolo	200	400
43	2	pc	Tumbling bolo	200	400
44	1	pc	Puncher	180	180
45	2	pc	Pipette (50 mL)	180	360
46	2	pc	Pipette (10 mL)	175	350
47	8	pc	Carbuoy alcohol lamp (20 L cap)	160	1,280
48	3	pc	Goggles	160	480
49	12	pc	Apron	150	1,800
50	2	pc	Clear graduated cylinder (10 mL)	125	250
51	3	pc	Sharpening stone	125	375
52	3	pc	Heavy duty stapler	120	360
53	15	pc	Plastic trays	80	1,200
54	6	pc	Atomizer	75	450
55	12	pc	Fluorescent tubes (20 watts)	70	840
56	6	pc	Thumb forcep	70	420
57	6	pc	Surgical blade handle no. 4	55	330
58	15	pc	Cap	40	600

Item No.	Qty.	Unit	Item	Unit Price (₱)	Cost (₱)
59	3	pc	Staple remover	20	60
60	5,000	pc	San Miguel packet jars (0.18 L)	7	35,000
61	5,000	pc	San Miguel packet jars (0.12 L)	6	30,000
62	7,000	pc	Magnolia bottles (nos.1–3)	6	42,000
63	24	pc	Mask	5	120
			Total		**1,142,848**

Supplies

Item No.	Qty.	Unit	Item	Unit Price (₱)	Cost (₱)
1	25	kg	Agar-agar	1,500	37,500
2	1,500	L	Coco water	10	15,000
3	2,500	pc	Test tube rubber stopper	5	11,250
4	1	set	Assorted office supplies	10,000	10,000
5	1	drum	Ethyl alcohol	9,500	9,500
6	1,500	pc	Corms/suckers	5	7,500
7	100	gal	Purified water	60	6,000
8	1	unit	Fectant-3	5,500	5,500
9	4	load	LPG (50 kg)	1,300	5,200
10	1	roll	Welded mesh wire 0.6 cm eye	5,000	5,000
11	50	kg	Detergent powder	60	3,000
12	1	roll	Heavy duty welded mesh wire 2.5 cm eye	3,000	3,000
13	2	bag	White sugar	1,350	2,700
14	3	roll	Surgical gauze (0.9 x 91.4 m)	750	2,250
15	25	roll	Cotton (400 g)	80	2,000
16	10	kg	Rubber band	175	1,750
17	1	pc	Surgical blade no. 22	1,200	1,200
18	25	bot	Rubbing alcohol (70% isopropyl 500 mL)	45	1,125
19	100	kg	Scratch paper	10	1,000
20	6	pc	Leather slippers	150	900
21	10	gal	Zonrox	60	600
22	3	cone	Crochet thread	135	405
23	5	pack	Flat tissue paper	65	325
24	6	pc	Household gloves	48	288
25	12	pc	Towel	24	288
26	10	pc	Bottle brush	25	250

Item No.	Qty.	Unit	Item	Unit Price (₱)	Cost (₱)
27	10	pc	Rubber slippers	25	250
28	2	roll	Heavy duty aluminum foil	120	240
29	10	pc	Disposable lighter	15	150
30	2	pack	Precut tissue paper	65	130
			Total		**134,301**

Chemicals[a]

Item No.	Qty. (in bottle)	Unit	Item	Unit Price (₱)	Cost (₱)
1	10	500 g	Ammonium nitrate	1,025	10,250
2	10	500 g	Potassium nitrate	1,025	10,250
3	1	1 kg	Sodium EDTA	10,000	10,000
4	1	100 g	Biotin	9,420	9,420
5	1	1 g	Benzyl adenine	9,420	9,420
6	1	1 g	Folic acid	5,760	5,760
7	3	25 g	Thiamine HCl	1,690	5,070
8	3	25 g	Naphthalene acetic acid	1,500	4,500
9	6	500 g	Zinc sulfate	667	4,002
10	1	100 g	Myo-inositol	3,810	3,810
11	1	500 g	Cobalt chloride	3,187	3,187
12	1	1 kg	Activated carbon powder	2,500	2,500
13	1	1 kg	Potassium permanganate	2,400	2,400
14	1	25 g	Pyridoxine HCl	2,362	2,362
15	1	100 g	Glycine	2,280	2,280
16	3	500 g	Magnesium sulfate ($MgSO_4.7H2O$)	620	1,860
17	3	500 g	Calcium chloride	612	1,836
18	1	500 g	Sodium molybdate	1,830	1,830
19	1	500 g	Potassium iodide	1,800	1,800
20	1	1 L	Buffer solution no. 6	1,800	1,800
21	1	23 g	I-NAA	1,740	1,740
22	2	500 g	Potassium phosphate	862	1,724
23	2	2.5 L	Formalin AR (formaldehyde)	840	1,680
24	2	2.5L	Hydrochloric acid	712	1,424
25	1	100 g	Nicotinic acid	1,400	1,400
26	2	500 g	Boric acid	650	1,300
27	1	1 L	Buffer solution no. 4	1,026	1,026
28	1	1 L	Buffer solution no. 7	1,026	1,026
29	1	500 g	Copper sulfate	960	960
30	1	2.5 L	Acetone	712	712

Item No.	Qty. (in bottle)	Unit	Item	Unit Price (₱)	Cost (₱)
31	1	100 g	Magnesium sulfate ($MgSO_4$.4H2O)	576	576
32	1	500 g	Sodium hydroxide	500	500
33	1	50 g	Ferrous sulfate	160	160
			Total		**108,565**

[a]All chemicals quoted are in the smallest packaging.

Establishing a Banana Nursery

In the Philippines, banana corms or suckers are not normally produced in nurseries. They are usually ordered and bought from banana farms at a designated time. No information on nurseries maintained specifically for corms or suckers is available.

The banana nursery discussed here is specifically for tissue culture plantlets. Clients can modify some requirements if there is a need to set up a nursery for corms or suckers.

Once the decision to establish a commercial banana farm is made, it becomes necessary to put up a nursery as a year-round source of planting materials. The planting materials may be meristems that are produced in a tissue culture laboratory or suckers and seed pieces from corms. Meristems are reared for two to three months in the nursery before being planted on the farm.

The nursery area is about 2,900 m^2. It has a hardening area, pathways/canals, a bagging area, and an office/bodega. It can be made of either a bamboo framework or G.I. (galvanized iron) pipes that will have a capacity of 100,000 plantlets per month. It must have good ventilation, a good source of water, and good drainage. It must be located in an exposed area that is not too far from the laboratory. The laboratory should not be located along the roadways.

Technology

Roofing and Netting

- Use bamboo poles as posts and beams. For the long term, use G.I. pipes (2.5 cm and 5.1 cm). The distance between posts should be 5 m for G.I. pipes or 2.5 m for bamboo poles.

- Construct the roof with a 2.4-m height.
- Use fishnets in four layers.

Flooring Materials

- Put gravel and sand (3–5-cm thick) over the topsoil for flooring.
- Provide enough walkway.
- Elevate the floor at least 10 cm from the level of the walkway.

Acclimatizing or Hardening the Tissue Culture Plantlets

- Place the subcultures in a screen house with 80% shade. Harden rooted cultures for one week.

Potting Out in the Nursery

- Prepare the potting media using the following: a) 1 part coir dust plus 5 parts decomposed sawdust or b) 5 parts sawdust plus 1 part rice hull plus 1 part compost. Fill the plastic (black) bag with soil mixture to capacity.
- Bag out rooted shoots when they have three to four expanded leaves, generally after four to six weeks in the rooting medium.
- Carefully remove the hardened plants from the jar. Wash thoroughly to remove the media residues. Sort out according to size and place in a tray.
- Prepare a systemic fungicide (e.g., Aliette) solution in an appropriate container. Dip the roots of the plantlets quickly and allow the residues to drip in the same tray.
- Plant the medium- and large-sized (up to 12.7 cm) plantlets in the prepared plastic bag. For small plants, prick in trays containing sterilized potting media. Place all the plantlets in a nursery with a net.
- Leave the small plantlets in the nursery for another 10–15 days, and plant.
- Water the plantlets at the establishment stage as this stage is critical. Do not over water to prevent rotting.

Fertilizing

- Apply fertilizer a month after planting following the table below.

Age (week)	Fertilizer	Frequency	Mixture	Method of Application
1	No fertilization			
2–3	Foliar	twice a week	1 tbsp/L water	spraying
	Foliar (19-19-19)	once a week	5 g/L water	drenching
4	Foliar (19-19-19) or	once a week	5 g/L water	spraying or drenching
	Solid (14-14-14)	once a month	3 g/bag	topdressing

Managing Pests

Chemical[a]	Frequency	Mixture	Time of Spray Application
Captan 50 WP	once a week	2 g/L	Early morning and late afternoon
Dithane M-45	once a week	2 g/L	Early morning and late afternoon
Decis	once a week	0.5 mL/L	Early morning and late afternoon
Malathion	every 2 weeks	1.2 mL/L	Early morning and late afternoon

[a]The brand names given above are only examples of many other recommended fungicides and insecticides. Use banana oil or stickers to improve the effectivity of the pesticides.

Requirements (Based on 2002 Prices)

Labor, Materials, and Rental

Quantity	Item	Unit Price (₱)	Cost (₱)
Rental	Nursery area (2,900 m^2)		5,000
	Construction materials:		
250 pc	Bamboo posts (2.5 x 2.5 m)	30	7,500
200 pc	Bamboo beam/rafter (10 m)	25	5,000
24 rolls	Net (orchid net) 90 m/roll	2,500	60,000
3 kg	Nylon twine	220	660
10 kg	Tie wire no. 12	40	400
4 kg	Common nails no. 2	27	108
	Total		**78,868**

Structure and Facilities

Item	Cost (₱)
Construction of nursery area	5,000
Raised plantlet beds or plots	2,500
Sections containing growth medium, blending and bagging, store room, office/rest house	50,000
Rest room (labor and materials)	10,000
Total	**62,500**

Equipment and Tools

Quantity	Item	Unit Price (₱)	Cost (₱)
4 pc	Wheel barrow	2,000	8,000
4 pc	Shovel	300	1,200
2 pc	Rake	250	500
2 pc	Bolo	200	400
3 pc	Grass hook	150	450
1 unit	Power sprayer (1 hp)	15,000	15,000
1 unit	Weighing scale (25 kg)	1,200	1,200
	Total		**26,750**

Supplies and Materials

Quantity	Item	Unit Price (₱)	Cost (₱)
25,000 pc	Black bags (15.2 x 15.2 x 0.003 cm)	0.50	12,500
300 bags	Coir dust	30	9,000
3 pc	Plastic drums	800	2,400
3 pc	Complete fertilizer (14-14-14)	400	1,200
20 kg	Crop Giant (19-19-19)	94	1,880
1 L	Decis	1,200	1,200
20 kg	Captan 40EC	350	7,000
1 L	Malathion	240	240
1 L	Lorsban	365	365
10 L	Algafer	115	1,150
1 L	Karate	915	915
20 kg	Dithane	350	7,000
2 pairs	Rubber boots	250	500
2 pc	Gas mask	300	600
	Total		**45,950**

Labor Requirements for Nursery Operation

The requirements are already subsumed in the laboratory portion.

Operating a Tissue Culture Laboratory, a Nursery, and an Office

The cash flow for operating a commercial tissue culture laboratory that can produce 25,000 meristems per week and a complementary nursery that can accommodate 100,000 at any given time is given in Appendix 1. If the plan is to establish a smaller laboratory and nursery of about one-fourth the capacity of the given model, the cost of the laboratory hardware may be reduced. The glassware, chemicals, laboratory and nursery supplies, and manpower may also be reduced proportionally.

Establishing a Banana Farm

Before establishing a banana farm, which may range from a backyard to a 20-ha farm, it is best to do the following:

- Determine the suitability of the prospective site by getting the necessary requirements such as climatic data; rainfall distribution; soil analysis; and soil properties such as depth, texture, and pH.
- Conduct a feasibility study to serve as a guide on the anticipated cost of establishing a banana farm, payout time, and expected profit.
- Prepare a plantation layout that includes drainage and irrigation; road network; building that will serve as a packinghouse; office and accommodation for farm personnel; and a communication system.
- Check labor availability.

The following services can be contracted out at a cost of ₱2,500: sketch of property; physical and chemical analysis of soil sample; topographic survey and soil classification; and farm layout.

Establishing a Drainage System

Bananas require adequate drainage. A drainage system is important in waterlogged areas. A good drainage system enhances soil aeration and provides adequate oxygen in the root zone, preferably at a depth of 1.2–1.5 m. It gets rid of flood and stagnant water at the soil surface, reducing yield losses (Figs. 2, 3, and 4). It is also used to impound water during prolonged dry spells (Fig. 5). Hence, the drainage system must be maintained regularly (Fig. 6).

A good drainage enhances the uptake of soil nutrients; prevents leaf- and soil-borne diseases; and aids in developing better roots and in producing quality fruits.

Fig. 2. A flooded banana farm.

Fig. 3. Twisted fingers, hands, and bunch and "bunching" because of more than 48 hours of flooding.

Fig. 4. An aborted bunch as a result of prolonged floods of 48 hours or more.

Fig. 5. A minidam (left) to impound water in a drainage canal, and an adequate supply of impounded water (right) during El Niño.

Fig. 6. A well-maintained drainage canal.

Technology

A drainage system has the following: primary or main canals, secondary canals, tertiary canals, and supplementary ditches. The supplementary ditches are designed to drain very small areas not indicated in the topography map. Table 3 shows the characteristics of each type.

Requirements (Based on 2002 Prices)

Labor

For installation

Activity	Cost (₱)/ha
Main canal excavation	11,000
Secondary canal excavation	10,000
Tertiary canal excavation	9,787
Tertiary canal soil spreading	2,900
"Boquete" excavation/silted stagnant water	2,333
Total	**36,020**

Table 3. Characteristics of drainage system types.

Indicator	Primary or Main Canals	Secondary Canals	Tertiary Canals	Supplementary Ditches
Spacing	Usually spaced 800 m apart, but may be more or less, depending on the terrain, soil texture, topography, rainfall, and other environmental conditions	Generally 400–600 m apart depending on soil properties and land conditions	From 20 to 100 m apart depending on soil properties and land conditions	Depends on soil surface gradient
Direction	Depends on land physiography	Preferably at right angles to the main canals. However, it may vary depending on the terrain of the area	At right angles to the secondary canals	Depends on the local topography and the spacing
Ratio of depth to width	1:1	1:1	1.5:1–1:1	1:0.5–1:1
Depth	Usually 4–5 m but of sufficient depth to allow approximately 1.5 m at the end of tertiary canals	Normally about 3 m	To provide the minimum 1.5-m drainage	About 1.5 m or less depending on the area to be drained
Gradient	From 0.05% to 0.25% (i.e., 0.5–2.5 m per 1,000 m of length)	From 0.05 to 0.25%	About 0.05% depending on topography	Depends on local topography

For maintenance (deepening)[a]

Component	m^3/MD	Cycles/ Year	Cost (₱)/ha per Cycle	Total Cost (₱)/ha per Year
Primary canal	9	2	320	640
Secondary canal	10	2	480	960
Tertiary canal	13	2	1,600	3,200
Total				**4,800**

[a]Deepening covers side slashing and a minimum depth of 0.30 m of silt, soil, and trashes.

