MANUAL ON CROP PRODUCTION IN UPLAND AREAS OF PALAU

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COLLEGE OF MICRONESIA
PALAU COMMUNITY COLLEGE

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MESSAGE

Aside from taro, many crops can be grown on upland areas of Palau. These crops have to be grown so that there will be continuous and abundant supply of food for the people of Palau even when lowland areas have become unfit for taro production.

These upland crops are cassava, sweet potato, banana, papaya, corn, soursop, citrus, guava,, pineapple, dragon fruit, and vegetable crops such as long beans, cucumber, okra, eggplant, radish, kangkum, Chinese cabbage, bittermelon, green onions, tomato, chili pepper and watermelon.

This report ensures that Palau can resort to planting other crops in case lowland taro become in short supply.

DR. SINGERU SINGEO
Executive Director
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MESSAGE

A former employee and two research staff of the Palau Community College Cooperative Research and Extension have prepared a list of crops that can be grown in upland areas of Palau when there is limited supply of food due to climate change.

In this report, each crop have the following information such as land preparation, method of planting, fertilization, weeding, pest control and harvesting. Nutritional value of each crop is included to make the report complete. These information are valuable and can be followed easily by Palau farmers.

PATRICK U. TELLEI, Ed.D.
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PREFACE

Aside from taro, *Colocasia esculenta*, other crops can be grown successfully and profitably in the upland areas of Palau, thus, ensuring availability of food on the island.

These crops are sweet potato, cassava, corn, pineapple, banana, papaya, dragon fruit, soursop, guava, and citrus. Vegetable crops such as long beans, cucumber, okra, eggplant, radish, kangkum, Chinese cabbage, squash, bitter melon, green onions, chili pepper, tomato and water melon can also be grown.

Once grown, the above crops can get established and provide abundant and continuous supply of nutritious food, hence ensuring food security and preventing malnutrition among the populace in the island country.

The information obtained was derived from the actual experiences of the CRE Staff in growing the crops, from farmers in Asia and from the experiences of Palauan farmers themselves. It is hoped that these information will help other farmers successfully grow many crops in Palau.

In the very near future many lowland areas in Palau and Micronesia will become unfit for crop production due to climate change. Farmers in Palau can resort to utilizing upland areas for crop production. These crops are listed in this manual.

In this Manual each crop mentioned has the following information: nutritional value the components of which are based on 100 gram sample of the edible portion, varieties, land preparation, distance of planting, fertilization, weed control, pest control and harvesting.

We would like to thank the College of Micronesia for funding the production and printing of this Manual which can be available for use by farmers and interested individuals.

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I. CROPS FOR UPLAND AREAS IN PALAU

A. SWEET POTATO

It is a spreading prostrate herbaceous hairy vine forming edible small or large tuberous roots which are a staple food in Palau. The leaves are cooked and eaten as vegetable.

Fig. 1. Field planting of sweet potato

Table 1. Nutritional Value of Sweet Potato

Component	Nutritional Content	
	Tubers	Leaves
Edible Portion	89%	100%
Water	73.5%	93.2%
Energy	104 kcal	29 kcal
Protein	0.7 g	1.1 g.
Fat	0.5 g.	0.7 g.
Carbohydrate	24.3 g.	4.6 g.
Crude Fiber	(2.3 g.)	0.9 g.
Ash	1.0 g.	0.5
Calcium	15.2 mg.	57 mg.
Phosphorus	50 mg.	23 mg.

Table 1. (Cont'd)

Component	Nutritional Content	
	Tubers	Leaves
Iron	1.1 mg.	1.6 mg
Retinol	0	0
B-Carotene	25 ug.	1280ug.
Total Vitamin A	4 ug.	213 ug.
Thiamine	0.13 mg.	0.03 mg.
Riboflavin	0.04 mg.	0.05 mg.
Niacin	0.7 mg.	0.4 mg.

The tuber is a good source of energy and phosphorus while the leaves are a good source of calcium, B-carotene and total Vitamin A.

Varieties

There are 17 distinct varieties of sweet potato in Palau. These are Bent 1, Bent 2, Bent 3, Bertakl, Dirradid, Guam Orange, Hawaiian, Ishiobing, Kangkum, Kangkum 2, Ngaraard, Nikangets, Ningsing, OISCA, Techeboet, Telekeok and Telentund. There are also several introduced varieties from the Center for Pacific Crops and Trees (CePaCT), of the Secretariat of the Pacific Community (SPC) in Fiji which are maintained at the PCC Research and Development Station.

Land Preparation

Newly established areas for planting are cleared of shrubs and trees. Before rototilling the soil, lime is applied by broadcast at 750 kg./ha. Rows are made 1 meter apart.

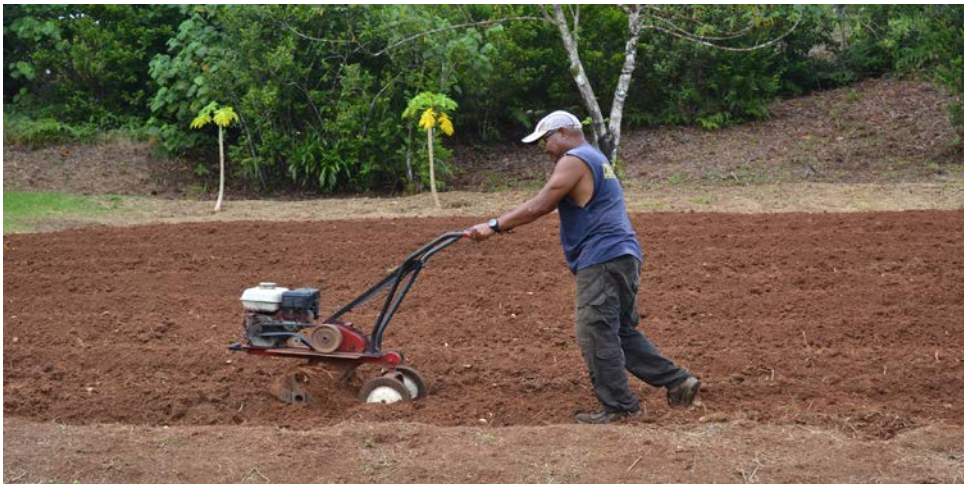

Fig. 2. Rototilling the field

Planting Materials

Before harvest, planting materials are collected from the vines. Stems measuring 12 inches from the tip are cut. Stems are planted immediately or placed in the shade for 2 to 3 days before planting in the field.

Distance Of Planting

Two cuttings measuring 12 inches long from the tip of the plant are placed on each planting hole. The distance between plants is 60 cm. A handful of chicken manure is applied at the base of each plant at planting time.

Fertilization

One month after planting, inorganic fertilizer in the form of 10-30-10 (NPK) is applied at the base of each seedling at the rate of 1,500 kg/ha.

Weed Control

Manual weeding is done during the first 2 months after planting. The bases of the plants are cultivated and hilled up.

Pest Control

The most common pest attacking sweet potato is the tortoise shell beetle causing perforations on the leaves. Blotch miners are also present as larvae feed on the leaves. The most common disease is a fungal parasite that causes scabs and lesions on the leaves and leaf shoots. Since farmers plant different varieties of sweet potato, control of these insect pests and diseases is seldom done.

Fig. 3. Tortoise shell beetle damage on sweet potato leaves

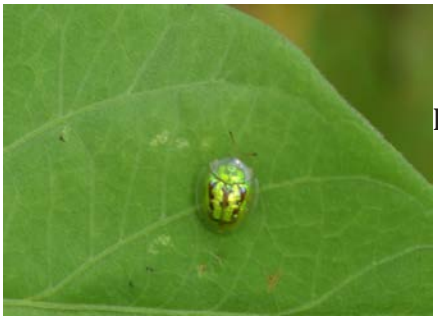

Fig. 3a. Close up of tortoise shell beetle

Harvesting

The tubers are harvested 4 to 5 months after planting. Using knives or machetes, farmers dig around the base of the plant to expose the tubers. The plants are pulled and the tubers are removed. The tubers are placed in baskets and then washed to remove the dirt.

Fig. 4. Harvested sweet potato tubers

B. CASSAVA

Cassava is an erect, smooth, shrubby plant 1.5 to 3 meters high and is planted for the tuberous roots. The tuber is high in food energy, phosphorus and ascorbic acid while the leaves are high in calcium, ascorbic acid and beta-carotene.

Table 2. Nutritional Value of Cassava

Component	Nutritional Content	
	Boiled Tubers	Leaves
Edible Portion	71 %	100 %
Water	71.8 g.	89.5 g.
Energy	111 k cal	43 k cal
Protein	0.6 g.	3.4 g.
Fat	0.1 g.	0.7 g.
Carbohydrate	27.1 g.	5.7 g.
Fiber	(1.3 g.)	1.5 g.
Ash	0.6 g.	0.7 g.
Calcium	10 mg.	102 mg.
Phosphorus	22 mg.	48 mg.
Iron	0.3 mg.	0.6 mg.
B-Carotene	Traces	11,735 ug.
Total Vitamin A	Traces	1956ug.
Thiamine	0.03 mg.	0.04 mg.
Riboflavin	0.01 mg.	0.09 mg.
Niacin	0.4 mg.	0.8 mg.
Ascorbic acid	22 mg.	84 mg.