Total cost of drainage installation and maintenance

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Labor				
For installation[b]	36,020	-	-	-
For maintenance[c]	4,800	5,280	5,808	6,388
Total	**40,820**	**5,280**	**5,808**	**6,388**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost for installation is indicated on page 23.
[c]Breakdown of cost for maintenance is indicated above.

Clearing and Preparing the Land

Land preparation maximizes the potential of the land in producing quality banana fruits over a long time (Fig. 7). It is accomplished by ripping (sub soiling), plowing, and harrowing to improve soil conditions.

For smallholders farming 1 ha or less, heavy equipment is not necessary; animal-drawn plowing and harrowing will suffice. In sloping areas, clearing the area and digging planting holes will suffice.

Moreover, the drainage system should be laid out and installed before land cultivation.

Technology

- Remove or burn all trees and logs. Other nonwoody plants should be cut into small pieces and plowed into the soil.

Fig. 7. Preparing the land and staking the banana plants.

- Lay out, by using markers, the road network, including the drainage system.
- Level the irregular soil surface and provide slight slope areas to avoid water ponding.
- Use a ripper in ripping or subsoiling in the center of the block, between the two tertiary canals. Finish ripping along the tertiary drainage canals to ensure a more uniform land level and prevent water ponding.
- Harrow the land once to incorporate the applied soil ameliorants (e.g., lime).
- Establish the road network of the banana farm by bulldozing.

Requirements (Based on 2002 Prices)

The equipment to establish the road network and drainage system described in Table 4 can be rented. However, the whole operation can be done manually or by hired labor.

Table 4. Equipment needed to establish a road network and a drainage system.

Equipment	Description	Use
D-7 caterpillar, K-10 Hanomag or equivalent[a]	With dozer blade attachment to remove trees or logs from the area to be planted	Land clearing
Towner harrow[a]	A serrated 4-gang disc (0.51 m diameter to knockdown and uproot herbaceous plants)	Clearing and final plowing
Stump cutter[a]	A heavy-framed 2-gang implement consisting of 0.8 m diameter blades spaced at 0.3 m. The rear seven blades are arranged in such a way that each blade is in between the two blades of the front gang.	Chopping herbaceous and small woody plants into small pieces
Disc plow[a]	A 6-bottom overhead with a disc diameter of 0.8 m, provided with individual disc scraper, land and furrow wheels, and a drag to level the pulverized soil	Plowing, pulverizing soil, and final plowing
Davis plow[a]	A 6-disc gang implement that can also be used for uprooting of corms	Plowing, uprooting, and knocking down weeds
Heavy duty plow[a]	A single moldboard plow with a length of 2.2 m weighing about one ton Depth of cut = 0.66 m–0.81 m Width of cut = 0.76–0.91 m Tractor speed = 2nd to 3rd gear Plow rate/hour = 0.25 ha	Plowing
Animal-drawn plow and harrow		Plowing and harrowing

[a]Applicable to medium- and large-size farms or plantations.

Manpower

Activity[a]	Cost (₱)/ha
Dozing/leveling/sloping	32,785
Ripping	10,000
Moldboard plowing	4,000
Harrowing	2,582
Road clearing	1,813
Total	**51,180**

[a]The amount includes both the rental of equipment and manpower cost.

Lining and Staking

Bananas are planted in various planting patterns to ease movement inside the farm and to maximize the plants' exposure to sunlight. Lining is done to achieve straight-row planting and straight spacing between plants in a row at any given planting pattern. Lining allows convenience in predetermining the actual number of hills per unit area.

Technology

- Use a transit and nylon twine or wire, premarked or knotted at a predetermined planting distance.
- Mark each planting spot with a stake to guide the planting crew. Orient the rows along drainage canals, cable ways or road networks, or perpendicular to the path of the sun, from sunrise to sunset.
- Use a nylon twine to establish two base lines that are perpendicular to each other (for small farms). Put a reference stake at one corner of the land at half the predetermined planting distance from the fence. Tie one end of the nylon twine that is knotted at a predetermined planting distance and extend the other end up to the opposite side of the land. Do the same for the second twine toward the other side of the land, forming a right angle. Stake the knotted parts of the twines and use these as references in staking the other rows.

- Choose the planting pattern or plant arrangements (Fig. 8) from the following:

  For smallholders
  - Rectangular system – when using bamboo props
  - Square system

  For mechanized plantation
  - Double-hedge rows – when using aerial props and cable, fertigation, tractor-drawn, or power sprayer

- Choose the number of plants per hill from the following:

  - Single plant per hill (for double-hedge rows)
  - Alternate single and double plants per hill (for rectangular and square system)
  - Triple plants per hill (along roadsides and canals)

- Estimate the planting distance depending on the following:

  - Variety or cultivar (for tall varieties like 'Saba,' 'Giant Cavendish,' and 'Lakatan,' wider distance; for dwarf varieties like 'Grand Naine' and 'Dwarf Cavendish,' closer distance)
  - Soil type or land class (the poorer the soil type like sandy/ infertile soil, the closer the distance; the more fertile the soil, the wider the distance)
  - Planting pattern (the distance between double-hedge rows is wider than the distance between plants; for the rectangular system, the distance is wider between rows and the distance is closer between plants in the row; for the square system, the spacing is equidistant)

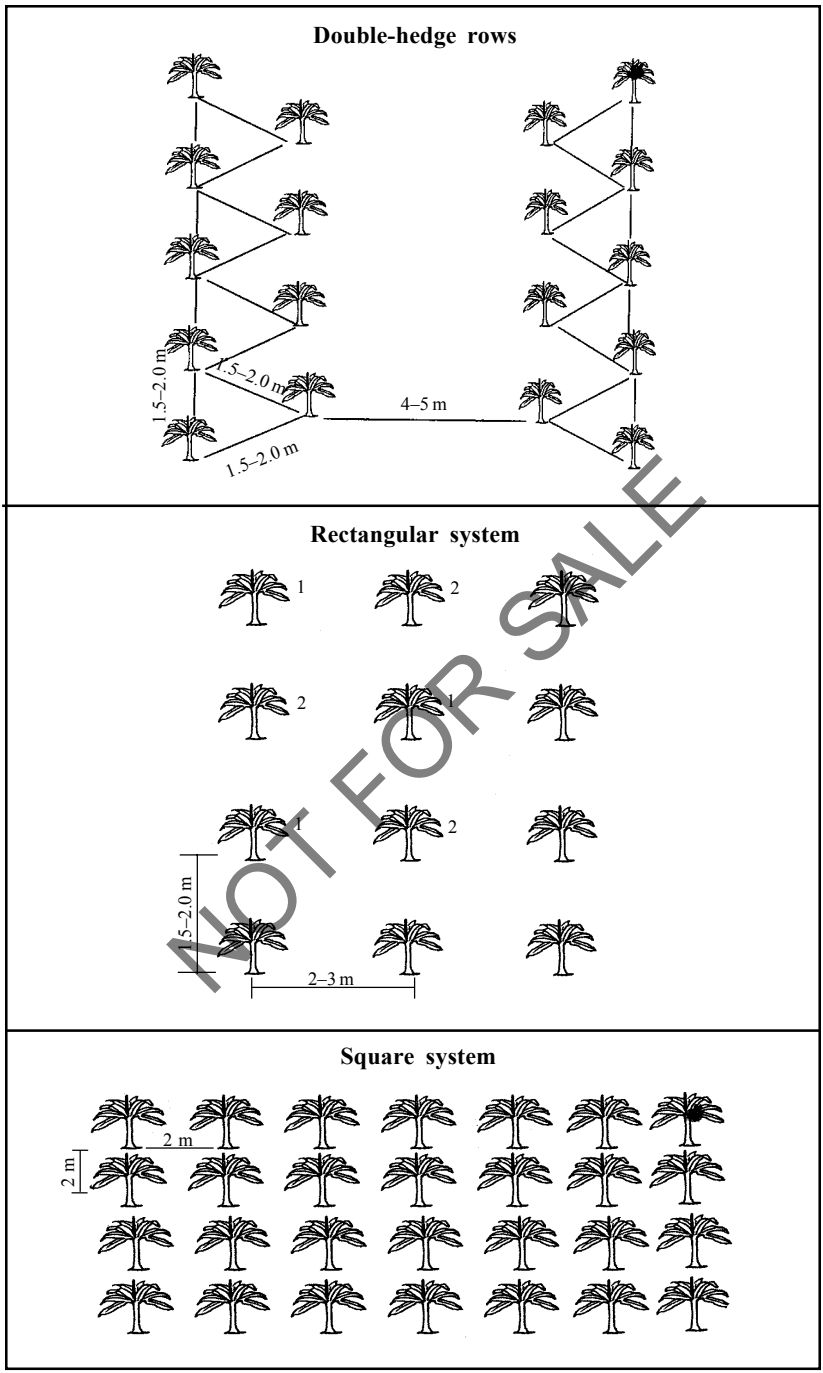

Fig. 8. Systems of growing banana.

Requirements (Based on 2002 Prices)

Supplies and Materials

Quantity	Item	Unit Price (₱)	Cost (₱)
1 pc	Steel tape	150	150
1 kg	Polyethylene twine	76	76
2,000 pc	Bamboo stakes (1.0 m)	0.02	40
1 pc	Triangular frame (30 x 40 x 50 cm)	50	50
	Total		**316**

Labor

Activity	MD)/ha	Cost (₱)/MD	Cost (₱)/ha
Lining and staking[a]	4	160	640
Total			**640**

[a]Two line men and two stakers.

Total cost of lining and staking operation

Item	Amount (₱)
Supplies and materials[a]	316
Labor[b]	640
Total	**956**

[a]Breakdown of cost of supplies and materials is indicated above.
[b]Breakdown of cost of labor is indicated above.

Planting

One of the most important cultural practices that determine the ultimate outcome of a banana farm is the technique of planting. Healthy and strong tissue-cultured plantlets or appropriately treated corms and suckers must be used.

Technology

- Start planting as soon as the drainage system is established and the land preparation is completed.
- Follow the following planting distances, considering the variety to be planted, and the land classification: 1.5–2.0 m between plants in a row; 2.0–3.0 m between rows; and 4.0–5.0 m between double-hedge rows. These specifications may yield a population density ranging from 1,667 to 3,333 plants per hectare.
- Plant at the start of or during the rainy season; also if irrigation is available.
- Dig the planting holes of about 30–40 cm^3. Prepare 2 kg of compost or organic fertilizer and 0.33 kg of the recommended ameliorants (i.e., 0.22 kg of calcic lime and 0.11 kg of dolomitic limestone) and mix them with the soil in the hole.
- For tissue-cultured plantlets, prepare 1–2 kg of organic fertilizer plus 0.2 kg of the recommended inorganic fertilizers (ammonium sulfate–20% N; super phosphate–20% P_2O_5; and muriate of potash–60% K_2O), and 0.33 kg of ameliorants.
- Haul early the required quantity of planting materials to the field. Leave the remaining planting materials in the nursery for replanting.
- Distribute the planting materials in strategically located areas so that planters can readily access them. Cover the planting materials with appropriate materials to protect them from excessive heat.
- Distribute the planting materials on each stake.
- Properly place the planting material into the hole, cover it with soil to not more than 6 cm, and firm it up with the foot.

Requirements (Based on 2002 Prices)

Supplies and Material

Quantity	Item	Unit Price (₱)	Cost (₱)
2,005 pc	Plantlets	12	24,060
2 pc	Spades or shovels	200	400
5 pc	Calibrated containers	20	100
5 pc	Bucket (37.8 L)	160	800
	Fertilizers[a]:		
4 t	Farm manure	2,400	9,600
4.4 bags	Ammonium sulfate (20-0-0)	270	1,188
1.76 bags	Super phosphate (0–20-0)	240	423
2.2 bags	Muriate of potash (0-0-60)	420	924
	Ameliorants[a]:		
8.8 bags	Calcic lime (35% Ca)	50	440
4.4 bags	Dolomitic limestone	95	418
	Total		**38,353**

[a]The recommended fertilizers and ameliorants will vary depending on soil analysis.

Labor[a]

Activity	MD[b]	Cost (₱)/ha
Hauling, holing, applying fertilizers and mixing with soil inside the planting hole[c]	6.0	960
Distributing planting materials in staked spots	0.5	80
Planting	2.0	320
Total		**1,360**

[a]Requirements to plant 1 ha at a population density of 2,000 hills.
[b]At ₱160/MD.
[c]Hauling 13 bags fertilizers; holing 2,000 holes/ha.

Total Cost of the Planting Operation

Item	Amount (₱)
Supplies and materials[a]	38,353
Labor[b]	1,360
Total	**39,713**

[a]Breakdown of cost of supplies and materials is indicated on page 33.
[b]Breakdown of cost of labor is indicated on page 33.

Replanting

It is normal to have some planting materials that die. They should be replaced within eight weeks so that they can catch up with the initial plants. Off-types like mutants should also be replaced. Replanting restores the desired population density.

Technology

- Determine the number of dead hills.
- Use the remaining plants maintained in the nursery for replanting.

Requirements (Based on 2002 Prices)

Labor

Activity	MD/ha	Cost (₱)/MD	Cost (₱)/ha
Replanting	1	160	160
Total			**160**

Plant Care Operations

Sanitation

Base Cleaning and Ring Weeding

Base cleaning, together with ring weeding, removes the hiding places of insect pests, specially the corm weevils.

Technology

- Remove trash and grasses around the base of the mat within a radius of 0.60–0.75 m.
- Do not cut or damage the mother plant and the followers (suckers).
- Clean the base and ring weed before fertilization, population control, and stem and mat spray operation.

Requirements (Based on 2002 Prices)

Materials/Tools

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per year
2 pc	Sickle	150	300
2 pc	Slashing bolo	200	400
2 pc	Sharpening stones (2.5 x 5.1 x 20.3 cm)	100	200
	Total		**900**

Labor

Activity	MD/ha	Cost (₱) /MD	Cost (₱)/ha per year
Base cleaning/ring weeding[a]	2	160	2,560
Total			**2,560**

[a]At eight cycles per year. This activity is an integral part of controlling plant population, cutting dropped bunches, chopping mediocre bunches, removing dried leaf sheaths, cutting dried stumps (50% rotten), filling dried leaf sheaths/stumps, base cleaning at 1-m radius, and removing other obstacles.

Total Cost of Base Cleaning and Ring Weeding Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	900	990	1,089	1,197
Labor[c]	2,560	2,816	3,098	3,408
Total	**3,460**	**3,806**	**4,187**	**4,605**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of materials/tools is indicated on page 36.
[c]Breakdown of cost of labor is indicated above.

Leaf Pruning or Trimming

Leaf pruning or trimming reduces the source and the spread of the inoculum, especially that of the black leaf streak or Sigatoka. It is done 13 times or more a year depending on disease pressure.

Technology

- Cut all nonfunctional and disease-infected leaves.
- Pile all the cut leaves along the rows at a little distance away from the base of the plant.

Requirements (Based on 2002 Prices)

Materials/Tools

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per Year
1 pc	Pruning knife	150	150
1 pc	Bamboo pole	8	8
Total			**158**

Labor

Activity	MD/ha	Cost (₱) /MD	Cost (₱)/ha per Year
Leaf pruning or Trimming	13	160	2,080
Total			**2,080**

Total Cost of Leaf Pruning or Trimming Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials/Tools[b]	158	174	191	210
Labor[c]	2,080	2,288	2,517	2,769
Total	**2,238**	**2,462**	**2,708**	**2,979**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of materials/tools is indicated above.
[c]Breakdown of cost of labor is indicated above.

Stem and Mat Sanitation

This operation (Fig. 9) gets rid of the habitat of insect pests, particularly aphids, mealybugs, thrips, and corm weevils; exposes aphids, mealybugs, and thrips to heavy rains, direct sunlight, and insecticide sprays that adversely affect their life systems; and improves the look of the farm/plantation.

Technology

- Cut the dried portions of the leaf sheaths left after leaf pruning.
- Cut the base of dried or semi-dried harvest stumps.
- Remove the weeds and debris from the base of the mat to enhance proper growth and to improve fertilizer placement.

Requirements

The requirements for stem and mat sanitation are the same as that of base cleaning and ring weeding.

Fig. 9. Stem (left) and mat (right) spray for the control of aphids and mealybugs.

Stem Sanitation after Harvest

This operation eliminates dead stumps that may harbor pests in the farm. Removing the decayed pseudostem helps destroy the life cycle of pests. This is done regularly at a 45-day cycle or eight times a year.

Technology

- Remove all dried bracts (15 cm from the dried portion) to expose mealybugs and all other insects dwelling inside the bracts.
- Cut carefully the dead stumps using a bar. Avoid inflicting damage to the mother plant and the followers (suckers) while cutting the stumps.

Requirements

The requirements for stem sanitation after harvest are the same as that of base cleaning and ring weeding.

Stem and Mat Spray

Stem and mat spray controls the aphid *Pentalonia nigronervosa* Coq. It is also a supplemental control for mealybugs, scarring beetle, and thrips. This operation requires a power sprayer to cover wider areas in a shorter time and to cope with the required interval between spray cycles. If a power sprayer is not available, a knapsack sprayer may be used.

This operation is done six times a year depending on the degree of pest infestation.

Technology

- Prepare all the materials required (see chemicals under supplies and materials).
- Mix appropriate chemicals (i.e., 7.9 L water, 320 mL Basudin 60 EC, 11.8 mL Sumithion, 17.8 mL Lorsban, and 3.9 mL Decis).
- Spray the pseudostem, starting from the base going up to the base of the leaf petiole, but avoid directly hitting the fruits to prevent possible phytotoxicity. Other precautionary measures include

conducting stem sanitation before stem and mat spraying, mixing spray solution thoroughly; avoiding spraying when there is rain or eminent rain; and avoiding spraying against the direction of the wind.

Requirements (Based on 2002 Prices)

Supplies and Materials

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per Year
1 pc	Drum	600	600
	Calibrated cups[a]		
1 pc	Graduated cylinder (100 mL capacity)	250	250
1 pc	Pail	50	50
	Chemicals:[b]		
320 mL	Basudin 60 EC	462 (/ L)	148
11.8 mL	Sumithion 50 EC	240 (/ L)	3
17.8 mL	Lorsban	1,460 (/gal [4L])	26
3.9 mL	Decis	1,200 (/ L)	5
	Total		**1,082**

[a]Used caps/cans could be used at no cost.
[b]This is intended for a one-cycle operation and sprayed for 2,000 mats.

Equipment

Quantity	Item	Unit Price (₱)	Cost (₱)/ha
1 pc	Knapsack sprayer[a]	6,000	6,000
	Total		**6,000**

[a]Life span is two years.

Labor

Activity	MD/ha	Cost (₱)/MD	Cost (₱)/ha per Year
Spraying[a]	6	140	5,040
Total			**5,040**

[a]Six cycles per hectare per year depending on the degree of pest infestation.

Total Cost of Stem and Mat Spray Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Supplies and materials[b]	1,082	1,191	1,311	1,442
Depreciation of equipment[c]	3,000	3,000	3,300	3,300
Labor[d]	5,040	5,544	6,098	6,708
Total	**9,122**	**9,735**	**10,709**	**11,450**

[a]Assumption: 10% increase in cost per year per hectare except for the depreciation cost that is dependent on the life span of the equipment.
[b]Breakdown of cost of supplies and materials is indicated on page 41.
[c]Breakdown of cost of equipment is indicated on page 41.
[d]Breakdown of cost of labor is indicated above.

Fertilization

Banana requires large amounts of nutrients to produce the desired bunch size and weight. Banana plant nutrition is very essential in producing healthy plants to build up pest resistance and high-quality fruits.

Fertilization supplies and maintains adequate and balanced nutrition of the plant and replenishes the soil nutrients used up by the plants, including losses due to leaching; volatilization; physical, chemical, and biological nutrient fixation; and runoff.

Technology

Field fertilizer trial is the most accurate method of determining the appropriate kinds and amounts of fertilizers to apply. However, this kind of assessment is expensive, laborious, and time-consuming. Rapid, inexpensive, and relatively dependable methods are soil and leaf analyses.

Procedure for Soil Analysis

- Establish permanent sampling stations. For smallholdings, assign permanent sampling rows.
- Collect random samples at least 40–70 cm away from the base of the follower.
- Get a soil sample from the soil surface down to 20 cm and another separate sample at 21–40 cm. Do the same in at least ten locations to represent one soil class or soil group. The groupings will depend on soil texture, soil color, slope, or any other soil-differentiating physical properties.
- Submit 1 kg of one composite sample to the Bureau of Soils and Water Management (BSWM) near the locality or to other soil laboratories for analysis. The soil test value will indicate the kind and amount of nutrient reserve in the soil. Follow the recommendations of the laboratory.

Procedure for Leaf Analysis

- Select the plants that are at shooting to bending stage.
- Get the leaf lamina (third youngest fully opened leaf) on both sides of the midrib at the midsection of the leaf. Take leaf strips from the midrib to the margin.
- Sample at least ten plants to represent a soil class or soil group.
- Submit leaf samples to BSWM near the locality. The leaf test values will reflect the kind and amount of nutrients that are in excess or deficient and will be the other basis for formulating the fertilizers to be applied. Follow the recommendations of the laboratory.

The paired soil and leaf samples should be taken from the same mat.

If laboratory analyses are not available, nutrient needs of the plants may be manifested as deficiency symptoms in the leaves as described by E. Lahav and Y. Israeli (1999) in Table 5.

Procedure for Fertilizer Application

For Solid Fertilization

- Formulate the correct amount and right kind of fertilizers and ameliorants to be used based on the result of soil and leaf analyses.
- Mix the recommended kind and amount of fertilizers and ameliorants per hectare in the working area.
- Haul the required quantity of mixed fertilizers for the day to the field to prevent the leftover from caking when exposed to rains. Distribute around the area to be fertilized prior to actual application.
- Blend the mixture with an equal volume of soil from the planting hole as a basal treatment.
- For a standing crop, apply the fertilizer/ameliorant at 40–70 cm away from the base of the mat and at "half-moon" oriented to the follower.
- In the highlands or undulating areas, deeply place or dibble the fertilizers/ameliorants in two to three holes at the same distance and orientation as above (Fig. 10).
- Defer the application of fertilizers/ameliorants during periods of prolonged dry spells and during successive heavy rains.

For Foliar Fertilization

Foliar fertilizer supplements soil fertilization. It helps correct nutrient deficiencies, avoids fixation and leaching losses of applied nutrients in the soil, and provides nutrients to the plant when nutrient uptake through the roots is impeded by lack of soil moisture, root damage, or waterlogged conditions.

- Do it immediately after prolonged dry spells and stop as soon as normal rainfall is back. Apply foliar fertilizer when nutrient deficiency symptoms appear, especially the micronutrients that are needed in small amounts.
- Follow the recommended dosage of the product's manufacturer.

Table 5. Symptoms of nutrient deficiency in banana leaves.

Age of Leaf	Symptoms of Leaf Lamina	Additional Symptoms	Element Lacking
All ages	Uniform light-green or yellow coloration	Pink petioles; stunted growth	N
Old leaves	"Sawtooth" marginal chlorosis	Petiole breaking; dark green-purple color of young leaves	P
		Midribs curving resulting in weeping, drooping leaves	Cu
	Yellow-orange and brown scorching along margins	Leaf bending; rapid leaf desiccation	K
	Marginal chlorosis	Thickening veins; necrosis from margins inward; leaves deformed	Ca
	Yellow discoloration in midblade; midrib and margins remain green	Limit of chlorotic borders not clearly defined; pseudostem disintegrating	Mg
	Dirty yellow-green		Mn
Young leaves	Yellow strips along veins	Reddish coloration on lower side of young leaves	Zn
	Yellow to almost white coloration with inter-veinal chlorosis		Fe
	Streaks across veins	Leaf lamina incomplete	B
	Pale green to yellow coloration including veins	Thickening of secondary veins; leaves deformed	S

Fig. 10. Deep placement of fertilizer blend in a rolling terrain.

Requirements (Based on 2002 Prices)

Materials

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per Year
4 pc	Plastic pail containers	50	200
4 pc	Calibrated tin (sardine) cans	-	-
2 pc	Spades or shovels	300	600
	Fertilizers[a]		
23 bags	Ammonium sulfate (20–0–0)	270	6,210
10 bags	Urea (45–0–0)	410	4,100
1 bag	Ammonium phosphate (18–46–0)	400	400
18 bags	Muriate of potash (0–0–60)	420	7,560
80 bags	Compost or organic fertilizer	120	9,600
	Ameliorants[a]		
40 bags	Calcic lime	40	1,600
80 bags	Dolomitic limestone	60	4,800
	Total		**35,070**

[a]The recommended rate of fertilizers and ameliorants is based on 'Cavendish' banana for export and on soil and leaf analyses. The rates are not fixed. This is just for computation. For 'Lakatan' and other local varieties except 'Saba,' the rate may be proportionally reduced by 10–30% depending on the population density and market requirements. For 'Saba' or 'Cardaba,' the rates may be reduced further by 40–50%.

Equipment

Quantity	Item	Unit Price (₱)	Cost (₱)/ha
1 pc	Weighing scale[a]	8,000	8,000
	Total		**8,000**

[a]Life span is two years.

Labor

Activity	MD/ha	Cost/MD (₱)	Cost (₱)/ha per Year
Hauling, mixing, applying, and returning of sacks	33.6[a]	160	5,376
Total			**5,376**

[a]The total is based on the efficiency of application of 7.5 bags/MD including hauling, mixing, applying, and returning of bags.

Total Cost of Fertilization Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	35,070	38,577	42,435	46,678
Depreciation cost of equipment[c]	4,000	4,000	4,400	4,400
Labor[d]	5,376	5,914	6,505	7,156
Total	**44,446**	**48,491**	**53,340**	**58,234**

[a]Assumption: 10% increase in cost per year per hectare except for the depreciation cost that is dependent on the life span of the equipment.
[b]Breakdown of cost of materials is indicated on page 46.
[c]Breakdown of cost of equipment is indicated above.
[d]Breakdown of cost of labor is indicated above.

Plant Population Control

Regularly pruning the suckers (Fig. 11) every six weeks, on average, controls the plant population. The operation adjusts the population density according to the desired fruit size, carrying capacity of the soil, disease pressure, and field operations; obtains the desired chronological production schedule based on market demand; and eliminates excess suckers that are not used or marketed.

Plants with hanging bunches should not be considered as part of the total plant population control because they will be cut after harvesting.

Technology

Three sucker pruning methods can be adopted: 1:1 practice or one mother plant and one follower (sucker); 2:2 practice or two mother plants, one follower each; and 1:2 practice or one mother plant and two followers.

Fig. 11. Sucker control at 1:1 mother-follower ratio.

A laborer can handle two rows per pass, following the length of the block from end to end.

- Remove the old, dried, diseased, and/or broken leaves and those leaves that come in contact with the fruit.
- Remove the weeds away from the base of the mat.
- Chop down fallen trunks or weak nonbearing plants and pile them neatly between the rows.
- If suckers or corms are needed, mark them way ahead before the sucker pruning operation. Mark by pruning the desired suckers to about 5-cm high.
- Retain the first sucker and all sword suckers, and remove other suckers that exceed the desired density in a hill.

  For 1:1 method, retain the first sucker unless the following conditions are prevalent: sucker is damaged; its growth and development are obstructed by the nearest neighboring plants; is growing toward the canal, cable line, or road; and is located in such a position that its bunch will be damaged. Otherwise, retain the first sword leaf sucker as a follower. For the 2:2 method, retain one sucker for each mother plant. The suckers should almost be of similar height. For the 1:2 method, retain the two suckers that are of almost similar heights.

Requirements

The requirements for materials and labor are the same as that of base cleaning and ring weeding.

Irrigation

Banana requires a large amount of water. In the tropics, it has been shown that banana requires from 1.0 to 1.4 x class A pan evaporation per week (Stover and Simmonds 1987). The rainfall requirement of 'Cavendish' banana in Davao is 7–9 mm/day, or 196–252 mm/month. These measurements may not be necessary for small banana farms, but irrigation is commonly practiced in provinces or regions where there are distinct wet and dry seasons.

Experiences in Davao show that during prolonged dry spells and more severely during El Niño, banana plantation yields can drop from 40% to 70%. There had been instances where plantation operators gave up the venture because of prolonged droughts. This suggests the need for irrigation to save the farm investment during periods of droughts. This can also happen to smallholders.

Four irrigation systems are well known in banana farms. They are the overhead irrigation system where sprinklers are installed above the canopy; the under-tree system where sprinklers are below the canopy; the drip irrigation system; and the furrow irrigation system which smallholders commonly use. Each has its own advantages and disadvantages.

Irrigation is an optional management practice for smallholders.

Fruit Care Operations

Propping

The aerial stem of banana entirely depends on the surrounding mass of leaf sheaths for support. Such a limp structure is mechanically incapable of supporting the vegetative portion of the plant and much less in supporting a huge bunch. Physiologically, the pseudostem mainly provides vascular connections from the roots to the leaves and to the bunch. Hence, there is a need for a mechanical support by propping.

Propping supports the pseudostem in carrying a heavy bunch and preventing fruit losses.

Technology

The three methods of propping are cable propping, pole propping, and guying. For large plantations, cable propping is practiced. For smallholdings, pole propping and guying are more practical.