Varieties

There are about 30 distinct varieties of cassava being grown in Palau. These varieties are Aderuangel, Angaur Red, Chemeraech, Cheual Buil, Dilubech, Dokkoiso, Fiji, Hide, Homusted, Idub, Ikrebai, Kamerang, Klerang, Kodep, Mechebechubel, Modekngei, Ngchar, Ngeaur, Ngesuong, Ngkud, Ochobirang, Oreor, Saibal, Shimizu, Stebania, Smiich, Terue, Tikei, Umad, and Yasireng. Farmers usually plant different varieties of cassava in their farm.

Land Preparation

Cassava grows well in open, flat or slightly sloping areas. The area is cleared with grasses, shrubs and other vegetation.

Liming

Lime at 750 kg/ha is applied by broadcasting before plowing. Using a rototiller, the lime is mixed with the soil. Rows are made 1 meter apart.

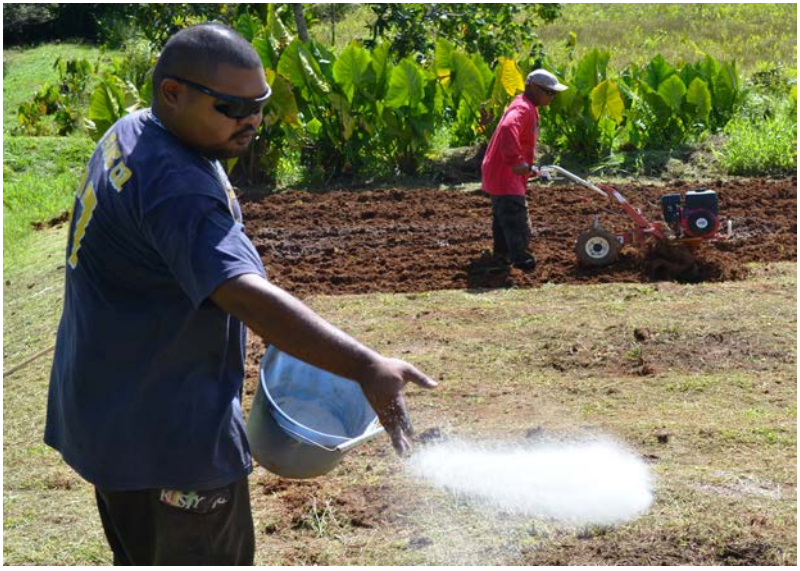

Fig. 5. Broadcasting lime and immediate rototilling of the field

Planting Materials

Stems of cassava are cut into stakes. Each stake must have about 5 to 7 nodes and are planted in vertical or slanting position.

Areas planted to cassava for three growing seasons must be rotated with legumes or grass to maintain soil productivity.

Distance of Planting

Planting is done at a distance of 50 to 70 cm between hills.

Fertilization

Two to 6 weeks after planting, a handful of compost or chicken manure is applied in a hole 15 to 20 cm from the base of the plants. Inorganic fertilizer such as 10-30-10 or a mixture of equal parts of 10-20-0 and 14-14-14 are also applied on the base of seedlings at the rate of 1,500 kg/ha.

Weed Control

Manual weeding is done during the first three months after planting. Once canopy closes, weeding is stopped.

Fig. 6. Field planting of cassava

Pest Control

The most serious pest of cassava in Palau is the spider mite, *Tetranychus* sp. However, the predatory mite had been released in many cassava growing areas of Palau and is contributing in lowering the population of spider mites in cassava fields.

Fig. 7. Cassava leaves damaged by spider mite

Harvesting

Cassava is harvested 9 to 10 months from planting. The stems of cassava are cut and then the plant is pulled by hand from the ground. Cassava tubers should be peeled and stored in a freezer immediately after harvest to prevent loss of quality due to dark streaks caused by oxidation and fungal attack.

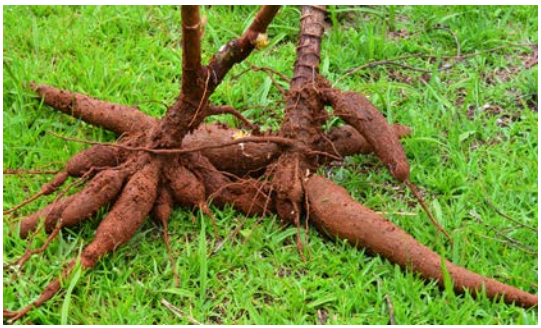

Fig. 8 Harvested cassava tubers

C. CORN

Fig. 9. Ears of sweet corn

Corn is planted in many areas of Palau. Its ears are a good source of carbohydrates for energy, high in phosphorus and total Vitamin A.

Table 3. Nutritional Value Of Corn

Component	Nutritional Content
Edible Portion	54%
Water	59.2 gm.
Energy	167 k cal
Protein	3.3 g.
Fat	1.2 g.
Carbohydrate	35.7 g.
Fiber	(5.0 g.)
Ash	0.6 g.
Calcium	10 mg.
Phosphorus	92 mg.
Iron	1.2 mg.

Table 3. (Cont'd)

Component	Nutritional Content
B-Carotene	10.4 ug.
Total Vitamin A	17 ug.
Thiamine	0.09 mg.
Riboflavin	0.08 mg.
Niacin	0.9 mg.
Ascorbic acid	5.0 mg

Varieties

Sweet corn is the most common type of corn grown in Palau. The common varieties available from the stores in Palau are Supersweet, Bright Jean No. 2, Sweet Jean and Snow Jean. These seeds come from the Philippines and Taiwan.

Land Preparation

The area for planting is cleared of weeds, grasses and small vegetation. Once cleared, the area is rototilled and one meter rows are made.

Liming

Lime is applied by broadcast on top of the soil immediately before rototilling.

Distance Of Planting

On top of the furrow, the soil is slightly made open with the use of a hoe. Two to three seeds are placed every 5 cm and then covered with soil.

Fertilization

At seedling emergence, inorganic fertilizer and manure are applied in band application about 5 cm from the bases of the seedlings. The fertilizer and manure are covered with soil. Second fertilizer application is done at whorl stage. Hilling up is done to cover bases of seedlings and at the same time remove the weeds.

Fig. 10. Field planting of sweet corn

Weed Control

Weeding is done manually with the use of sickle or hoe. Weeds are removed from the base of the seedlings. Weeds in between the rows are removed with the use of a hoe.

Pest Control

The corn borer is a major pest of sweet corn in Palau. The mature larvae bore into the stem and feed inside. As a result, the plant can be toppled over by winds.

One way of controlling infestation is by applying granular pesticide, Diazinon, on the leaf whorl. Newly hatched larvae of corn borer come in contact with the pesticide and are killed.

Harvesting

The ears of corn with their husks are removed from the plant manually. Some of the old husks are removed before they are placed in a container.

Fig. 11. Sweet corn with husk

D. BANANA

The banana is a monocotyledonous plant and considered the largest plant on earth without a woody trunk. Its stems and leaf sheath produce a trunk like structure that can grow as high as 10 meters. It has a crown of wide long leaves with fruits hanging heavily in a cluster. It bears fruit only once.

Fig. 12. The banana plant.

Table 4. Nutritional Value Of Banana

Component	Nutritional Content
Edible Portion	73 %
Water	73.4 g.
Energy	105 k cal
Protein	1.2 g.
Fat	0.3 g.

Table 4. (Cont'd)

Component	Nutritional Content
Ash	0.7 g.
Calcium	17 mg.
Phosphorus	34 mg.
Iron	0.7 mg.
B-Carotene	30 ug.
Total Vitamin A	5 ug.
Thiamine	0.02 mg.
Riboflavin	0.02 mg.
Niacin	0.5 mg.
Ascorbic acid	21 mg

The fruit is mainly composed of water as well as carbohydrates which provide energy to the human body. It is high in phosphorus, calcium and ascorbic acid .

Varieties

There are several varieties of banana grown in Palau. Some of the popular varieties are as follows: Mechad, Lakatan, Medakt a Deleb, Meskebesang, Rubeang, Bechochod, Sato, Cavendish Variety, Emaus, Kurob, Meduch a Ngerel, Cherasech.

Land Preparation

Newly established areas for planting are cleared of vegetation and trees. Usually 50 cm holes are made at a distance of 3 to 4 meters between plants.