Procedure for Pole Propping

- Prepare wooden or bamboo poles of appropriate size for propping. The two common techniques are single propping and double propping. In single propping, only a single pole is used to support the plant. Two poles intersecting each other at the upper ends of the poles to form an "x," wherein the base of the bunch is anchored, are used in double propping. Another technique is called umbrella propping, wherein one single big pole is installed at a point equidistant to four or more plants and are anchored by a guy (rope).
- Bury the poles firmly into the ground close to the hill or cluster of hills.
- Position the poles so that they will not touch or obstruct the developing bunch.
- Slightly push the poles upward to tighten the hold on the stalk for more stability and to make the plant more upright to reduce the risk of tipping over.

- Tie the adjacent fruit-bearing plants for support.
- After propping, clear the bunch from all fruit obstructions.

Procedure for guying

Guying involves using a twine in tying the propped plant to two adjacent plants for support.

- Tie the bunch with looped twine at the base.
- Pass an appropriate length of twine through the loop and make a knot in the middle of the long twine so that both ends of the twine are free.
- Tie the two ends of the twine to the stem, 0.6–0.9 m from the base of two separate plants big enough to support the plant being propped and located on the opposite side where the bud bunch had bent.

Requirements (Based on 2002 Prices)

Material Specifications for Pole Propping

Item	Variety	
	'Giant Cavendish'	'Dwarf Cavendish'
Wooden pole		
Length[a] (m)	5–6	3–5
Butt diameter (cm)	8–10	8–10
Tip (cm)	3–5	3–5
Bamboo pole		
Length (m)	5–6	3–5
Butt diameter (cm)	10 (maximum)	10 (maximum)
Tip (cm)	2.5 (maximum)	2.5 (maximum)
Polytwine		
Length (m)	1.0–1.5	1.0–1.5

[a]Length of the pole depends on the height of the variety at fruiting.

Materials

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per Year
4,000 pc	Bamboo pole	7	28,000
4 kg	Polytwine	220	880
	Total		**28,880**

Labor

Activity	MD/ha	Rate//MD	Cycle[a]	Cost (₱)/ha per Year
Propping	0.33	160	once a week or 48 weeks/year	2,534
	Total			**2,534**

[a]Based on an average shooting rate of nine buds per hectare per day or a harvest spread of six months per year and a population density of 2,000 hills per hectare.

Total Cost of Propping Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	28,880	31,768	34,945	38,440
Labor[c]	2,534	2,787	3,066	3,372
Total	**31,414**	**34,555**	**38,011**	**41,812**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of materials is indicated above.
[c]Breakdown of cost of labor is indicated above.

Removing Fruit Obstacles

The operation can be integrated with bunch spraying, bud injection, and leaf pruning. It avoids or minimizes bruising and malformation of young developing fruits.

Technology

- Remove fruit obstruction like spadices, flag leaves, and follower leaves, and relocate props that touch the bunch.

Requirements

The requirements for materials and labor are the same as that of leaf pruning or trimming.

Bunch Spraying

Bunch spraying is regularly done to protect the fruits from fungal infection and insect damage. It is done from the time the first hand is out until the bunch is due for bagging.

Technology

Mixing Procedure

Centralized mixing is recommended.

- Mix in a mixing tank the recommended chemicals and dosage enough for a one-day operation. Wear a respirator (cartridge type) for safety while mixing and spraying.

Bunch Spray Procedure

- Remove fruit obstacles before spraying.
- Start spraying from the bended floral stem down to the bud and then reverse with a total swath of eight for the two different positions.
- Be sure that the four sides of the bunch are sprayed. The dosage per hand ranges from 8 to 10 mL depending on the size of the bunch.

- Direct the nozzle 25–30 cm from the bunch.
- Spray with full pressure.
- Do not spray when raining. Re-spray the bunch after a heavy downpour before bagging.
- Spray all bunches before bagging the fruits.
- Stir the spray solution as often as necessary to achieve a homogenous mixture.
- Discard leftover solution after 48 hours.
- Always observe the DOs and DON'Ts in the safe handling of chemicals.
- Spray three times a week at 2–3-day interval for six months (or 24 weeks x 3 sprayings = 72 sprayings) for the first year.
- For the second year and onward, spray thrice a week for 48 weeks, or a total of 144 sprayings.

Requirements (Based on 2002 Prices)

Materials

Quantity	Item[a]	Unit Price (₱)	Cost (₱)/ha per Year
	Chemicals[b] and Dosages:		
320 mL	Basudin at 0.16 cm^3/bud[c]	462 (/L)	148
75.60 g	Myco SF 202 at 0.0378 g[c]	1,137 (/kg)	86
	Total		**234**

[a]Solution: Mix the above chemicals in 7.3 L water or any other recommended treatment.
[b]Many other choices of chemicals can be used in rotation to avoid insect pest resistance.
[c]2,000 bunches sprayed.

Equipment

Quantity	Item	Unit Price (₱)	Cost (₱)/ha
1 unit	Knapsack sprayer[a] with TX-3 nozzle and extended lancer	6,000	6,000
	Total		**6,000**

[a]Life span is two years.

Labor

Activity	MD/ha	Rate/MD	Cost (₱)/ha per Year
Bunch spray[a]	0.1	160	1,152
Total			**1,152**

[a]For six months, spray (72 sprayings) for the first crop or year one.

Total Cost of Bunch Spray Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	234	257	283	311
Depreciation of equipment[c]	3,000	3,000	3,300	3,300
Labor[d]	1,152	2,534[e]	2,787	3,066
Total	**4,386**	**5,791**	**6,370**	**6,677**

[a]Assumption: 10% increase in cost per year per hectare except for the depreciation cost that is dependent on the life span of the equipment.
[b]Breakdown of cost of materials is indicated on page 55.
[c]Breakdown of cost of equipment is indicated on page 55.
[d]Breakdown of cost of labor is indicated above.
[e]144 sprayings for second and succeeding years.

Fruit Bagging

Fruit bagging protects the bunch from pest damage and the fruit from mechanical injuries. It hastens fruit maturity by providing a favorable microclimate for fruit development inside the bag, and it makes the fruit skin smoother and glossier.

Technology

- Use polybags with 50–100% colorant on bunches along roads, canals, and other exposed areas within the blocks to minimize sunburning the fruits during the summer months. Otherwise, use lightly shaded polybags at other times of the year, especially during the rainy months to avoid pale-colored fruits.
- Perforate the polybags to complement an open bottom to aerate the fruits and to regulate the relative humidity and temperature inside the bag.
- Space the bagging rounds every seven days at most to ensure an accurate bagging census from which fruit projections are based.
- Cut the guard leaf or *kapote* if it tends to damage the bunch. If there is any danger of bunch exposure to the sun, the guard leaf could be used to cover the bunch temporarily.
- Use a bamboo ladder to start bagging when about 4–6 male hands are already exposed or when the last female hand starts curling upward. Early bagging can also be done (Fig. 12). Make sure that the bunch is freshly sprayed with a mixture of fungicides before bagging.
- Use newspapers to protect the bunch from sunscalding in exposed areas or in plants with a low number of functional leaves. Place the newspaper inside the bag or outside the bag during sunny days.
- Remove the male hands and cut the bud 10–15 cm from the false hand. Likewise, remove some of the fingers of the false hand to serve as index fingers where the date of bagging and block number are written. Remove the last one or two distal hands, depending on the hand-pruning scheme for the area.
- Remove all fused fingers in a hand and fingers that form a three-layered hand or prune one or more hands if the number of functional leaves is low (i.e., four or less functional leaves) (Fig. 13).
- Slowly slip the bag (open on both ends) on the bunch from the bottom upward. Avoid damaging the fingers.

Fig. 12. Early-bagged bunch for early protection from pest attack.

Fig. 13. Hand-pruning for index tagging (left) and an index-tagged bunch (right) ready for bagging.

- Girdle around the bunch stalk and tightly tie with a piece of string several inches above the first hand.
- Tie color strips at the cut portion of the bunch stem to indicate the age of the bunch or the number of hanging days as reference for harvesting the bunch.
- Leave the bottom of the polybag open to avoid the accumulation of floral rubbish/water. Close the bottom of the polybag in areas infested by scarring beetles and other insects.

Requirements (Based on 2002 Prices)

Materials

Quantity	Item	Unit Price (₱)	Cost (₱)/ha per Year
3.44 kg	Color strips, standard width and length currently used in the plantations	75.60	260
84.5 kg	Lorsban impregnated polybag	119	10,055
1 pc	Bamboo ladder (standard length of 5–7 steps)	28	28
1 pc	Knife – selector or pruning knife	150	150
1 pc	Coding tool – pointed wood or metal	5	5
1 pair	Tally sheets and pencils	50	50
	Newspaper – especially along open areas[a]		
	Total		**10,548**

[a]Use whenever necessary.

Labor

Activity	MD/ha	Rate/MD	Cost (₱)/ha per Year
Fruit bagging[a]	0.125	160	960
Total			**960**

[a]Bagging is done once a week for 24 weeks for the first crop or year one. Bagging will be done for 48 weeks in the succeeding year.

Total Cost of Fruit Bagging Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	10,548	11,603	12,763	14,039
Labor[c]	960	1,056	1,162	1,278
Total	**11,508**	**12,659**	**13,925**	**15,317**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of materials is indicated on page 59.
[c]Breakdown of cost of labor is indicated above.

Bud Injection

Bud injection controls flower thrips that blemish banana fruits. The blemishes are known as corky scab and blotching (Fig. 14).

Technology

- Use nonphytotoxic insecticides such as monocrotophos.
- Use the right dosage and volume of solution, that is, monocrotophos at 1.0 mL/L of water. The volume of solution is 50–70 mL to be injected into the inflorescence.
- Observe the right timing of injection.
- Look for injectable inflorescence or flower bud. The correct age is when one-half or three-fourths of the total length of the bud is exposed.
- Inject each inflorescence 10–15 cm below the tip of the bud at 45° angle by using an injector connected to a knapsack sprayer.

Fig. 14. Bunch injection for the control of banana flower thrips.

- Allow the whole length of the needle to penetrate the bud, but do not pierce the other side of the bud.
- Mark with a marking pen the pseudostem of the injected bud to indicate that the bud has been injected.
- Inject each bud only once. However, the laborer has to survey his area every other day or at least three times a week to accomplish 10 ha per day.

Requirements (Based on 2002 Prices)

Materials

Quantity	Item	Unit Price (₱)	Buds Injected	Cost (₱)/ha per Year
1 pc	Bamboo pole	7	-	7
	Insecticides:			
175.5 cm^3	Agrimek	8.108	975	1,423
66.3 cm^3	Ascend	1.38	195	91
46.8 cm^3	Success	5.807	780	272
93.6 cm^3	Confidor	7.926	780	742
	Total			**2,535**

Equipment

Quantity	Item	Unit Price (₱)	Cost (₱)/ha
1 pc	Bud injector[a]	500	500
	Total		**500**

[a]Life span is 5 years.

Labor

Activity	Cycles/mo	MD/ha	Rate/MD	Total Cost (₱)/ha per Year
Surveying/injecting bunches[a]	10	0.1	160	960
	Total			**960**

[a]For the first crop, bud injection is done for six months; for the succeeding crops, 12 months.

Total Cost of Bud Injection Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	2,535	2,788	3,067	3,374
Depreciation of equipment[c]	100	100	100	100
Labor[d]	960	2,112	2,323	2,555
Total	**3,595**	**5,000**	**5,490**	**6,029**

[a]Assumption: 10% increase in cost per year per hectare except for the depreciation cost that is dependent on the life span of the equipment.
[b]Breakdown of cost of materials is indicated on page 62.
[c]Breakdown of cost of equipment is indicated on page 62.
[d]Breakdown of cost of labor is indicated on page 62.

Pest Management

Major Insect Pests of Banana and Their Control

Thrips

These are minute insect pests that blemish the fruits. There are several kinds of thrips.

1. Flower thrips (*Thrips florum* Schunts)

Description

The larva is whitish-yellow with no distinct body region at an early stage. It becomes yellow after sometime. The adult's head and thorax are yellow while its forewings and hindwings are light brown. The adult's length ranges from 1.4 to1.7 mm. Both the larva and the adult inhabit and feed on undeveloped fruits in unopened buds.

Damage Symptoms

The blemishes on the infected banana are referred to as blotching or small water-soaked spots caused by the thrips' feeding punctures usually at the basal and lower parts of the fingers. Corky scab (Fig. 15) is another fruit blemish caused by the thrips' egg-laying injuries. It starts as a brown, irregular eruption on the peel that becomes rough and often turns into brown-colored cracks when the fruit matures. These injuries are inflicted while the bud is still unopened.

Control

- Inject bud with insecticide solution (see entry on bud injection).
- Stem and mat spray with insecticide (see entry on stem and mat spray).

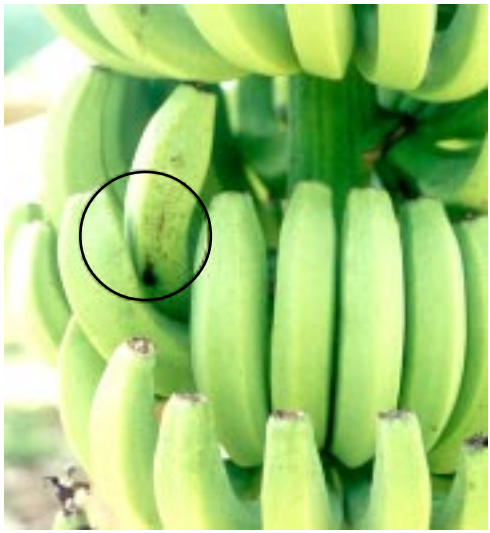

Fig. 15. Corky scab damage caused by banana flower thrips.

- Bunch spray with an insecticide-fungicide combination (see entry on bunch spray).
- Do stem sanitation (see entry on stem and mat sanitation).

2. Red rust thrips (*Chaetanaphothrips signipennis* Bagnall)

Description

Its nymph or larva is white without markings, while its adult has a yellow thorax with two dark spots on the back toward the anterior end of the body.

Damage symptoms

The damage on the young fruit initially appears to be water-soaked areas, which later become reddish-brown or rusty as the fruit reaches maturity. The damage is commonly observed at points of contact between adjacent fingers.

Control

Same as that for flower thrips.

3. Red rust thrips (*Etixothrips brevisetes* Bagnall)

Description

This is another type of red rust thrips identified by Bagnall, but it differs with the earlier type described earlier. The adult has a light brown thorax and a dark brown body. The head is subrectangular that is distinct from the thorax. The nymph carries globules of liquid feces at the tip of the abdomen.

Damage Symptoms

The red rust blemish is a reddish-brown discoloration on the fruits.

Control

Same as that for flower thrips.

Scarring Weevil (*Philicoptus iliganus* Heller)

Description

The weevil or beetle is metallic-green and its body length is about 6–8 mm (Fig. 16). Its scales look metallic green as they appear in irregular patterns on the elytra, thorax, head, and abdomen.

Damage Symptoms

The adult feeds and inflicts scars along the ridges of the fruits (Fig. 17). These scarred fruits are rejected in the export market. The scars are also observed at the base of the youngest leaf veins and on flower bracts.

Control

- Use chlorpyrifos-impregnated, miniperforated polyethylene bags with closed bottom ends.
- Stem and mat spray with insecticide (see entry on stem and mat spray).
- Handpick adults.

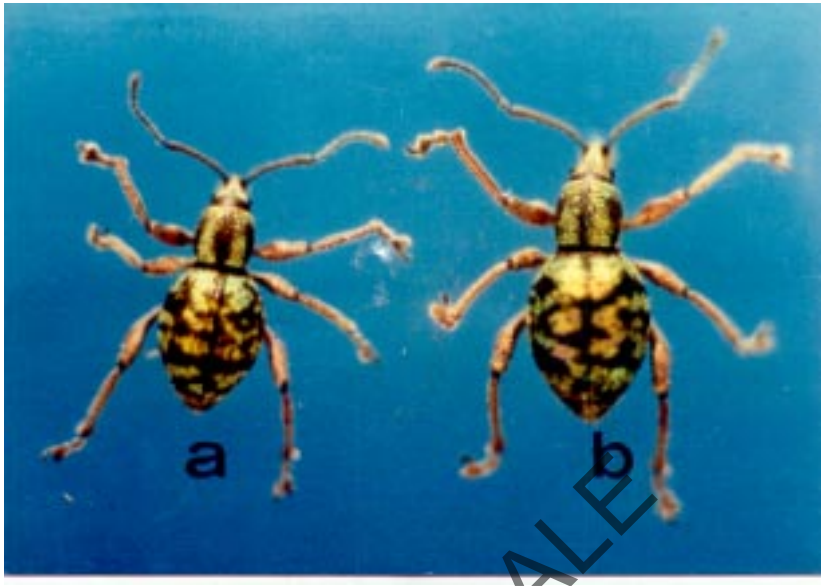

Fig. 16. Adult banana scarring weevils.

Fig. 17. A scarred banana hand infected by the scarring weevil.

Corm Weevil (*Cosmoplites sordidus* Germar)

Description

The destructive stage of this insect is at its larval stage. It has a creamy white body with a reddish-brown head (Fig. 18). The adult weevil, a nocturnal that hides in the pseudostem of the harvested plants and under the piled trashes during the day, is black. The female lays its eggs in small chambers on the corm at ground level, while the larvae feed on the banana corm.

Fig. 18. A larva (left) and adults (right) of the corm weevil.

Damage Symptoms

The larva makes tunnels into the banana corm and damages large portions of the corm tissues, nutrient vessels, and root origins resulting in poor uptake of nutrients and water. The damage also weakens the root anchorage resulting in tip-over losses. The damaged tissues become the entry points of secondary attack by pathogens.

Control

Mechanical trapping

- Cut a disc on the pseudostem stump. This is done by cutting crosswise a 15-cm thick portion of the harvested pseudostem then putting it back to the original stump to attract adults. Another way is to split the pseudostems into trap cuts by cutting a 45-cm portion of the harvested pseudostem then splitting it into two. Invert the split

pseudostems on the top of the ground near the base of the mat to attract adults.
- Collect the trapped weevils and place them into any insecticide solution.

Cultural method
- Use bagged seed pieces or tissue-cultured plantlets instead of suckers.
- Clean the surroundings of the corm and remove the old leaf sheaths.
- Chop the harvested pseudostem into pieces in order to hasten drying, and eventually disrupt the pest's life cycle.

Chemical Method
- Apply the recommended insecticides, like Counter 10G, at 30 g/mat at two cycles per year in blocks with critical weevil population level.

Banana Aphid (*Pentalonia nigronervosa* Coq.)

Description

Banana aphids can be winged or wingless. The wingless aphid has a shiny brown dorsal part, while the winged aphid has very prominent dark wing venation. Aphids are found between the leaf sheaths and at the base of the trunk.

Damage Symptoms

The aphids do not directly cause significant injury to the banana plant. They transmit the bunchy top virus, while they suck the juice of the plant and consequently inject the virus into the plant system. This results in banana bunchy top virus disease, a very deadly disease that makes the banana plant totally nonproductive.

Control

- Use disease-free planting materials, preferably tissue-cultured plantlets.

- Practice good sanitation in the plantation.
- Stem and mat spray by using recommended botanical biocides (e.g., neem extracts and tubli).
- Properly eradicate infected plants. Spray them, including the surrounding healthy-looking plants, first with insecticides prior to eradication.

Mealybugs (*Dysmicoccus neobrevipes* Beardsley*)*

Description

The nymph is pinkish-yellow. The adult has a soft body with a white powdery wax (Fig. 19). Both nymph and adult are found inside the leaf sheaths and fruit bunches. They move very slowly and are transported by ants to the different parts of the banana plant where food is abundant. In return, the ants feed on the honeydew excreted by the mealybugs.

Fig. 19. Exposed mealybugs that are hiding in the leaf sheaths.

Symptoms

The sooty mold, which is caused by the presence of mealybugs, makes an unsightly appearance on the peel of the fruits. Mealybugs excrete honeydew on the fruit, which is attacked by fungi that form the sooty mold. To save the fruits from rejections and be accepted in the export market, they have to be cleaned of their sooty molds. Doing so becomes an added cost. It may also inflict bruises on the fruits that may end up being rejected.

Control

- Bag the bunches with Lorsban-impregnated polyethylene. Use only newly extruded polyethylene bags. Do not stock for more than a month. Store the bags in a tight, well-sealed container.
- Do selective control, for stem and mat spray, during outbreaks of mealybugs in pinpointed critical blocks.
- Do stem sanitation to expose mealybug colonies to the sun and rain, which can reduce their population.

A number of insecticides (Table 6), aside from those earlier mentioned, can be used to control insect pests of banana.

Table 6. Cost of insecticides[a] used per hectare per year to control insect pests of banana.

Chemicals	Quantity	Unit Cost (₱)	Rate/Bud per Ha per Mat	Mats Applied/Bud Injection	Cost/ha per Year (₱)
Agrimek	175.5 cm^3	8.108/cm^3	0.18	975	1,423
Success	46.8 cm^3	5.807/cm^3	0.06	780	272
Confidor	93.6 cm^3	7.926/cm^3	0.12	780	742
Basudin stem spray	405.6 cm^3	0.485/cm^3	0.16	2,535	197
Basudin Erad	29.0 cm^3	0.335/cm^3	20.00	-	10
Furadan	40,956 g	0.142/cm^3	21	1,950	5,816
Formalin	5 L	18.90/L	5	-	94
Myco	47.91 g	1.137/g	0.0189	2,535	54

[a]Other choices of insecticides can be used.

Major Diseases of Banana and Their Control

Moko Disease (Bacterial wilt)

Causal organism: Bacterium (*Pseudomonas solanacearum* B.F. Smith)

This bacterium has four major strains (strains D, B, SFR, and I). Strains SFR and I are readily transmitted by insects visiting flowers, but these have low soil persistence. Strain B can persist in the soil for up to 18 months. Strain D infects *Heliconia* spp. and has low virulence on banana.

Symptoms

Moko is a very contagious disease that can kill an infected banana in just a few weeks. At its initial stage, bacterial wilt develops as a yellowish coloration of the inner leaf lamina, close to the petiole. Then the inner leaves, except the unrolled heart leaf, wilt. In some cases, the heart leaf also collapses. The disease symptoms are manifested within ten days or more after the entry of the bacterium into the plant.

The lower leaves of 'Cavendish' become yellow, followed by similar changes in the other leaves. The leaves later become dull, whitish-yellow, dry and placid, and readily droop in the heat. Later, the petiole, with the lamina or trunk, breaks at its junction. When the affected leaves break down in quick succession, they droop around the trunk.

When a diseased trunk is cut transversely, practically all the vascular strands are discolored, ranging from pale yellow to dark-brown or bluish-black. Dirty-white, yellow, and/or brown exudates are observed.

In bearing plants, individual fingers appear distorted or turn yellow. The pulp turns very dark-brown.

External symptoms of late-stage Moko can be confused with Panama disease. Moko disease, however, is differentiated with two diagnostic internal symptoms: 1) presence of bacterial exudates and the 2) browning or blackening of the fruit pulp.

Control

Option 1

- Detect early and immediately eradicate the infected plants as follows:
  - Conduct a disease survey once a week in areas with previous disease occurrence.
  - Immediately eradicate infected plants.
  - Remove and chop the plants surrounding the infected mat within a radius of 6 m from the infected plant (Fig. 20).

Option 2

- Immediately eradicate infected plants.
- Remove and chop the plants surrounding the infected mat within a radius of 6 m from the infected plant.
- Fallow the area after spraying the chopped plant debris and soil with formalin.
- Keep the area free from any weeds by spraying with Round-up (Glyphosate).
- Disinfect used tools and implements with 10% formaldehyde solution.

Fig. 20. A Moko eradication site sprayed with formalin solution and burned with rice hull.

- Enforce stringent plant quarantine and phytosanitary measures.
- Replant after one year.

Option 3

- Cordon off the 6 x 6-m area, with about a 3-m radius from the Moko-infected mat.
- Excavate and chop all the healthy mats within the 3-m radius into small, halved pieces, leaving the plant debris in place.
- Excavate the Moko-infected mat, then chop into small pieces, then immediately burn them to ashes by using the following materials: rice hull at 10–15 sacks per incidence, old bamboo props, or dried saw dust.
- During the rainy days, place all the plant debris of the Moko-infected mat inside big plastic bags sprayed with 1:3 formalin/water solution. Tie the bottom of the bag to close it. Burn the bagged plant debris.
- Place a small placard indicating the day, month, and year on the site of the Moko-infected hill to determine the replanting date.
- Disinfect all tools and rubber boots before leaving the quarantined area by immersing them for 10 seconds in 1:3 formalin/water solution or Dowicide-A at 10 g/L of water.
- Cultivate the 1-m radius from the site of the Moko-infected mat 14 days after eradication.
- Keep the Moko-quarantined area free of weeds by applying herbicides and kill all the banana regrowth during the one-year fallow period.
- Replant the quarantined area after one year with disease-free, tissue-cultured plantlets.

Panama Disease (Fusarium wilt)

Causal organism: Fungus (*Fusarium oxysporum* f. sp. *cubense* [E.F. Smith])

Description

The soil-borne fungus enters only through the roots and grows and then sporulates abundantly in the xylem vessels. The transport of the spores upward in the transpirational stream facilitates the fungal invasion of the entire vascular system. The growth of the fungus blocks the vascular system, causing the plant to wilt.

The most common means of spreading the pathogen is through infected rhizomes. The fungus can also be spread in the soil, in running water, and from farm implements. The root tips are the natural, initial sites of infection.

Symptoms

The oldest lower leaf turns yellow and continues to collapse and dry up. The upper leaves show the same symptoms one after the other until eventually, all the leaves wilt. The pseudostem may crack at the base but it may remain standing for several weeks until it decays and falls. When cut horizontally, the pseudostem shows brown to purple discoloration of the vascular tissues with a reddish tinge. The discoloration may extend throughout the pseudostem, including the fruit stalk, without any symptom observed on the fruit.

Control

An economical method to eliminate the fungus from an infested soil is not yet available. What can only be done is to implement strict quarantine measures to prevent the transfer of diseased planting materials into new areas. Infected banana plants, including those within a 6-m radius, must be immediately eradicated to minimize the spread of the disease.

Some chemical control approaches such as fumigation with methyl bromide; injection of rhizome with 2% carbendzin; injection of 20% potassium phosphonate; and heat treatment of the soil have not always been found effective.

Bunchy Top

Causal organism: banana bunchy top virus

Description

The banana aphid *Pentalonia nigronervosa* Coq. transmits the virus. It acquires the virus as it feeds on the virus-infected plant and transmits it into a healthy plant for as fast as two hours after feeding. When introduced into the plant, the virus multiplies and moves to all parts of the plant.

The vector

The brown aphids that transmit the bunchy top virus are found in colonies in the crown of the plant, around the base of the pseudostem, and between the sheaths of the outer leaf and the pseudostem. The wingless aphids reproduce for 7–10 generations and then alate (winged) adults are produced. These are similar in color to the wingless generations and have dark-brown to black wing veins. The alate aphids migrate to new host plants.

Symptoms

The affected leaves show green streaks on the secondary veins on the underside of the lamina and on the midrib and petiole. The streaks are about 0.75 mm-wide and vary in length up to 2.5 mm. The dark-green streaks can be clearly seen on the midrib and petiole when the powdery bloom is rubbed off. The streaks vary from a series of dark-green dots to a continuous dark-green line with a ragged edge.

The other leaves subsequently show similar symptoms as that in the first affected leaf. The plant is dwarfed and shows marginal chlorosis and curling (Fig. 21). The affected leaves are brittle and the petioles are incompletely elongated. As the disease progresses, the subsequent leaves unfurl prematurely but slowly. In this case, several leaves unfurl at the same time, resulting in smaller leaves, and eventually producing stunted leaves on the crown of the plant.

The infected plants seldom bear fruit and if they do, the hands are deformed and the fingers are reduced in size.

Control

- Do an early detection survey of initial symptoms and eradicate promptly.
- Do a weekly survey of symptoms when disease incidence reaches epidemic proportions. Tolerable degree of incidence should be one case per hectare per survey schedule.
- Enforce strict quarantine measures by preventing the movement of virus-infected materials into new areas.

Fig. 21. Banana infected with bunchy top virus.

Eradicating an infected plant

Option 1

- Spray all the plants, including the ground and grasses, within a 6-m radius from the infected plant. Use Lorsban 40 EC at 1.25 mL/L water, or Malathion at 1.0 mL/L water, or Sumithion at 2.6 mL/L water. The last plant to be sprayed should be the infected plant.
- Excavate the infected plant, including all the suckers.
- Chop all the rogued (damaged) plant parts into small pieces and carefully pile them up on top of the leaves, with the corm at the topmost position, to prevent re-growth and enhance drying.
- Re-spray the chopped and piled-up plant parts.
- Use bunchy top-free planting materials when replanting the eradicated area.
- Replant three or more days after eradication.

Option 2

The use of Glyphosate-impregnated sticks is a faster, easier, and more economical method of eradicating bunchy top-infected mats than the manual way. The latter involves much time and effort in digging out large, heavy corms, placing them on top of the piled leaves and pseudostems, and paring off all the bud eyes from the corm.