Planting Materials

Planting materials used are suckers, corms and corm bits. Different varieties of banana produce varying number of suckers on the sides of mother plants. Suckers that grow vigorously tapering in general for over a meter tall are selected. Corms are about 10 to 15 cm in diameter with a minimum of one good bud and "2 eyes" weighing about 0.5 kilogram.

Bits are bigger corms that has been cut into 2 to 4 pieces, Each bit should have an "eye". Plant these bits in a row 30 cm apart. After several weeks, shoots will start to grow from each bit.

Fertilization

Two handfuls each of manure or compost and inorganic fertilizers are placed at the bottom of the hole before planting. Manure and fertilizer are covered with soil. The planting material is placed in the hole and then covered with soil. During the first 5 months of growth two handful of fertilizer is applied 30 to 60 cm from the pseudostem in a ring or band placement.

In Palau, irrigation is not needed as rainfall is well distributed throughout the year.

Weed Control

Farmers use "green machines" or "grass cutters" to cut the grass in the farm to prevent weeds from overgrowing the banana plants.

Sucker Removal

Suckers that exceed three are removed to prevent competition for soil nutrients. In Palau however, farmers do not remove extra suckers.

Pest Control

In Palau, *Marasmiellus* is a very serious disease on banana. It is caused by the fungus *Marasmiellus moderna*. Pink fungal growth occurs between leafsheaths. Affected plants usually have smaller leaves and the fruit bunch is drastically reduced. Fungal fruiting bodies (mushroom-like) are produced on the leafsheaths or on debris on the ground. Lakatan variety is particularly susceptible to the disease.

Affected outer leafsheaths are removed to reduce infection on the plant.

Fig. 13. *Marasmiellus* infected banana (left) and removal of infected leafsheath (right).

Propping and bagging of fruits are done to prevent damaging the fruits.

Harvesting

Fruits are harvested when they are green at varying stage of maturity. As basis for maturity the number of days from flower emergence is recommended. For example for Mechad, the fruit must be harvested 9 to 11 weeks after flower emergence; for Lakatan, 12 to 14 weeks and for Meskebesang 20-24 weeks after.

Fig. 14. Fruits of Lakatan (left) and Meskebesang (right) banana.

E. PAPAYA

The papaya is a fast growing single stemmed polygamous arborescent herb that grows up to 10 meters tall. Its trunk is cylindrically hollow 10 to 30 cm in diameter and roughened by large prominent leaf and inflorescence scars.

Table 5. Nutritional Value Of Papaya

Component	Nutritional Content	
	Young Fruit	Ripe Fruit
Edible Portion	64 %	64 %
Moisture	92.9 g.	86.6 g.
Energy	27 k cal	53 k cal
Protein	1.0 g.	0.5 g.
Fat	0.1 g.	0.3 g.
Carbohydrate	5.5 g.	12.1 g.
Fiber	1.3 g.	1.3 g.
Ash	0.5 g.	0.5 g.
Calcium	60.0 mg.	34 mg.
Phosphorus	28.0 mg.	11.0 mg.
Iron	0.3 mg.	1.0 mg.
B-Carotene	0	450 ug.
Vitamin A	0	75 ug.
Thiamine	0.03 mg.	0.03 mg.
Riboflavin	0.02 mg.	0.04 mg.
Niacin	0.2 mg.	0.5 mg.
Ascorbic acid	20 mg.	74 mg.

The ripe fruit of papaya is a good source of B-carotene, ascorbic acid and calcium.

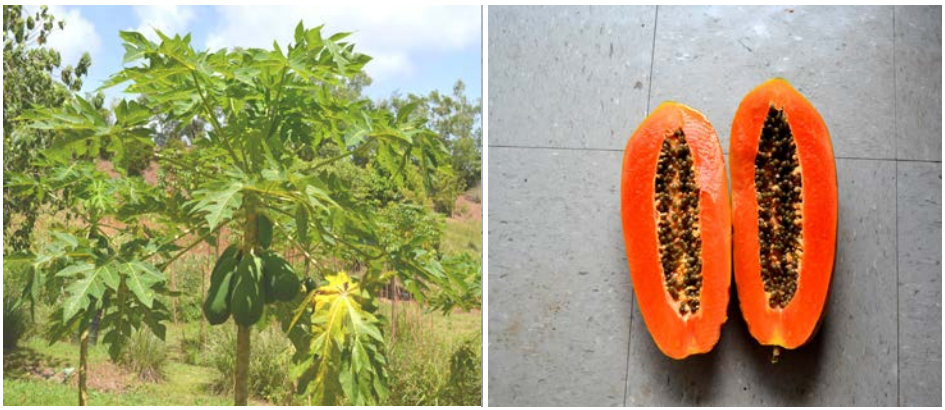

Fig. 15. 'Red Lady' papaya plant (left) and close up of fruit (right)

Varieties

The most common varieties being grown are the native, Solo, and Red Lady.

Land Preparation

Papaya grows well in light well drained acidic soil, rich in organic matter. In Palau, farmers dig a hole 30 cm in diameter and about 30 to 40 cm deep. A kilo of compost and 50 grams of complete fertilizer are placed in the hole. A thin layer of soil is added to prevent direct contact of roots of seedlings with the fertilizer.

Planting Materrials

Seeds are grown first in seedboxes. About one month old seedlings are transplanted. Three seedlings are planted in each hole. At flowering, male seedlings and sickly looking seedlings are cut and only one vigorous seedling is retained and allowed to continue to grow.

Distance Of Planting

In semi-commercial plantings, the land is rototilled and rows are provided where to plant seedlings. The distance between plants is about two meters and 3 meters between rows.

Fertilization

At flowering, the plants are fertilized again with a handful of fertilizer placed in a hole 5 cm from the base of the seedlings. Another handful of fertilizer is placed on the other side. After first harvest, the plants are provided again with fertilizer.

Weed Control

The grass and weeds between plants and between rows are cut to prevent the weeds from outgrowing the plants. Cutting of grasses is done as often as necessary.

Pest Control

Spider mites, *Tetranychus* sp., often infest seedlings after transplanting, causing death of mature leaves. Throughout the island, a predatory mite, *Neoseiulus longispinosus,* had been released to control spider mites.

The most destructive disease that affects papaya is the papaya ringspot virus. It has never been observed to occur yet on papaya in Palau. Care must be taken to prevent it from reaching the island. The disease is characterized by the presence of faint chlorosis on younger leaves. Fruits show characteristic ring spotting or with small watersoaked or oily spots on the surface.

Fig. 16. Mature papaya leaf severely damaged by red spider mite

Harvesting

Fruits must be harvested at the right stage of maturity. The presence of a streak of yellow at the ridges of the apical end is a good indicator. The fruits are harvested and allowed to ripen in the shaded areas in the house.

F. SOURSOP

The plant is grown for its 20 to 30 cm long, prickly green fruit which can weigh up to 6.8 kg. The flesh of the fruit contains an edible white pulp, some fiber and a core of indigestible black seeds.

The pulp is also used to make fruit nectar, smoothies, juice drinks, as well as candies, sorbets and ice cream flavorings.

Table 6. Nutritional Value Of Soursop

Component	Nutritional Content
Edible Portion	70 %
Water	82 gm.
Energy	70 k cal
Protein	1.1 g.
Fat	0.1 g
Carbohydrate	16.2 g.
Crude Fiber	0.6 g.
Ash	0.6 g.
Calcium	16 mg.
Phosphorus	23 mg.
Iron	6.0 mg.
B-Carotene	0
Total Vitamin A	0
Thiamine	0.09 mg.
Riboflavin	0.07 mg.
Niacin	0.9 mg.
Ascorbic acid	27 mg.

Soursop is a good source of Vitamin C, phosphorus and calcium.

Fig. 17. Soursop fruits

Varieties

Seeds are locally available from trees that have ripe fruits.

Planting Materials

Seeds from ripe fruits are collected and dried. The seeds are initially grown in polybags with soil and manure. When seedlings are about 10 cm tall, one seedling is planted in each polybag. The seedlings are watered to promote growth of seedlings. Six months after, the seedlings are ready for transplanting in the field.

Land Preparation

The area for planting is cleared of weeds and shrubs before transplanting.

Distance Of Planting

Holes 30 cm in diameter and 30 cm deep are made with the use of hoe and spade. The distance between trees must be about 4 meters.

In each planting hole, a kilo each of manure and complete fertilizer are placed and lightly covered with soil.

Weed Control

Overgrown weeds and grasses found in the spaces between plants are cut using a "green machine". Some of the weeds growing near bases of plants are removed manually.

Pest Control

The tail jay butterfly is a pest of soursop. The larvae feed on the leaves. It is not a serious pest and no control measures are being implemented to reduce its damage on the leaves.

Harvesting

Mature fruits are harvested and allowed to ripen in shaded areas in the house. The fruits are mature if the skin is shining green in color and the spines are well separated.