- Prepare the Glyphosate (Round-up)-impregnated bamboo sticks.
  - Select an immature bamboo pole of the 'Botong' or 'Laac' variety.
  - Cut the pole into sticks measuring 16-cm long, 2-cm wide, and 0.5-cm thick after slicing off the inner and outer epidermis of the bamboo.
  - Sharpen one end of the bamboo stick.
  - Allow the sticks to dry under the sun for three days.
- Immerse the sticks in pure Glyphosate (Round-up).
  - Pour 240 mL of pure Glyphosate into an empty container. The volume in the container is based on the maximum absorbing capacity of 3 mL/stick.
  - Place the sticks with the sharpened ends, which are in contact with the Glyphosate, into the container
  - Immerse the sticks for five days. Be sure that the calculated volume of absorption is achieved by examining any remaining volume of the solution. If the desired volume of absorption is not yet accomplished, continue immersion for another two more days.
- Use the Glyphosate-impregnated sticks.
  - Spray all the banana mats within a 6-m radius from the bunchy top-infected mat with the appropriate insecticides mentioned earlier.
  - Cut the pseudostem of the mother plant in the bunchy top-infected mat, leaving only 4–6 cm of the pseudostem intact with the corm of the mother plant. Cut the leaves and lay them on the ground. Chop the pseudostem into 45-cm pieces and pile them on top of the leaves.
  - Chop off all the followers and peepers.
  - Position one Glyphosate-impregnated stick at the center of the remaining pseudostem of the mother plant and drive it full length into the corm using a wooden stick as hammer. Also, drive one

Glyphosate-impregnated stick into each of the corms of the followers in the bunchy top-infected mat.

- Re-spray the eradicated mat, including the ground surrounding it, with insecticide.

Blackhead, Root Rot, and/or Toppling Diseases

Causal organism: nematode (*Radopholus similis*)

Description

This nematode is slender and microscopic, about 0.69-mm long. It spends much of its life within the banana roots and lays its eggs in the root tissues. Its life cycle is completed in 25 days. All its larval stages and females are infective.

Symptoms

The infected banana roots have reddish-brown lesions that extend throughout the cortex. The disease first appears on the surface of the roots as small, elongated lesions that eventually form a dark patch. The stele (the central portion of the stem and roots) is not invaded by the nematode and remains healthy and white until late in the infection when fungi damage the root tissues, causing necrosis, which penetrates into the stele, thus severing the root. Severely infected plants become weakly anchored resulting in tipping over.

Control

- Use nematode-free planting materials such as tissue-cultured plantlets.
- Treat soil with nematicides and fumigants.

Black Leaf Streak (BLS) Disease

Causal organism: Fungus (*Mycosphaerella fijiensis*)

The fungus produces two types of microscopic spores (seeds) called conidia and ascospores. Conidia form dark-brown and black streaks on portions of the banana leaf. They emerge from the leaf

stomata and are disseminated by wind. Ascospores develop massive brown spots inside the portions of the leaf. They are released into the air when the leaf gets wet. When the spores land on the unfurling (opening) ear leaf and the first fully opened leaf (the most susceptible leaf of bananas), they germinate when they are covered with a film of water. The fungus then grows over the leaf surface for several days before it enters the stomata and infects the cells in the leaf.

Symptoms

Tiny brown streaks (lines) appear around the stomata a few weeks after infection. The streaks enlarge, turn blackish, and later on become brown oval spots with yellow margins. Under highly favorable conditions (frequent and high rainfall, and temperatures above 20°C) and in the presence of abundant inoculum (spores from streaks and spots), streaks which may group together, appear abundantly causing the leaf to turn black and dry up prematurely. When few leaves are left in a bearing banana at harvest, the fruits may ripen prematurely in the field or while they are in transit to the market.

Control

Apply contact fungicides (e.g., Dithane M-45 and Bravo 720) to kill fungal spores on the leaf surface and systemic fungicides (e.g., Tilt, Calixin, and Benlate) to kill fungal growth inside the leaf. Use banana oil (at 0.5 L/ha) to facilitate the entry of systemic fungicides into the leaf, inhibit fungal growth by itself, and improve the sticking ability of contact fungicides. The suggested fungicide formulations are indicated in Table 7.

Table 7. Suggested fungicide formulations for BLS control.

Fungicide Formulations	Rate/ha	Interval (days)[a]	Application (mo)[b]
Tilt	0.4 L	11–14	January 5, February 7, May 8, June 10, July 18, October 31, December 3
Oil	5.0 L		
Lutensol (spreader/ sticker)	0.05 L		
Calixin	0.60 L	11–14	March 28, August 29, September 29
Oil	5.0 L		
Lutensol	0.05 L		
Dithane M-45	2.0 kg	10–21	January 26, May 29, July 5, August 8 and 18, October 10 and 20, November 21, December 24
Oil	6.0 L		
Lutensol	0.06 L		
Bravo 720	1.56 L	10–14	February 28, March 14, April 10 and 24
Dithane M-45	2.0 Kg	10–21	September 8 and 19
Benlate	0.28 Kg		
Oil	5.0 L		
Lutensol	0.05 L		

[a]Spray intervals depend on disease pressure; the greater the disease infection, the closer the interval of the sprays.
[b]Twenty-five sprayings during normal climatic conditions in Mindanao. The more rains, the more cycle of spraying by reducing intervals (days) of application using the same rate of chemicals.

BLS disease monitoring

If the threshold level for any of the parameters listed below occurs, then apply the suggested fungicide formulation for BLS control indicated in Table 7.

Parameters	Threshold Level
1. Average number per area of youngest leaf spotted (counting from the topmost open leaves going downward)	9
2. Percentage of plants having spotted leaves younger than leaf 8	20%
3. Number of functional leaves at shooting stage	12 or less
4. Number of functional leaves eight weeks after bagging	8
5. Number of functional leaves at harvest	6

Other fungicides (Table 8), aside from those earlier mentioned, can be used to control leaf diseases of banana.

Table 8. Cost of fungicides per hectare per year to control the leaf diseases of banana.

Chemicals[a]	Cost (₱)/ha per Year
1. Banana oil	2,817
2. Baycor	4,256
3. Sico	1,332
4. Manzate	25,301
5. Daconil	17,350
6. Triton X-45	12,984
7. NU Film Surfactant	11,036
8. Vondozeb 42 EC	14,560
9. Folicur	1,788
Total	**91,424**

[a]Other choices of fungicides for the control of leaf diseases of banana include Bankit, Basudin, Dithane, Bumper, Bravo, Calixin, Indar, Dithane, Kocide, Tilt, Zinc Mono, Al – 100, and Mancozeb WP.

Requirements (Based on 2002 Prices)

Labor

Activity	MD/ha	Cost (₱)/ MD	Cost (₱)/ha per Year
Field control of Moko[a]	0.25	140	420
Chemical control of Panama disease[a]	0.16	140	269
Eradicating bunchy top-infected plant[a]	0.25	140	420
Soil treatment for nematode[b]	2.00	140	560
BLS fungicide control[c]	2.00	140	7,000
Total			**8,669**

[a]Once a month.
[b]Twice a year.
[c]Twenty sprayings per year (Table 7).

Total Cost of Disease Management Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Chemicals[b]	91,424	100,566	110,623	121,685
Labor[c]	8,669	9,536	10,490	11,539
Total	**100,093**	**110,102**	**121,113**	**133,224**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of chemicals is indicated on page 82.
[c]Breakdown of cost of labor is indicated above.

Weed Control

Weeds can significantly reduce banana yield. The most common weeds in banana-growing areas are as follows:

Local Name	English Name	Scientific Name
Alikbangon	Spreading dayflower/ Commelina	*Commelina diffusa* Burm. f.
Gatas-gatasan	Garden spurge	*Euphorbia hirta* L.
Kogon	Cogon grass	*Imperata cylindrica* (L.) Beauv
Kulape	Sour paspalum/ Carabao grass	*Paspalum conjugatum* Berg.
Kulatai/Kawad-kawad	Bermuda grass	*Cynodon dactylon* (L.) Pers.
Mutha	Purple nutsedge	*Cyperus rotundus* L.
Para grass	Para grass	*Brachiaria mutica* (Forsk.) Stapf.
Pulang puit	Jungle rice	*Echinocloa colona* (L.) Link
Sabung-sabungan	Goose grass	*Eleusine indica* (L.) Gaertn.
Ulasiman	Common purslane	*Portulaca oleracea* L.
Urai	Spiny amaranthus	*Amaranthus spinosus* L.

Weeding reduces or eliminates weed competition for light, water, and nutrients; eliminates weeds as secondary hosts for pests; removes weeds that may reduce the effectiveness of drainage systems; and minimizes poor drainage caused by weeds that may contribute to the incidence of fruit spotting diseases.

Weeding is done periodically. However, it cannot be scheduled at regular intervals. It is very necessary during the early stages of plant growth and development when the banana canopy has not yet closed. Weeding cycles are established according to the need and to varying conditions.

Several weeding techniques are given below. Each has its own specific purpose in the weeding operation at different periods, stages of the plant development, and section or part of the farm such as along canals, road networks, and eradication or re-entry areas.

Technology

For smallholdings, use the following procedure:

Manual weeding

- Use a slashing bolo in weeding along drainage canals and road network.
- Use a sickle or a slashing bolo to ring weed by scraping the weeds in either an inward or an outward motion around the base of the plant to a distance of 0.75–1.0 m.

For plantation type, use the following procedures:

Mechanical weeding

This procedure uses a tractor equipped with a grass cutter that makes a pass through the pathways between the rows.

- Do line weeding in a strip along the rows at a specified distance from the base of the plant. This can be done by slashing the weeds close to the ground when the weeds are about 15-cm tall or before the weeds produce flowers or seeds.

Chemical weeding

- Calibrate the knapsack sprayers by checking the air pressure and the speed of the laborers. This is done to calculate the required volume of spray for a complete coverage of the weed growth.
- Direct a spray swath on one-half of the row, the other half on the return trip. The spray nozzle should normally be less than one foot from the ground, and the spray mist must be at least one foot from the base of the plant.
- Slash weeds one week before herbicide application to encourage regrowth. The succulent and active regrowth makes the herbicide more effective.
- Ring weed before herbicide application to avoid hitting the mother plant and the follower.
- Spray a booster spot application of herbicide about two weeks following the initial spray if needed.

The frequency of herbicide sprays, especially systemic, should not exceed 4–6 cycles per year to avoid the buildup of herbicide residues.

Requirements (Based on 2002 Prices)

Supplies and Materials

Quantity	Items	Unit Price (₱)	Cost (₱)/ha per Year
Manual weeding			
4 pc	Slashing bolos	200	800
2 pc	Sharpening stones	100	200
Chemical weeding			
1 pc	Pail	50	50
1 pc	Mixing drums	600	600
1 pc	Respirator	400	400
1 pc	Goggles	300	300
1 pc	Gloves	150	150
	Herbicides:		
2 L	Round-up	379.05	758
3 L	Basta	400.56	1,202
Total			**4,460**

Equipment

Quantity	Items	Unit Price (₱)	Cost (₱)/ha
Manual weeding			
1 unit	Grass cutter[a]	15,000	15,000
Chemical weeding			
1 unit	Knapsack sprayer[a]	6,000	6,000
Total			**21,000**

[a]Life span is two years.

Labor

Activity[a]	MD/ha	Cycles/year	Cost (P)/ha per Year
Manual weeding			
General weeding	4.000	2	1,280
Ring weeding	1.300	12	2,496
Mechanical weeding			
Line weeding	2.000	12	3,840
Chemical weeding			
Transporting chemicals to the block; spraying around the mat, drainage canals, cables ways, and sidewalks	0.165	12	317
Total			**7,933**

[a]Rate is ₱160/MD.

Total Cost of Weed Control Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Supplies/Materials[b]	4,460	4,906	5,397	5,937
Depreciation of equipment[c]	10,500	10,500	11,550	11,550
Labor[d]	7,933	8,726	9,599	10,559
Total	**22,893**	**24,132**	**26,546**	**28,046**

[a]Assumption: 10% increase in cost per year per hectare except for the depreciation cost that is dependent on the life span of the equipment.
[b]Breakdown of cost of supplies and materials is indicated on page 86.
[c]Breakdown of cost of equipment is indicated on page 86.
[d]Breakdown of cost of labor is indicated above.

Harvesting

Harvesting consists of various stages. It actually starts by estimating the production to ensure the desired volume demand in the market. This is followed by fruit marking and calipering (measuring the dimensions of the fruit) to ensure the right age and grade-fruit age control, and the right age and fruit size upon reaching the market destination.

In the export market, maturity requirement is dependent on the buyer. Here, fruit calibration and age of the fruit are the most commonly used indices. Determining these parameters is integrated in the fruit care operations. Hence, cost of materials and labor are no longer presented in the manual under harvesting operations.

For the plantation type, the standard procedures, particularly for 'Cavendish' and 'Lakatan,' are estimating the production, marking the fruits or preharvest calipering, and controlling the grade-fruit age.

Production Estimates

This operation is applicable to 'Cavendish' and 'Lakatan' if shipped to distant markets.

- Assign a row in the middle of the one-hectare farm.
- Bag the fruits from the assigned row per week. Use colored ribbons to indicate the time of bagging to harvest. Establish your own color-coding scheme when using the colored ribbons (e.g., white ribbon for the first week, then another color for the next week, and so on).
- Record the date of bagging, the number of bunches bagged per week, and the number of days or weeks from bagging to harvest. The information will determine the number of bunches to be harvested per hectare.
- Harvest the bunches.
- Determine the number of hands per bunch, weight of bunch, and the number of boxes per bunch. The information will provide the grower with the production estimate per hectare.
- Carry out this operation for at least one year. Two years will provide a more accurate information.

Fruit Marking/Preharvest Calipering

This is another standard practice for 'Cavendish' to complement the age criteria in harvesting. This is not necessary for 'Saba' and 'Cardaba,' and may not be necessary for 'Lakatan' if shipped to distant markets. This is used when the weather affects the maturity of the fruits.

- Mark or caliper, on the day prior to harvest, all fruits to be harvested for a given shipment or delivery. Use the reference values established by using the production estimate discussed earlier.

  A bunch is calipered as follows:
  - When the marker finds a bunch that appears to be at or near harvesting grade, the bunch will be calipered in one of the three fingers in the center of the outer whorl of the second hand from the top.
  - The bunch is ready for harvest when any of the three fingers fail to enter the caliper or when they enter with difficulty or they fit tightly.

- Mark a bunch for harvesting by removing all the plant's leaves, except those that actually protect the bunch from direct sunlight or which, when removed, would allow the latex from the cut leaves to drip into the bunch.

Grade-Fruit Age Control

This operation, done after establishing the reference values, is for commercial purposes. This applies only to 'Cavendish' and sometimes 'Lakatan' when shipped green to the market. It is one important measure that permits maximum grade fruits to attain maximum yield without ripening while in transit to the market. It permits greater flexibility to increase the grade when there is a lesser risk of ripening.

- Get the record of the age of the fruit from the time of bagging to harvest and the caliper size.
- Place all the colored ribbons in chronological order on the fruits that are bagged each week.

- During the first two weeks, when the fruits have reached the minimum grade as calibrated, harvest all the fruits with ribbons pertaining to the designated week's color.
- In the third week of the three-ribbon sequence, harvest all the fruits, whether they have reached the minimum grade or not. Here, grade is used as the determining factor in the first two weeks of the three-week cycle and age in the third week.

Maturity Indices

This technology is intended for smallholders growing the local varieties such as 'Señorita,' 'Latundan,' Lakatan,' 'Buñgulan,' 'Saba,' and even 'Cavendish.'