Fig. 18. Cross section of soursop fruit showing white flesh

G. PINEAPPLE

The pineapple plant is a terrestrial herb 0.75-1.5 m high with a spread of 0.9-1.2 m; a very short, stout stem and a rosette of waxy, 50 to 180 cm long-pointed strap like leaves; usually needle tipped and generally bearing sharp, upcurved spines on the margins. The leaves may be all green or variously striped with red, yellow or ivory down the middle or near the margins. At blooming time, the stem elongates and enlarges near the apex and puts forth a head of small purple or red flowers, each accompanied by a single red, yellowish or green bract. The stem continues to grow and acquires at its apex a compact tuft of stiff, short leaves called the "crown" or "top". Occasionally a plant may bear 2 or 3 heads, or as many as 12 fused together, instead of the normal one.

As individual fruits develop from the flowers they join together forming a cone shaped, compound, juicy, fleshy fruit to 30 cm or more in height, with the stem serving as the fibrous but fairly succulent core. The tough, waxy rind, made up of hexagonal units, may be dark-green, yellow, orange-yellow or reddish when the fruit is ripe. The flesh ranges from nearly white to yellow. If the flowers are pollinated, small, hard seeds may be present, but generally one finds only traces of undeveloped seeds.

Fig. 19. The 'Queen' variety of pineapple.

Table 7. Nutritional Value Of Pineapple

Component	Nutritional Content
Edible Portion	100 %
Water	71.1 g.
Energy	119 k cal
Protein	0.4 g.
Fat	0.8 g.
Carbohydrate	27.5 g.
Crude Fiber	1.2 g.
Ash	0.2 g.
Calcium	12 mg.
Phosphorus	4 mg.
Iron	Traces
B-Carotene	Traces
Total Vitamin A	Traces
Thiamine	0.12 mg.
Riboflavin	0.01 mg.
Niacin	0.3 mg.
Ascorbic acid	7.0 mg.

Pineapple slices are rich in calcium and ascorbic acid.

Varieties

There are two varieties of pineapple being grown in Palau. These are the sweet type or Queen variety and the Hawaiian variety. The Queen variety has smaller fruits with small eyes and the leaves are spiny. On the other hand, the Hawaiian variety has bigger fruits and bigger eyes with less spines on the leaves.

Land Preparation

The area for planting is rototilled and rows are made 1 meter apart.

Liming

Liming is not practiced in areas planted to pineapple as the plant can tolerate acid soils.

Distance Of Planting

The distance of planting within each row is 30 cm between plants and 1meter between rows.

Planting Materials

Slips, suckers and crowns are used as planting materials Generally farmers in Palau make holes at a distance of about 30 cm between plants. A handful of manure and a handful of fertilizer (10-30-10) are placed in the holes, covered slightly with soil to prevent roots of pineapple from coming in direct contact with manure and fertilizer.

Fig. 20. 'Hawaiian' variety of pineapple showing crown and slips as planting materials.

Fig. 21 . Suckers of pineapple as planting materials

Flower Inducing Agent

In semi-commercial planting of pineapple, calcium carbide mixed with water is applied on the growing point of one year old pineapple plantings. This is done to attain uniform flowering and fruiting of pineapple.

Small farmers however do not apply any flower inducing agents. They just wait for the fruit to come out more than a year after planting.

Fertilization

A handful of fertilizer is applied at the base of each plant 6 months after planting.

Weed Control

Control of weeds is done by hoeing at the early stage of plant growth. When the canopy of plants begins to touch each other, weeding is no longer done. Sometimes “grass cutter” are used to cut grass in between rows of plants.

Pest Control

The pineapple mealy bug, *Dysmicoccus brevipes*, infests pineapple in Palau. The colonies of mealy bugs are partially covered with soil made by ants at the bases of fruits. Ants usually tend on them. In semi-commercial planting of pineapples, Malathion is sprayed at the recommended rate at the bases of fruits and plants.

Harvesting

In small plantings since flower inducing agent is not used, fruits come out at different dates during the growing season. Some fruits harvested are for home consumption while the rest of the fruits are sold in the market.

The fruit is harvested once it becomes light yellow or golden yellow in color. The fruits are harvested manually and are placed in suitable containers.

H. CITRUS

This plant is a shrub or small tree with a long tap root, 2 to 7.5 m tall. Trees grown from seed start fruit production 5 to 6 years after planting, but this is shortened to 3 years or less by planting asexually propagated seedlings.

Flowering and fruiting is year round with a peak harvest season lasting for three months which falls during the months of August to October.

Fruits are round, greenish to yellow with a diameter of about 2 to 4 cm and reaches full maturity in about 3 months after flowering. The fruit is rich in phosphorus, calcium, iron and vitamin C.

Table 8. Nutritional Value Of Citrus

Component	Nutritional Content
Edible Portion	38 %
Water	89.8 g.
Energy	44 k cal
Protein	0.4 g.
Fat	1.0 g
Carbohydrate	8.3 g.
Crude Fiber	Trace
Ash	0.5 g.
Calcium	18 mg.
Phosphorus	12 mg.
Iron	0.8 mg.
B-Carotene	0
Thiamine	0.02 mg.
Riboflavin	0.01 mg.
Niacin	0.2 mg.
Ascorbic acid	45 mg.

Citrus fruit is high in ascorbic acid, calcium and phosphorus.

Fig. 22. Calamansi tree.

Varieties

The most common variety of citrus grown in Palau is the calamansi or "kingkang" in Palauan language.

Land Preparation

The area for planting is cleared of weeds and low vegetation. A 30-cm wide planting holes and about 30 cm deep are established in the area.

Planting Materials

The ripe fruits of calamansi are harvested and seeds are collected. The seeds are washed with water to remove the mucilaginous material which covers them. The seeds are then planted in seedboxes and placed in shaded areas around the house. Two to three week old seedlings are transferred to polybags, one seedling in each bag with soil and manure. Watering is done to provide moisture for rapid growth of seedlings. Six months after, the seedlings are ready for transplanting in the field.

Distance Of Planting

The distance of planting is about 4 meters. In each hole, a kilo each of manure and complete fertilizer are applied and then covered with soil. One seedling is planted in each hole and the base of the seedling is covered with soil.

Fertilization

At flowering time, one kilo each of manure and complete fertilizer are placed about 30 cm from the base of the plants. The fertilizer and manure are again covered with soil.

Weed Control

Weeds are removed manually from the base of the plants. Weeds that grow in areas between plants are cut with the use of "green machines" or "grass cutter".

Pest Control

Although many serious diseases of calamansi are present in many countries where citrus is grown, none of these have been found to be present in Palau. Care must then be exercised to prevent their introduction to Palau.

Sometimes scabs and canker are present on the fruit and bark. It is not serious enough to warrant control measures.

The orange spiny white fly is also present in Palau. A parasitic wasp had been introduced to Palau and is keeping the spiny white fly under control.

Harvesting

With the use of a ladder, the fruits are individually collected by hand and placed in a container or basket. Fruits that are ready for harvest usually assume golden yellow color.

Fig. 23. Trees bearing calamansi fruits

Fig. 24. Close up of calamansi fruits

I. GUAVA

Guavas are common tropical fruits cultivated and enjoyed in many tropical countries. It is a small tree with tough dark leaves that are opposite, simple, elliptic to ovate and 5-15 cm long. The flowers are white with 5 petals and numerous stamens. The fruits are many seeded berries.

The guava fruits, usually 4 to 12 cm long are round or oval. They have a pronounced and typical fragrance. The outer skin maybe rough, often with a bitter taste or soft and sweet. The pulp inside may be sweet or sour and off white (white guavas) to deep pink (red guavas). The seeds in the central pulp vary in number and hardness.

Table 9. Nutritional Value Of Guava

Component	Nutritional Content
Edible Portion	99 %
Water	88.4 g.
Energy	70 k cal
Protein	0.8 g.
Fat	0.3 g
Carbohydrate	16 g.
Crude Fiber	(5.3 g.)
Ash	0.5 g.
Calcium	31 mg.
Phosphorus	26 mg.
Iron	0.9 mg.
B-Carotene	40 ug.
Total Vitamin A	7 ug.
Thiamine	0.06 mg.
Riboflavin	0.05 mg.
Niacin	1.2 mg.
Ascorbic acid	127 mg.

Guava fruits have high ascorbic acid, calcium, phosphorus and B-carotene.

Fig. 25. Fruits of native (left) and introduced (right) varieties of guava

Varieties

Planting materials of guava are available at the Taiwan Technical Mission. The seedlings are ready for transplanting.

Land Preparation

The area for planting is cleared of weeds and shrubs. Planting holes are made 30 cm wide and 40 cm deep. On each hole, a kilogram each of manure and complete fertilizer are placed. The hole is covered slightly with soil to prevent the planting material from getting in touch with the fertilizer and manure. One seedling is planted in each hole. The bases of the seedlings are then covered with soil.

Distance Of Planting

The recommended spacing is 3 meters apart.