Banana fruits are harvested before they are fully ripened so that they can reach their market destination fresh and green. The fruits must be harvested at a mature stage in order to attain their natural sweetness.

The following are visual physical appearances of the fruit that indicates certain maturity stages (PCARRD 1988):

- Angularity or shape of the fingers (Fig. 22), which describes the fruits as follows:

  - three-quarters (fruits with clearly visible angles, about one-half of their maximum size)
  - full three-quarters (fruits with less prominent angles)
  - full stage (fruit angles have virtually disappeared)

  It is recommended that bananas should be harvested when the fruits' shape is full three-quarters or full stage, depending on the target market.

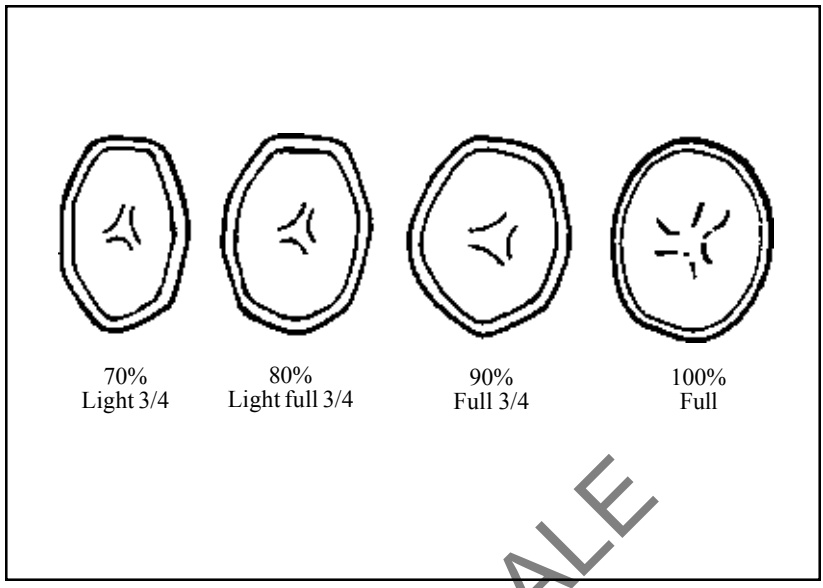

Fig. 22. Fullness of finger as a maturity index for banana (PCARRD 1988).

- The physiological age of the fruit based on the number of days from shooting to maturity is as follows:

Variety	Weeks after Shooting
'Señorita'	6–8
'Latundan'	9–11
'Cavendish'	11–14
'Buñgulan'	12–14
'Lakatan'	12–14
'Saba'	20–24

Harvesting

For Smallholdings

- Harvest the bunches preferably in the morning.
- Cut the trunk slowly and partially, about one-third from the top for the bunch to fall slowly. Use a knife, bolo, or sickle.
- Hold the tail end of the bunch before it touches the ground.
- Cut the peduncle, leaving about 30 cm of the stalk, for easy handling.
- To transport bananas from steep hillsides, tie the bunches in pairs (already dehanded) to each end of a yoke or *pingga* (usually made of bamboo) and carry them on the shoulder.
- On flat or moderately rolling lands, place the bunches on animal-drawn sleds and move toward the roadside or to a packing shed. Put banana leaves in between the bunches to prevent bruising.

For Plantations

- Harvest all the bunches that have already attained full maturity.
- Use the pole props or other poles to help lower the bunch for harvest to the shoulder pad.
- Before finally cutting off the bunch, place plastic sheets of proper thickness between the hands that will directly rest on the shoulder pad in order to minimize new bruises.
- After cutting off the bunch, cut the pseudostem in V-shape about 1 m from the base, or leave the pseudostem standing, but cut off the leaves that directly shade or obstruct the follower. This is done to continue nourishing the follower.
- Take the bunches to the fruit patio by using a tractor-drawn trailer.
- In some cases, dehand the bunches in the field before transporting.
- Provide cover on all hauling trailers to avoid sunscalding the fruits while in transit to the packinghouse.
- Under no circumstances should the bunch ever be placed on the ground or stood up alongside a banana plant. This is to avoid bruising the hands.
- Strictly supervise the cutting and hauling process because harvesting is the major source of bruising.

Requirements (Based on 2002 Prices)

Materials

Quantity (pc)	Items	Unit Price (₱)	Cost (₱)/ha per Year
2	Bolo or machete	180	360
15	Shoulder pad made of lightweight plywood that is curve-shaped to receive the bunch. The concave side should be lined with a spongy material such as foam rubber. The shoulder pad should be of sufficient length and width to accommodate the bunch and prevent it from falling while being carried by the backer or conchero to the cable or tractor-drawn trailer-hauler.	550	8,250
2	Fixed aluminum calipers of different grades or measurements (e.g., 43"/32" and 44"/32"), mounted on a wooden rod to reach the fruits.	200	400
	Total		**9,010**

Labor

Activity[a]	Efficiency (Stems/group/day)	Stems/ha per Year	Cost (₱)/ha per Year
Harvesting/Dehanding	60	2,000	9,600
Total			**9,600**

[a]For four persons (e.g., one pair of harvesters composed of cutter and a backer as well as two bunch carriers) doing the operation at a rate of P160/MD. The efficiency is 8.33 stems/MD for four persons.

Total Cost of Harvesting Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Materials[b]	9,010	9,911	10,902	11,992
Labor[c]	9,060	9,966	10,963	12,059
Total	**18,070**	**19,877**	**21,865**	**24,051**

[a]Assumption: 10% increase in cost per year per hectare.
[b]Breakdown of cost of materials is indicated on page 93.
[c]Breakdown of cost of labor is indicated on page 93.

Table 9. Summary of establishment and maintenance costs for a 1-ha banana farm.[a]

Activity	Amount (₱)			
	Year 1	Year 2	Year 3	Year 4
Prior to establishment	2,500	-	-	-
Drainage	40,820	5,280	5,808	6,388
Clearing and preparing the land	51,180	-	-	-
Lining and staking	956	-	-	-
Planting	39,713	-	-	-
Replanting	160	-	-	-
Base cleaning and ring weeding[b], stem and mat sanitation[b], stem sanitation after harvest[b], and plant population control	3,460	3,806	4,187	4,605
Leaf pruning or trimming, fruit obstacle removal	2,238	2,462	2,708	2,979
Stem and mat spray[b]	9,122	9,735	10,709	11,450
Fertilization	44,446	48,491	53,340	58,234
Irrigation[c]	-	-	-	-
Propping	31,414	34,555	38,011	41,812
Bunch spray[b]	4,386	5,791	6,370	6,677
Fruit bagging	11,508	12,659	13,925	15,317
Bud injection[b]	3,595	5,000	5,490	6,029
Disease management	100,093	110,102	121,113	133,224
Weed control	22,893	24,132	26,546	28,046
Harvesting	18,070	19,877	21,865	24,051
Total Cost[d]	**386,554**	**281,890**	**310,072**	**338,812**

[a]See preceding sections for details. Based on 2002 prices.
[b]Includes pest management for major insect pests.
[c]Optional management practice for smallholders.
[d]Rounded off to the nearest peso.

Table 10. Estimated rate of return to total operating cost (RRTOC) for a 1-ha banana farm.

Parameters	Year				
	1	2	3	4	Total
Harvestable fruits (kg)[a]	37,800	41,580	45,738	50,312	175,430
Gross income[b] (₱)	378,000	415,800	457,380	503,112	1,754,292
Production cost[c] (₱)	386,554	281,890	310,072	338,812	1,317,328
Yearly net income (₱)	(8,554)	133,910	147,308	164,300	436,964

[a]Based on 'Cavendish' yields (conservative). For year 1, approximately 2,800 boxes at 13.5 kg/box. For years 2–4, assume an increase of 10%/year.
[b]At ₱10/kg of fruit (domestic price).
[c]See Table 9.

$$\text{Average RRTOC} = \frac{436{,}964}{1{,}317{,}328} \times 100\%$$

$$= 33\%$$

Postharvesting Handling and Storage

This is the final stage of packing the fruits into crates for the domestic market and cartons for the export market.

Quality

Constant upgrading of the product quality is the key ingredient in capturing the market. The ever-changing tastes of consumers demand a continuing process of improving product quality. Quality is a concern in all aspects of banana production, but in the succeeding topics, it is focused on fruit quality in the mini-packinghouse (Table 11).

As soon as the bunch reaches the mini-packinghouse, close scrutiny is absolutely necessary to ensure that the fruit does not suffer further quality deterioration. Below are the basic guidelines to achieve consistency and uniformity of product quality:

Table 11. Cost of establishing a mini-packinghouse for banana.[a]

Items	Amount (₱)
Shed (bamboo and nipa)[b]	20,000
Wash/dehanding tanks (steel)[b]	6,000
Furniture (e.g., bench, table)[b]	1,000
Hog wire (250 rolls)[b]	800
Labor cost[c]	24,000
Electrical, plumbing, and related costs[d]	5,000
Total	**56,800**

[a]Floor area is 30 m^2. Based on 2002 prices.
[b]Life span is four years.
[c]One year only.
[d]Maintenance cost.

Quality Standards

Standards differ from one exporter to another and from one buyer to another. This situation is more so in the domestic market. Below are the generalized export requirements and many changes have been made with time.

Qualities of a Good Hand

General appearance of an ideal hand:

- No blemishes, spots, or bruises.
- No malformed fingers.
- No underdeveloped fingers.
- The diameter and length of fingers are of even sizes.
- No finger is cut off from the cushion.
- The cushion is cleanly cut of sharp corners and the arc of the crown is very visible.

General appearance of an acceptable hand:

- Fingers have slight blemishes because of natural causes.
- A whole hand has only one major bruise.
- Any single finger has no more than one spot with a diameter of 3"/32".
- No more than two visible spots on any single finger.
- No more than four fingers affected by visible spots.
- No more than a single cut finger in the hand.

Qualities of a Good Cluster

General appearance of an ideal cluster:

- No blemishes or spots and bruises.
- No deformed or underdeveloped fingers.
- All fingers have uniform diameters and lengths.
- Each cluster must have no less than six fingers or more than 11 fingers.
- Clusters should come from big hands weighing at least 4 kg.
- No fingers should be cut off between existing fingers in the cluster.
- The cushions should be clean and should have no sharp corners, with the outside portion rounded off.

General appearance of an acceptable cluster:

- One or two fingers in the cluster have slight blemishes caused by the reaction of chemicals and mechanical damage in the field.
- Any single finger has no more than two visible spots.
- Slightly visible spots must not affect no more than three fingers in the cluster.
- Slight bruising must not be visible in more than three fingers in the cluster.
- The cushions are cleanly cut of sharp corners, with rounded outside portion.
- Total fingers must be no less than five but not more than 12.

Quality Control

The following are important measures to be adopted in order to ascertain that established quality standards are met:

Strict supervision on

- Proper fruit calibration for bunches delivered into the packinghouse
- Proper way of dehanding (rate must be proportional to the rate of selection)
- Selection as fruit recovery depends on it

  Fruits must be well-selected as the quality of the fruit can hardly be improved when it reaches the flotation tank.
- Accurate weighing and combination of uniform hands
- Correct packaging
- Loading of finished products

  Random inspection of finished product needs to be done to confirm whether or not control measures in the process of packing are being strictly adhered to.

Statistical chart

- Production per hour and proportion of cluster packs to hand packs
- Box/stem ratio to determine recovery per bunch
- Information regarding bunches damaged by handling, insects, fruit spots, sunburn, and chemical spots
- Percent shrinkage (as fruit and as stalk)

Packinghouse Operation

Small-scale banana growers usually dehand bunches right in the field. Here, harvested fruits should be cushioned and covered with banana leaves and placed under the shade before they are brought to the packinghouse to maintain freshness.

In commercial banana plantations, the harvested bunches are hauled on aerial cables to the packinghouse or are dehanded in the field and loaded to tractor-drawn trailers and brought to the packinghouse.

The processing operation that follows is routine for the fruits for export but can also be applied to the fruits for the domestic markets. This measure ensures fruit quality and a higher price in the market.

Procedure

- Provide the packing plant with clean water with approximately 378.5 L per minute (lpm) in the dehanding tank and 227.1 lpm in each flotation tank at a pressure of 30–40 psi. For smallholders' packinghouse, the preceding specifications are not necessary. A small dehanding tank and a wash tank, filled up with clean water to a certain level for a specific duration, may suffice.
- Keep the water relatively free of bacteria by applying chlorine that is maintained at 10 ppm in the tank.
- Inspecting - Prior to actual fruit processing, first check the bunches in the packinghouse whether or not they reach the prescribed calibration or other required maturity indices.
- Deflowering - Deflower the bunches in the fruit storage area within 2–3 minutes before cutting the hands off the stem to keep the latex from drying and causing spots. Avoid scratching the fruit. Deflower each finger completely.
- Dehanding - In removing a hand from the stem, leave as much crown as possible in the hand. Carefully hold the banana hand by having the palm support the lower part of the hand being cut. Do not just take hold of two or three fingers, which may break the neck. Once dehanded, carefully place, not throw, the fruits in the flotation tank, to avoid bruising. Control the speed of dehanding so as not to overfill the dehanding tank. Maintain the floating fruits no closer than 0.9 m from the border of the tank. Gently lower the hands into the tank to avoid bruising.

- Washing - Wash off the dirt and spores of fungus adhering to the fruits, then transfer the fruits to selectors or sorting tanks where the hands are selected and sorted according to quality specification.
- Culling – Remove/cull fruits with bruises, scabs, scars, oversized or undersized fruits, and small or malformed fingers.
- Weighing - Combine a number of hands, never more than seven, to meet the required weight standard for a fruit pack. Apply alum on the crown using spray or sponge to control fungus.
- Controlling crown mold – For the Japan market, dip, spray, or brush the crown with foam soaked with alum (homogeneous alum-chlorine solution of 10g alum/L water + 0.2 g chlorine/L water). For the Middle East, use the preceding solution plus 1.5 cm^3 Bycor 300 EC/L water.
- Labeling - Place labels on two fingers per hand prior to packaging, in which case, the labels are usually the brand names of the company growing or marketing the fruit.
- Packaging - Place the hands in a box according to a specified pattern, which is determined by the net weight of the fruit to be packed in each carton. One kind of packaging is for the domestic market and the other, for the world market.

For the Domestic Market

- Use rectangular wooden crates as packaging containers. These crates are most commonly used because they are more resistant to rough handling and are easier to load in container vans than the cylindrical-shaped *kaing* or bamboo baskets.
- Line the inner side of the crates or baskets with any of the following: cool and durable leaf sheaths from the pseudostem. Sometimes, banana leaves, polyethylene plastic sheets, or newspapers may be used. The linings are necessary to minimize fruit bruises and injury during handling and transport.

For the World Market

- Use carton boxes for packing the fruits.

  For the Japan market, line the inner side with a closed-bottom polyethylene bag such that when the fruits are loaded inside the carton, the upper end of the polyethylene bag is closed and tied with a rubber band.