At flowering time, the trees are pruned carefully to induce flowering and formation of fruit buds.

Fertilization

One kilogram each of manure and complete fertilizer are placed about 30 cm from the bases of the tree at flowering time. The fertilizer and manure are then covered with soil.

Fruiting

When fruits start to appear, they are enclosed with a white paper bag to prevent fruit flies from attacking them and at the same time allow the fruits to mature and attain full size.

Fig. 26. Guava trees with bagged fruits.

Weed Control

Weeds which grow near the base of the trees and in between trees are cut with the use of "green machine".

Harvesting

The fruits are harvested manually. Sometimes a ladder is used to facilitate harvesting the fruits on top of the trees. Fruits are placed in containers and sold in the market.

J. DRAGON FRUIT

Dragon fruit is cultivated both for ornamental vine and its edible fruit. It belongs to the Cactus family. The plant flowers at night. The flower is large, waxy, with white petals and very fragrant. It is called "moon flower" or "Queen of the Night".

Table 10. Nutritional Value Of Dragon fruit

Component	Nutritional Content
Water	83 %
Protein	0.229 g.
Fat	061 g
Crude Fiber	0.9 g.
Ash	0.28 g.
Calcium	8.8 mg.
Phosphorus	36.1 mg.
Iron	0.65 mg.
B-Carotene	0.012 mg.
Vitamin A	0.045 mg.
Thiamine	0
Riboflavin	0.044 mg.
Niacin	1.3 mg.
Ascorbic acid	9 mg.
Vitamin B3	0.43 mg.
Others	0.68 g.

** Letsgohealthy.blogspot.com/2013/01 health benefits and nutrition on line html.

The fruit contains Vitamin B3 which is known to lower bad cholesterol in the blood and also lowers sugar level for type 2 diabetes patients.

Fig. 27. Dragon fruit plant

Varieties

There are three known types of dragon fruit . These are :

1. *Hylocereus rendatus* - white flesh with pink skin
2. *Hylocereus polyrhicus* - red flesh with pink skin
3. *Selenicereus megalinichus*—white flesh with yellow skin

Land Preparation

The area to be planted with dragon fruit should be cleared with weeds and shrubs using a grass cutter, green machine and machete. Holes are made 3 meters apart.

Two handful each of manure and complete fertilizer are placed in a hole partly covered with soil.

Cement posts are placed where the plants can cling on for support when growing. The posts should be buried 60 cm deep and at least 180 cm above the ground.

Planting Materials

Cut the stems about 20 cm long. Plant one stem in each hole with a cement post.

Fertilization

Apply a kilo of manure and about 100 grams complete fertilizer at the base of the seedlings every year.

Pest Control

A fungal disease affects the growth of plants. Birds also feed on the fruits. Scale insects sometimes become a problem. In general, seldom if ever farmers apply pesticides to control disease and other pests.

In other countries, pests such as tussock moths, mealy bugs, aphids, flea beetles, bugworm, coffee bean weevil, black bug and Oriental fruitfly infest the plant. The diseases of dragon fruit include fruit rot, leaf spot, rust, leaf blight, yellow spot and flower rot.

Harvesting

Fruits can be harvested 40 to 50 days from flowering. When fruit skin turns from green to red, it is ready for picking. The fruit can be stored for 40 days at 5℃ and 90% relative humidity.

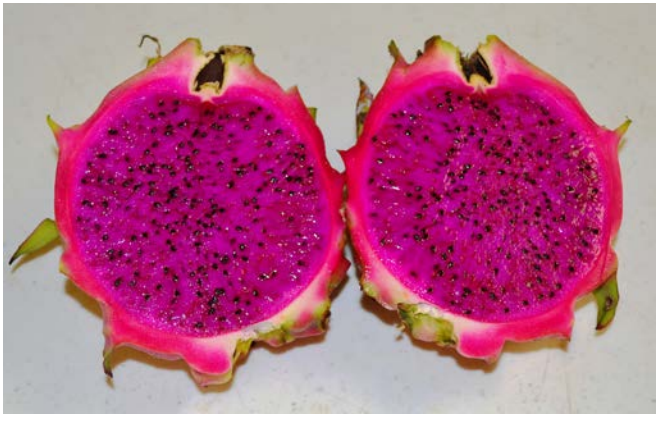

Fig. 28. Cross section of red fleshed dragon fruit

K. VEGETABLE CROPS

1. LONG BEANS

Long beans are climbing herbaceous crop raised primarily for its edible pods. Pods are slender, about 60 cm long and sometimes implanted with many seeds.

Table 11. Nutritional Value Of Long Beans

Component	Nutritional Content
Water	88.9 g.
Energy	43 k cal
Protein	3.1 g.
Fat	0.2 g
Carbohydrate	7.2 g.
Crude Fiber	2.2 g.
Ash	0.6 g.
Calcium	61 mg.
Phosphorus	47 mg.
Iron	0.9 mg.
B-Carotene	0
Total Vitamin A	42 ug.
Thiamine	0.12 mg.
Riboflavin	0.11 mg.
Niacin	1.0 mg.
Ascorbic acid	22.0 mg.

The pod contains high calcium, phosphorus and Vitamin A.

Fig. 29. Close up of long bean pods

Varieties

Seeds of long beans varieties 6001XL and Asparagus Beans come from Taiwan and the Philippines. They are available in some stores in Palau.

Land Preparation

Lime is broadcasted on the surface of the soil before land preparation. The field is rototilled and rows are made 1 meter apart. Holes are made 50 cm apart. Manure and inorganic fertilizer are placed in each hole.

Planting Materials

Two to three seeds are placed in each hole and covered with soil. Fertilizer and manure are partly covered with soil to prevent seeds from getting in contact with them.

Trellising And Nets

Vertical trellis is used for single row plots. Bamboo poles are placed two meters apart with GI wire. Nylon nets are then placed for the plants to climb on.

Fig. 30 . Close up of field planting of long beans

Fertilization

A handful of complete fertilizer is placed in each hole made 5 cm from the base of the seedlings. Fertilizer is then covered with soil.

In Palau, evenly distributed rainfall provides enough moisture to long beans throughout its growing period.

Weed Control

Hand pulling of weeds that grow at the bases of the plants is done. Hoeing is done to remove weeds between plants and between rows.

Pest Control

An important pest of long beans is the pod borer. The caterpillar bores into the pods and feeds inside. It also feeds on flowers and flower buds. Farmers usually apply either Diazinon or Malathion at the recommended rate starting at flowering time and one week after first spray.

Harvesting

Long beans are harvested 70 days from planting. It is harvested by hand every 3 to 4 days for up to 30 times during the growing season. Harvesting is done in the morning to avoid weight loss. They are placed in shaded area prior to selling them in the market.

2. CUCUMBER

Cucumber is a widely planted vegetable crop in Micronesia. It is grown for its immature fruits which are used in salads (slicing type) or soaked or stored in brine (pickling type). The common varieties of slicing cucumbers have sprawling vines with large green leaves and curling tendrils. The growth of these plants is fast and the crop yield is abundant.

Table 12. Nutritional Value Of Cucumber

Component	Nutritional Content
Edible Portion	81%
Water	95.5 g.
Energy	16 k cal
Protein	0.6 g.
Fat	0.2 g
Carbohydrate	2.9 g.
Crude Fiber	0.5 g.
Ash	0.4 g.
Calcium	22 mg.
Phosphorus	17 mg.
Iron	0.4 mg.
B-Carotene	Tr
Total Vitamin A	Tr
Thiamine	0.02 mg.
Riboflavin	0.02 mg.
Niacin	0.1mg.
Ascorbic acid	10 mg.

Fruits of cucumber have high calcium, phosphorus and ascorbic acid.

Fig. 31. Fresh cucumber fruits

Land Preparation

Established areas for planting are rototilled and rows are made 1 meter apart. Holes are made 30 cm apart 2-3 cm deep.

Planting Materials

Seeds of cucumber varieties Pipinito, Fountain F1 Hybrid come from Taiwan and the Philippines. They are available in some stores in Palau.

Fertilization

In each hole a handful each of compost and inorganic complete fertilizer are placed. A small amount of soil separates the seeds to prevent them from coming in direct contact with the fertilizer and compost. Two or three seeds are placed in each hole and covered again with soil. Another fertilization is done at flowering time.

Irrigation

Sometimes manual sprinkler irrigation is done when weather becomes too hot and there is no rain.

Pest Control

The most common insect pests that attack cucumber are orange cucumber beetles and melon worms. These insects feed on flowers, leaves and sometimes fruits of cucumber. Farmers apply Diazinon or Malathion at the recommended rates to control infestation.

Trellising And Netting

Cucumber nets are installed 1 – 2 weeks after seedling emergence to allow the plants to climb the trellis before flowering to facilitate harvesting the fruits and other farm works.