For the Middle East market, line the inside of the carton boxes with the "Vac-pack polytube." After loading the fruits inside the carton, suck the air out to create a vacuum inside the Vac-pack polytube.

- Provide hand separators inside the carton to prevent fruit bruises as a result of vibration of the fruits inside the box. Hand separators are either thick cardboards or foam.

Requirements (Based on 2002 Prices)

Materials

Quantity	Items[a]	Unit Price (₱)	Cost (₱)/Year
4.0 kg	Alum (at 10g/L water)	24.15	97
19.13 kg	Chlorine (at 0.2 g/L water)	94.50	1,808
3.0 kg	Detergent soap	36.60	110
3,500 pc	Polyethylene bags or	4.00	14,000
3,500 pc	Vac-pack polytubes	4.00	14,000
2,000 pc	Wooden Crates or	15.00	30,000
3,500 pc	Carton boxes	14.00	49,000
	Total		**109,015**

[a]Label for the fruit will be provided by the buyer.

Equipment

Quantity	Items	Unit Price (₱)	Cost (₱)/Year
1 unit	Weighing balance (20 kg capacity)[a]	30,500	30,500
4 pc	Scoop-shaped, sharp-edge dehanding instrument[b]	150	600
2 pc	Banana knives[b]	100	200
	Total		**31,300**

[a]Life span is five years.
[b]Life span is two years.

Labor[a]

Activity[b]	MD/week	Cost (₱)/ha per Year
Inspection/deflowering	1	3,840
Dehanding	1	3,840
Washing	1	3,840
Classifying/weighing/applying alum	1	3,840
Labeling/packaging	1	3,840
Total		**19,200**

[a]Includes one inspector and one washer.
[b]Rate is ₱160/MD at 1 day/week for 24 weeks for the first cropping year and at 48 weeks for succeeding years.

Total Cost of Packinghouse Operation

Item	Amount (₱)			
	Year 1	Year 2[a]	Year 3[a]	Year 4[a]
Facilities for establishing mini-packinghouse[b]	38,350	12,450	13,000	13,605
Materials[c]	109,015	119,916	131,908	145,099
Depreciation of equipment[d]	8,025	8,025	8,065	8,065
Labor[e]	19,200	42,240	46,464	51,110
Total	**186,915**	**182,631**	**199,437**	**217,879**

[a]Assumption: 10% increase in cost per year except for the depreciation cost that is dependent on the equipment's life span.
[b]Breakdown of cost to establish a mini-packing plant is indicated on page 97.
[c]Breakdown of cost of materials is indicated on page 102.
[d]Breakdown of cost of equipment is indicated on page 102.
[e]Breakdown of cost of labor is indicated above.

Transport

Bunches are either transported on trailers pulled by tractors or on cable lines to the packinghouse. The former is more commonly used for small growers. From the packinghouse to market destinations, they are transported by land transportation and by ocean vessels.

For the domestic markets, the fruits are transported by land in trucks or small trailer vans and by inter-island shipment. For inter-island shipment, the crates are loaded in container vans (ten-footers) with pallets, wherein doors are left open during transport to reduce heat buildup inside the van.

Fruits for export are kept refrigerated in the ship at 13˚–14˚C.

Whether the fruits are for the domestic or the world market, they should be packed tightly inside the cartons to reduce bruising.

The buyer normally shoulders the transport cost from the packinghouse to the port.

Storage

The buyer handles the following storage technology. It is presented for the benefit of the producer and buyer.

Low Temperature

The most effective way of prolonging the shelf life of banana fruits is to store them at a low temperature. The optimum storage condition for most bananas, either mature green or ripe, is 13˚–14˚C with a 95% relative humidity. Storing fruits below the optimum temperature results in chilling injury. Mature green fruits are more susceptible to chilling injury than ripe fruits.

Modified Atmosphere

Modified atmosphere (MA) can also delay ripening. MA storage at an ambient condition can be adopted for varieties (e.g., 'Cavendish,' 'Lakatan,' 'Latundan,' 'Señorita,' and 'Buñgulan') that respond favorably. Before being packed in cartons or crates, the fruits that are free from blemishes are sealed in polyethylene bags with suitable thickness of about 0.05 mm. Ethylene scrubbers are enclosed in the bag to further increase the storage life of the fruit.

A low temperature, combined with MA, further increases the shelf life and minimizes chilling injury.

Village Level Storage

Moist sawdust can delay fruit ripening by the principle of evaporative cooling, at a condition of 1 part sawdust with 1.5 parts of water (weight/volume). Under this condition, the fruits will ripen one month later. One kilo of sawdust mixed with 1.5 L water can cover one big hand weighing 2 kg.

Ripening and Degreening

Many ripening agents can be used for bananas. Table 12 presents a ripening guideline for bananas for the appreciation of the producer and buyer.

Ethylene gas is released into a room containing boxes of exportable banana fruits, and the temperature is maintained at 20°C. The pulp temperature should reach 18°C prior to ethylene treatment. The ripening room should not be opened unnecessarily for the first 24 hours. After that, the room must be ventilated, by opening the door for about 15–20 minutes.

The optimum ripening temperature for banana is 25°C. Below or above this temperature results in delayed or inhibited ripening.

Table 12. Ripening guideline for banana.[a]

Cultivar	Kind	Concentration	Method of Application	Length of Exposure	No. of Days to Ripen
'Saba'	Ethephon (Bondad 1972)	5,000 ppm	Dipping, spraying	5 minutes	Two days at ambient condition
	CaC_2 (Espanto 1985)	125 g/200-L drum 125 g/52 x 98 cm sack 1 kg/100 kg fruit	Place at the bottom	24 hours	3–5 days at ambient condition
	Immature gliricidia leaves[b]	5% of fruit weight	Enclosed in PEB with 16 DH	1–2 days	Five days at ambient condition
	Mature rain tree leaves[c] (Acedo and Bautista 1987)				
'Latundan'	Ethrel (Nermal et al. 1983)	500 ppm	Spraying	Until dipping wet	2–3 days at ambient condition
'Lakatan'	Ethrel (Bondad 1971)	2,500 ppm	Dipping	5 minutes	Six days at 25°C Seven days at 20°C
'Morado'	Ethephon (Bondad 1972)	5,000 ppm	Dipping, spraying	5 minutes	2.5 days at ambient condition
'Buñgulan'	Ethrel (Mendoza & Pantastico 1980)	500 ppm	Dipping	5 minutes	Eight days at 20°C

Table 12. (Continued).

Cultivar	Kind	Concentration	Method of Application	Length of Exposure	No. of Days to Ripen
'Cavendish'	Ethylene gas	1,000 ppm	Spraying or release of metered gas in enclosed chamber with controlled temperature	24 hours	Three days from gas release (color index 3) at 18°–20°C

[a]PCARRD 1988.
[b]*Gliricidia sepium* locally known as kakawate or madre de cacao.
[c]*Samanea saman* locally known as acacia.

Processing Banana Fruits

The following are some of the major processed banana products and their procedures, some of which are cited in *The Philippines Recommends for Banana*. Unfortunately, the information on the cost to produce each product is not available.

Banana Flour

1. Separate unripe bananas ('Cavendish' or 'Saba') by fingers and wash.
2. Immerse in water at 70°–75°C for five minutes to facilitate the removal of peel from the unripe fruit.
3. Cut peeled banana fruits into 0.6-cm thick.
4. Immerse in 0.2% sodium metabisulfite solution for one hour or place in a sulfur chamber and expose to sulfur dioxide gas for 20–25 minutes.
5. Dry in a cabinet dryer up to 8% moisture at a temperature of 75°C.
6. Cool and ground into flour and sift through a sieve.
7. Pack the flour in sacks lined with polyethylene to maintain the desired moisture content.

Banana Chips

1. Choose round and mature banana fruits.
2. Weigh and wash the fruits.
3. Peel and immediately immerse in 0.05% sodium metabisulfite for 15 minutes.
4. Slice the peeled banana to about 32 mm.
5. Soak the slices in sodium metabisulfite solution for an hour to prevent browning.
6. Remove slices and drop in boiling water for 30 seconds and in cold water for 5 seconds.
7. Deep fry at 175°C for 2–3 minutes or until the temperature lowers to 110°C.

8. Soak in 50° brix syrup with flavoring for five minutes.
9. Refry at 150°C for 2–3 minutes or until the temperature lowers to 135°C.
10. Pack in layers of polyethylene-foil-polyethylene and place in containers.
11. Store in a cool, dark, and dry place.

Banana Powder

1. Wash and peel fully ripe banana fruits.
2. Chop and pass through a colloid mill.
3. Add 1–2% solution of sodium metabisulfite before drying.
4. Dry the pulp or slurry up to a final moisture content of 2% by spray drying, drum drying, or foam mat drying.
5. Pack the powder in a moisture-proof container.

Banana Flakes

1. Wash and peel fully matured banana fruits (not overripe).
2. Blanch the fruits in steam for five minutes and then whip into a creamy pulp.
3. Add 500–550 ppm (160 mg/100 g banana pulp) sodium metabisulfite.
4. Dry to a moisture content below 2.6% in a drum dryer heated at 181°C.
5. Pack in a moisture-proof container.

Banana Catsup

Ingredients	Quantity (g)
Vinegar	100.0
Pepper, labuyo	1.0
Onion, powdered	5.0
Garlic, powdered	1.0
Refined salt	10.0
Sugar	80.0
Red dye (No.2)	2.7

Yellow dye (No. 5)	2.8
Cinnamon	5.0
Banana ('Saba')	200.0
Water	200.0

1. Cook, peel, and grind fully ripe banana fruits.
2. Weigh the ground pulp and add an equal amount of water.
3. Blend in a Waring Blender for 1 minute.
4. Adjust the pH of the puree to pH 4.0–5.3 by adding citric acid (0.05% of puree) and/or sodium hydroxide.
5. Adjust the pH of the vinegar to pH 4.0–4.3.
6. Grind the spices and dissolve in vinegar. Add to the puree.
7. Cook the mixture for 10 minutes at 75°–85°C, with continuous stirring to prevent scorching.
8. Add coloring and continue heating up to the desired consistency.
9. While catsup is hot, pour it into a clean sterile bottle.

Banana Vinegar

Ingredients	Quantity
Banana fruits	1 kg
Sugar	250 g
Water	2 L
Yeast	5 g
Mother vinegar	100 mL

1. Wash, peel, and cut ripe bananas into pieces.
2. Add water and boil for 5 minutes.
3. Allow to cool. Strain.
4. Add sugar and heat again. Cool again.
5. Pour into suitable containers.
6. Add yeast.
7. Plug the mouth of a demijohn with a clean piece of cloth and loosely cover it with a piece of paper to protect it from dust.
8. Allow to ferment for 2–3 weeks.
9. Transfer out clear fermented liquid into a sterile container.
10. Add 100 mL of mother vinegar. Plug the mouth of the container with cotton and cover loosely with clean paper.

11. Allow to ferment for 1–2 months.
12. Pasteurize at 70°C for 20 minutes.

Banana Wine

1. Peel and cut bananas ('Buñgulan,' 'Cavendish,' or 'Latundan').
2. Add two parts water for every part of banana pulp. Heat until boiling point.
3. Strain juice through a cheesecloth and add one part sugar to five parts of juice.
4. Adjust with citric or ascorbic acid the pH of the mush to 4.0–4.5.
5. Add 15% yeast starter (*Saccharomyces cerevisiae* var. *allipsoideus*) and ferment for one month.
6. Siphon the clear wine, then age for one year.

Pastillas de Saging

Ingredients	Quantity
Banana puree ('Cavendish' or 'Saba')	5 cups
Sugar	2 ½ cups
Margarine	

1. Follow the procedure of the banana puree recipe.
2. Mix the banana puree and sugar in a cooking pan.
3. Add margarine.

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Appendix 1

A Model One-year Cash Flow for Producing 25,000 Banana Plantlets a Week ('000 Pesos)

Expenses	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Manpower													
General Manager	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	360.00
Production manager	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	300.00
Supervisor II	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	120.00
Propagator	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	66.00
		4.04	38.38	38.38	38.38	38.38	38.38	38.38	38.38	38.38	38.38	38.38	387.84
Laboratory aide	4.17	4.17	4.17	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	125.01
			4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50		40.50
Utility man	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	51.60
Secretary/Cashier	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	60.00
Bookkeeper/Accountant				5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	45.00
Purchaser/Driver	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	54.00
Washers			7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	78.30
Cotton plug making	0.50	0.50	0.50										1.50
Test tube rack making	2.50	2.00	1.30										5.80
Accountant				4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	36.00
Legal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	48.00
SSS and EC	3.28	3.28	5.61	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	6.54	71.03
Pag-ibig	1.65	1.65	2.85	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	36.84
PhilHealth	0.72	0.72	1.40	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	17.96

Appendix 1. (Continued).

Expenses	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Other Bills													
Electricity	5.00	5.00	10.00	18.00	20.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	219.00
Water	0.50	1.00	1.00	2.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	16.50
Building rental	60.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	280.00
Communications	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	84.00
Internet	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	3.60
Drinking water	1.80	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	15.00
Representation	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	120.00
Meal allowance	0.30	0.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	5.60
Overtime pay				2.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	25.00
Equipment/Apparatus	685.70	125.70	125.70	205.75									1,142.85
Supplies	48.35	1.60	4.00	1.35	12.00	24.20	8.00	1.60	28.40	1.60	1.60	1.60	134.30
Chemicals	54.28					54.28							108.56
Business permit	10.00												10.00
BIR documentary stamps	20.00												20.00
Insurance	20.00												20.00
Building improvement	150.00												150.00
Electrical	120.00												120.00
Culture shelves	120.00												120.00
Transformer deposit	78.00												78.00
Pick up	800.00												800.00
Motorcycle	80.00												80.00
Total (Laboratory)	2,372.35	276.76	334.54	440.24	246.64	317.12	246.64	240.24	267.04	240.24	240.24	235.74	5,457.79

Appendix 1. (Continued).

Expenses	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Nursery													
Nursery construction				62.50									62.50
Land rental	5.00												5.00
Labor and materials				73.87									73.87
Supplies and materials	2.90		22.70	20.35									45.95
Equipment and tools	2.90	0.40	0.45	23.00									26.75
Manpower													
Nursery-in-charge	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	60.00
Laborer	2.10	2.10	2.10	2.10	1.40	1.40	2.10	2.10	2.10	2.10	2.10	2.10	23.80
Job contracts:													
Soil bagging/hauling	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	300.00
Sorting/hauling/filling	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	75.00
Loading	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	75.00
Total (Nursery)	55.40	45.00	67.75	224.32	43.90	43.90	44.60	44.60	44.60	44.60	44.60	44.60	747.87
Total (Laboratory & Nursery)	2,427.75	321.76	402.29	664.56	290.54	361.02	291.24	284.84	311.64	284.84	284.84	280.34	6,205.66
Sales													
Year 1 (8th–12th mo)										1,200.00	1,200.00	1,200.00	6,000.00
Year 2 (13th–19th mo)	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00						8,400.00
Total (Sales)	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	14,400.00

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