Fig. 32. Field planting of cucumber

Weed Control

Weeds are removed manually from the base of the plants and in between rows. Hilling up is practiced before flowering to suppress weed growth. In between rows, hoeing is done to prevent weeds from getting established in the area.

Harvesting

Harvesting of fruits is done in less than 2 months. Usually 7 to 8 harvesting of fruits is done. Harvesting is done twice a week to prevent occurrence of oversized fruits. Harvested fruits are placed in containers and placed in shaded areas before selling them in the market.

3. OKRA

Okra is a perennial plant and often grows to around 2 m tall. The leaves are 10-20 cm long and broad, palmately lobed with 5-7 lobes. The flowers are 4-8 cm in diameter with 5 white to yellow petals, often with a red or purple spot at the base of each petal. The fruit is a capsule up to 18 cm long with pentagonal cross section containing numerous seeds.

Table 13. Nutritional Value Of Okra

Component	Nutritional Content
Edible Portion	90 %
Water	92.2 g.
Energy	30 k cal
Protein	1.0 g.
Fat	0.2 g
Carbohydrate	6.1 g.
Crude Fiber	2.6 g.
Ash	0.5 g.
Calcium	79 mg.
Phosphorus	23 mg.
Iron	0.5 mg.
B-Carotene	80 ug
Total Vitamin A	13 ug.
Thiamine	0.04 mg.
Riboflavin	0.05 mg.
Niacin	0.6 mg.
Ascorbic acid	12 mg.

Okra is high in calcium, phosphorus and B-carotene.

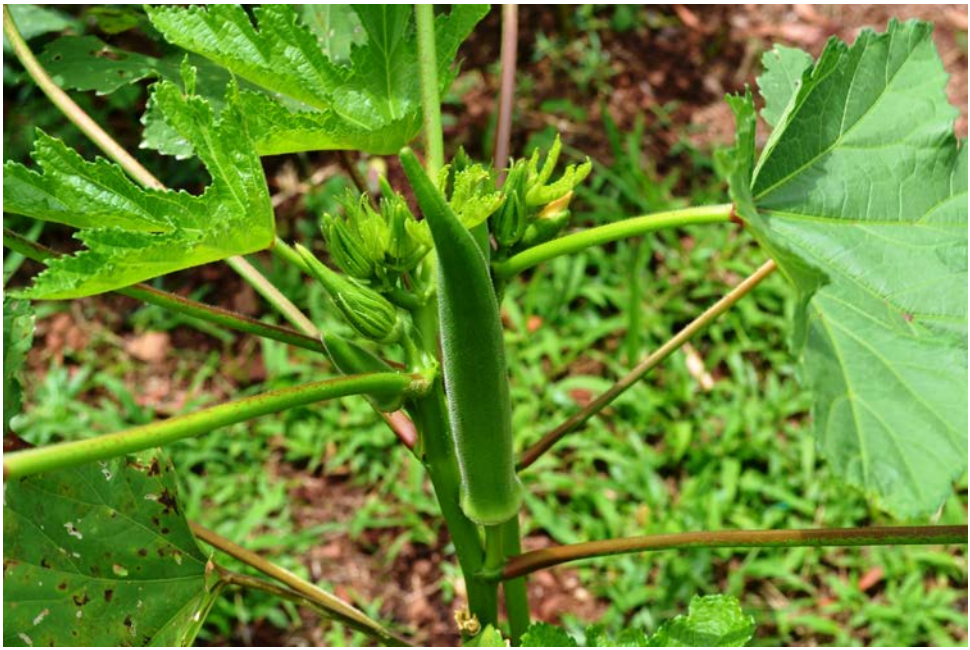

Fig. 33. Close up of okra plant and pods

Varieties

The seeds of okra varieties Smooth Green and Chant come from the Philippines and Taiwan. The seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared of grasses and shrubs. Lime at 750 kg/Ha is broadcast on top of the soil. The area is rototilled to mix the lime with the soil. Rows are made 1 meter apart. Holes are made 30 cm apart. A handful each of manure and inorganic fertilizer are placed in each hole. It is then covered with soil to prevent roots of seedlings to come in contact with the fertilizer and manure.

Planting Material

Two to three seeds of okra are placed in each hole and covered with soil.

Fertilization

At flowering, a handful each of complete fertilizer and manure are again placed in shallow holes made about 5 cm from the bases of the seedlings.

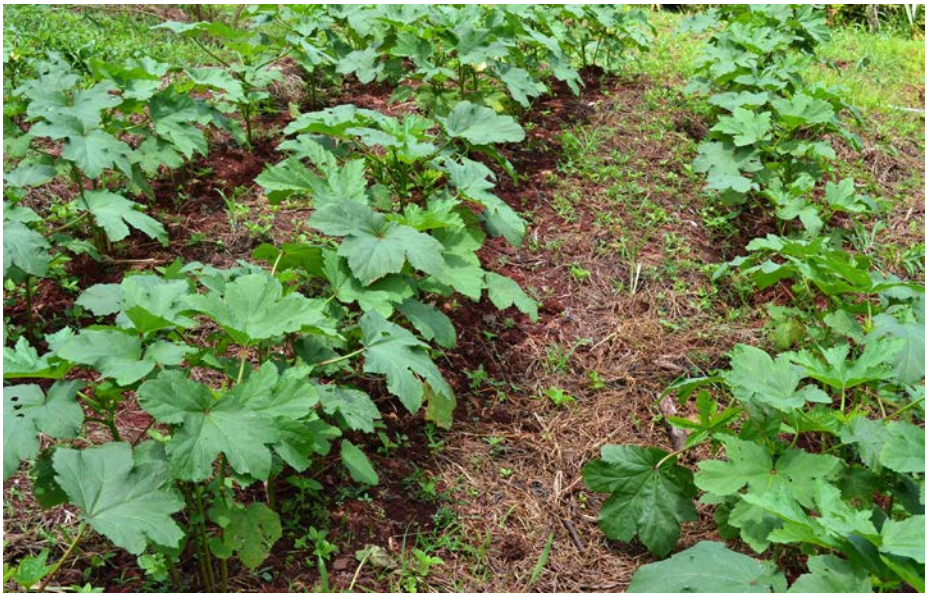

Fig. 34. Field planting of okra

Weed Control

Weeding is done manually especially in removing weeds and grasses near the base of the plants. In between rows, hoeing and hilling up are done to remove weeds and covering the base of the plants.

Irrigation

Sometimes during the dry spell, watering the plants is done with the use of a sprinkling can. This is done to provide moisture and hasten them to grow vigorously.

Pest Control

Leaf folders have been observed to damage the plant. The larvae roll the leaves and feed inside. It is a minor pest of okra.

Harvesting

Okra produces large flowers about 2 months after planting. The okra pods are ready to pick 3-4 days later.

When the pods are 3 to 4 inches long, harvesting is done using a small knife or scissor to remove the pods from the plant. Harvesting is done in the morning and afternoon each day to prevent occurrence of overmature and hard pods.

4. EGGPLANT

The eggplant is a delicate tropical perennial which grows 40 to 150 cm tall with large, coarsely lobed leaves that are 10-20 cm long and 5-10 cm broad. The stem is often spiny. The flower is white to purple with a 5-lobed corolla and yellow stamens. The egg shaped glossy purple fruit has a white flesh with a meaty texture. The cut surface of the flesh rapidly turns brown when the fruit is cut open.

Table 14. Nutritional Value Of Eggplant

Component	Nutritional Content
Water	93.6 g.
Energy	24 k cal
Protein	1.0 g.
Fat	0.1 g
Carbohydrate	4.9 g.
Crude Fiber	(1.9 g.)
Ash	0.4 g.
Calcium	30 mg.
Phosphorus	28 mg.
Iron	0.5 mg.
B-Carotene	80 ug.
Total Vitamin A	13 ug.
Thiamine	0.07 mg.
Riboflavin	0.04 mg.
Niacin	0.5 mg.
Ascorbic acid	Trace

Eggplant contain considerable amount of calcium, phosphorus and B-carotene.

Fig. 35. Eggplant fruits

Varieties

Seeds of eggplant varieties Bulakena, Long Purple, Charming, Longship and Pingtung Long come from Taiwan and the Philippines. The seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared of grasses and shrubs. Once cleared, lime is applied by broadcast on top of the soil. Rototilling the soil is done so that the lime mixes well with the soil. Rows are established 1 meter apart.

Planting Materials

Seeds of eggplant are grown initially in polybags with soil and are placed in a shaded area. Watering is done using a sprinkler. Urea is added at 1 teaspoon per gallon of water to provide good growth of seedlings. Hardening of seedlings is done gradually by exposing them under the sun and restricting watering. After one week, the seedlings are ready for transplanting.

Distance Of Planting

Planting holes are made in each row using a spade. The distance between planting holes is about 60 cm. In each hole, a handful each of manure and inorganic fertilizer (10-30-10) are placed and covered with soil. One seedling per hole is planted and then covered with soil.

Fertilization

At flowering, a handful each of manure and inorganic fertilizer (10-30-10) are placed in a hole about 10 cm away from the bases of the plants and then covered with soil.

Irrigation

If it is not raining for a few days, watering is done twice a week to promote growth of seedlings.

Weed Control

Pulling of weeds growing near bases of the plants are done. Hoeing removes the weeds in between plants and in between rows.

Pest Control

In many tropical countries, the eggplant fruit borer is a serious insect pest of eggplant. The caterpillar bores on the fruit and feeds inside causing rotting of fruits. This insect is not yet present in Palau. Extreme care must be taken to prevent it from being introduced to Palau.

Fig. 36. Field planting of eggplant

Harvesting

At maturity, the fruits are harvested manually using a small knife to detach it from the mother plant. Harvesting is done twice a week to prevent occurrence of oversized and over mature fruits.

5. RADISH

Radish, *Raphanus sativus*, is a herbaceous annual plant in the family Brassicaceae grown for its edible tap root. The radish plant has a short hairy stem and a rosette (ground level horizontal and circular leaves) of oblong shaped leaves which measures 5 – 30 cm in length. The top leaves of the plant are smaller and lance-like. The tap root of the plant is cylindrical or tapering and commonly white in color.

The radish root can be eaten fresh in salads or cooked with other ingredients such as meat. The leaves of the plant are also edible and can be used as salad green.

Table 15. Nutritional Value Of Radish

Component	Nutritional Content
Edible Portion	75 %
Water	96.2 g.
Energy	14 k cal
Protein	0.2 g.
Fat	0.1 g
Carbohydrate	3.2 g.
Crude Fiber	0.5 g.
Ash	0.3 g.
Calcium	24 mg.
Phosphorus	13 mg.
Iron	0.5 mg.
B-Carotene	0 ug
Total Vitamin A	0 ug.
Thiamine	0.01 mg.
Riboflavin	0.01 mg.
Niacin	0.3 mg.

Radish contains a high amount of ascorbic acid, calcium and phosphorus.

Fig. 37. Roots and leaves of radish

Varieties

The seeds of radish varieties K08060RK617 and Diwata come from Taiwan and the Philippines. They are available at some stores in Palau.

Land Preparation

The land for planting is cleared of weeds and shrubs. Lime at 450 kg/ha is applied by broadcast on top of the soil. Rototilling is done immediately to mix lime with soil. One meter wide beds are made with the use of a spade and hoe. Shallow lines are made across the bed. The distance between lines is about 7 cm.

Distance Of Planting

The distance between plants is about 7 cm. On each line a hole is made every 7 cm. Two to three seeds of radish are placed in each hole and covered with soil. One month after seedling emergence complete fertilizer is applied near the base of the seedlings.

Weed Control

The weeds between plants on the bed are removed manually using a small knife.

Pest Control

The diamond back moth is a serious pest of radish. The larvae feed primarily on leaves causing defoliation. Diazinon at the recommended rate is applied every week to control infestation.

Harvesting

At harvest time, the plants are carefully uprooted to prevent damage to the roots. The enlarged roots are separated from the mother plant.

Intact leaves can also be used as vegetables in soup dishes.

6. KANGKONG

It is a fast growing creeping herb with succulent hollow stem rooting at the nodes. Young leaves and stem are cooked with meat or fish. The vines are also used as fodder for cattle and pigs.

Table 16. Nutritional Value Of Kangkong

Component	Nutritional Content
Edible Portion	100 %
Water	92.9 g.
Energy	28 k cal
Protein	1.5 g.
Fat	0.4 g
Carbohydrate	4.7 g.
Crude Fiber	0.7 g.
Ash	0.5 g.
Calcium	51 mg.
Phosphorus	25 mg.
Iron	1.3 mg.
B-Carotene	1550 ug
Total Vitamin A	258 ug.
Thiamine	0.03 mg.
Riboflavin	0.08 mg.
Niacin	0.6 mg.
Ascorbic acid	10 mg.

Kangkong contains high B-carotene, Vitamin A, Vitamin C, calcium and phosphorus.

Fig. 38. Field planting of kangkong

Varieties

Seeds of dryland kangkong variety Longleaf come from Taiwan and the Philippines. The seeds are available at some stores in Palau.

Land Preparation

Liming is done by broadcasting about 750 kg./ha. The land is prepared by rototilling to mix lime with the soil. Rows are made 1 meter apart.

Planting Material

Seeds and cuttings are used for propagation.

Distance Of Planting

About 30 to 170 plants are planted per square meter. When seeds are used, make shallow lines 10 cm across the beds before sowing.

Fertilization

Fifteen days after emergence, apply urea or ammonium sulfate in between rows of plants.

Weed Control

Hand pulling of weeds is done to prevent weeds from taking over the plants. Hoeing is done between rows.

Pest Control

Caterpillars such as sweet potato hornworm feed on the leaves. Spraying with Malathion of Diazinon is done to get rid of the caterpillars.

Harvesting

Harvesting is done by cutting shoots 20 to 50 days after sowing. The plants are cut about 5 to 10 cm from the ground. Fertilizing is again done to allow the cut stem to produce new shoots for another harvesting.

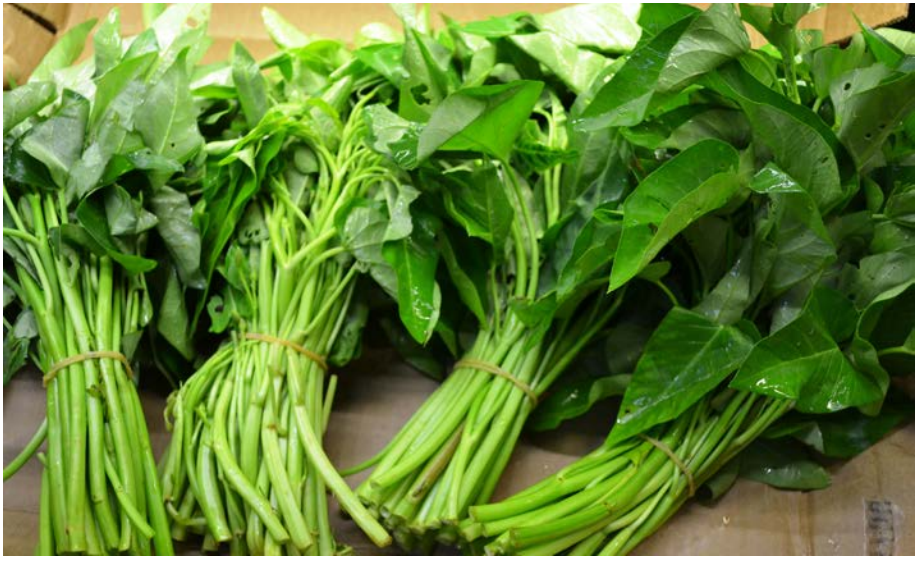

Fig. 39. Kangkong tops sold in the market

7. SQUASH / PUMPKIN

The squash or pumpkin is a vegetable crop that is grown for its fruits, flowers and young shoots. They are herbaceous annual plants which are either trailing vines or bush like in morphology. Vines generally have large lobed leaves and long vines which can climb by attaching to surfaces with their tendrils. Squash plants produce yellow to orange flowers and green, white or yellow fruit in a variety of shapes with smooth or ridged skin. Vining squash varieties can reach several meters in length and as annuals, survive only one growing season. Flowers and young shoots are also used as vegetables.

Table 17. Nutritional Value Of Squash / Pumpkin

Component	Nutritional Content
Edible Portion	100 %
Water	88.2 g.
Energy	47 k cal
Protein	0.4 g.
Fat	0.2 g
Carbohydrate	10.8 g.
Crude Fiber	0.6 g.
Ash	0.4 g.
Calcium	38 mg.
Phosphorus	20 mg.
Iron	0.3 mg.
B-Carotene	410 ug
Total Vitamin A	68 ug.
Thiamine	0.08 mg.
Riboflavin	0.02 mg.
Niacin	0.5 mg.
Ascorbic acid	8.0 mg.

The fruit contains high B-carotene, Vitamin A, calcium and phosphorus.

Fig. 40. Squash plant and fruits

Varieties

Seeds of squash varieties Winter Squash, and Crowning come from the Philippines and Taiwan. The seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared of weeds and vegetation. Once cleared, holes about 50 cm wide are made using hoe and spade.

Distance Of Planting

The distance between plants is about 2 meters. The soil in the holes are pulverized and a handful of lime is added to the hole. Each planting hole is provided with a handful each of manure or compost and complete fertilizer (10-30-10). A small amount of soil is applied to cover the manure and fertilizer to prevent the roots of seedlings to come directly in contact with them.

Planting Materials

Seeds of pumpkin are initially grown in plastic bags with soil. Watering is done to promote good growth of seedlings. Hardening of seedlings are done by gradually exposing the seedlings under the sun and by restricting watering. One week after hardening, the seedlings are transplanted in the field. Usually three seedlings are planted in each planting hole.

Fertilization

At flowering a handful of fertilizer and a handful of manure or compost are placed in a hole about 7 cm from the base of the plants.

Weed Control

Grasses that grow in between rows of plants. are cut using "grass cutter". Grasses and weeds at the bases of plants are pulled.

Pest Control

The important insect pest attacking squash is the orange cucumber beetle. During early morning hours, farmers hand collect the less active adult beetles and are placed in empty cans with kerosene to kill them.

Harvesting

When the fruits are mature, they are harvested by hand. Some of the fruits are cooked for home consumption while the others are sold in the market.

8. CHINESE CABBAGE / NAPPA

The Chinese cabbage or nappa is a vegetable crop that is grown for its leaves. It is a hardy biennial grown as an annual. It has broad, thick tender leaves and heavy midribs. There are several varieties of Chinese cabbage, some are loose head and some are tight headed, plants grow from 15-18 inches tall.

Table 18. Nutritional Value Of Chinese Cabbage / Nappa

Component	Nutritional Content
Edible Portion	100 %
Water	96.2 g.
Energy	14 k cal
Protein	1.0 g.
Fat	0.1 g
Carbohydrate	2.4 g.
Crude Fiber	0.4 g.
Ash	0.3 g.
Calcium	82 mg.
Phosphorus	18 mg.
Iron	0.4 mg.
B-Carotene	2.3 g.
Total Vitamin A	—-
Thiamine	0.02 mg.
Riboflavin	0.02 mg.
Niacin	0.5 mg.
Ascorbic acid	17 mg.

Chinese cabbage contains high amounts of calcium, phosphorus and ascorbic acid.

Fig. 41. Field planting of Chinese cabbage

Varieties

Seeds of Chinese cabbage variety Black Behi and Summer Bright come from Taiwan and the Philippines. They are available at some stores in Palau.

Land Preparation

Lime is applied by broadcasting on top of the soil. The soil is rototilled. Once rototilling is done, a 1 meter bed is made using hoe and spade. Shallow lines are made across the bed where the seedlings will be planted.

Planting Materials

Seeds of Chinese cabbage are planted first in seed boxes. Urea fertilizer at ½ teaspoon per gallon of water is mixed and sprayed on seed boxes with seeds. Hardening of the seedlings is done by gradually exposing the seedlings under the sun and by restricting watering. One week after hardening, the seedlings are ready for transplanting in the field. The seedlings are transplanted at a distance of 8 cm between plants and then watered with urea and water every other day especially if it is not raining. This promotes rapid growth of seedlings.

Fertilization

The distance between plants is 8 cm. Manure and complete fertilizer are placed in each hole 14 days before transplanting.

Weed Control

Weeding is done manually, removing the weeds that are close to the seedlings. Weeding is done as often as necessary until the plants have grown and can compete with the weeds.

Pest Control

The diamond back moth is a serious pest of Chinese cabbage. The larvae feed on the leaves and if serious infestation occurs, the plants look like brooms. Spraying with Diazinon or Malathion at the recommended rates is done every week to control infestation. Last spray application is done 7 days before harvest.

Harvesting

The plants are mature enough at about 45 days from transplanting. The plants are pulled carefully and soil is removed on root system. Plants are washed to remove dirt and make plants look fresh for sale in the market.

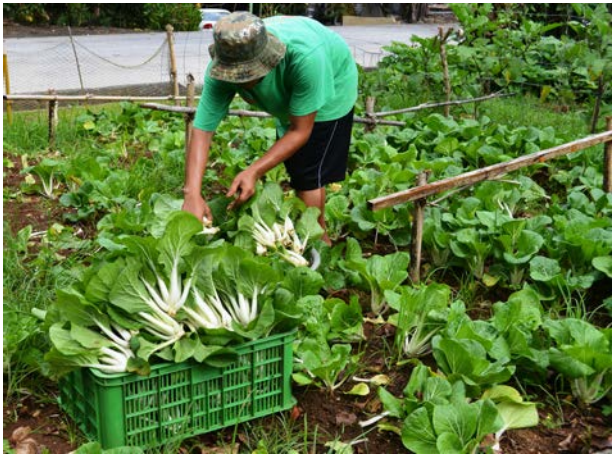

Fig. 42. Harvesting Chinese cabbage

9. BITTERMELON

Bittermelon is a herbaceous, tendril-bearing vine which grows up to 5 m in length. It bears simple alternate leaves 4-12 cm across, with 3-7 deeply separated lobes. Each plant bears separate yellow male and female flowers.

The fruit has a distinct warty exterior and an oblong shape. It is hollow in cross section, with a relatively thin layer of flesh surrounding a central seed cavity filled with large, flat seeds and pith. The fruit is most often eaten green, or as it is beginning to turn yellow. At this stage the fruit flesh is crunchy and watery in texture, but bitter. The skin is tender and edible. Seed and pith appear white in unripe fruits, they are not intensely bitter and can be removed before cooking. The leaves and shoots are also added to several dishes as vegetables too.

Table 19. Nutritional Value of Bittermelon

Component	Nutritional Content	
	Fruits	Leaves
Edible Portion	100 %	100%
Water	95.9 g.	87.6 g
Energy	19 k cal	50 k cal
Protein	0.4 g.	2.2 g.
Fat	0.2 g.	0.6 g.
Carbohydrate	3.8 g.	9.0 g.
Crude Fiber	0.4 g.	0.3 g.
Ash	0.3 g.	0.6 g.
Calcium	33 mg.	74 mg.
Phosphorus	13 mg.	25 mg.
Iron	0.3 mg.	0.3 mg.
B-Carotene	95 ug.	1205 ug.
Total Vitamin A	16 ug.	201 ug.
Thiamine	0.01 mg.	0.03 mg.
Riboflavin	0.01 mg.	0.11 mg.
Niacin	0.1 mg.	0.6 mg.
Ascorbic acid	15 mg.	14 mg.

Fig. 43. Bittermelon fruits (left) and leaves (right)

The leaves contain very high B-carotene, calcium and Vitamin A; while the fruit has appreciable amounts of calcium and B-carotene.

Varieties

The seeds of bitter melon variety Makiling and CY 00363 come from Taiwan and the Philippines. The seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared of weeds and shrubs. Lime is added to the soil at 750 kg/ha by broadcasting. Rototilling is done immediately to mix lime with the soil. Rows about I meter wide is made by using a rototiller.

Planting Materials

Seeds of bittermelon are initially planted in polybags with manure and fertilizer. Two to three seeds are planted in each polybag and covered with soil. Watering is done to hasten seedling emergence. Hardening of seedlings is done by gradually exposing them under the sun and by restricting watering. One week after hardening, seedlings are carefully transplanted into each planting hole and the base of the seedlings are covered with soil.

Distance Of Planting

Planting holes on the rows are spaced 30 cm between plants. On each hole a handful of manure and complete fertilizer are placed and partly covered with soil.

Trellising And Nets

Trellis and nylon nets are placed on each row to allow the seedlings to climb on it. This will facilitate spraying and harvesting of fruits.

Weed Control

Weeds are removed manually from the bases of plants. The weeds in between rows and plants are removed by using a hoe. Sometimes, hilling up is also being done.

Pest Control

Bittermelon is attacked by the orange cucumber beetle and melon worms. The beetles bore holes on the leaves while the melon worm larva feeds on leaves and surface of fruits. Spraying either with Diazinon or Malathion is done to control infestation.

Harvesting

The fruits are harvested manually twice a week to prevent ripening of the fruits.

Fig. 44. Bittermelon fruit still attached to the plant

10. GREEN ONIONS

Green onions may be any variety of onion and are simply harvested before they bulb. Each Green onion plant produces a singular underground bulb, known as the plant's roots, with multiple vertical green leaves that evolve above ground during the plant's growing process.

Green onions differentiate themselves from bulbing onions in not just appearance, but also taste. Their sleek linear shape is a reflection of the flavor that they represent. Their slightly sharp savoriness, grassy undertones and succulent crunch allow them the favor of adapting to many culture's cuisines and seasons beyond that of the common onion.

Table 18. Nutritional Value Of Green Onions

Component	Nutritional Content
Edible Portion	77 %
Water	90 g.
Energy	40 k cal
Protein	1.8 g.
Fat	0.5 g
Carbohydrate	7.2 g.
Crude Fiber	2.4 g.
Ash	0.5 g.
Calcium	54 mg.
Phosphorus	36 mg.
Iron	3.4 mg.
B-Carotene	1575 ug
Total Vitamin A	262 ug.
Thiamine	0.07 mg.
Riboflavin	0.09 mg.
Niacin	0.6 mg.
Ascorbic acid	46 mg.

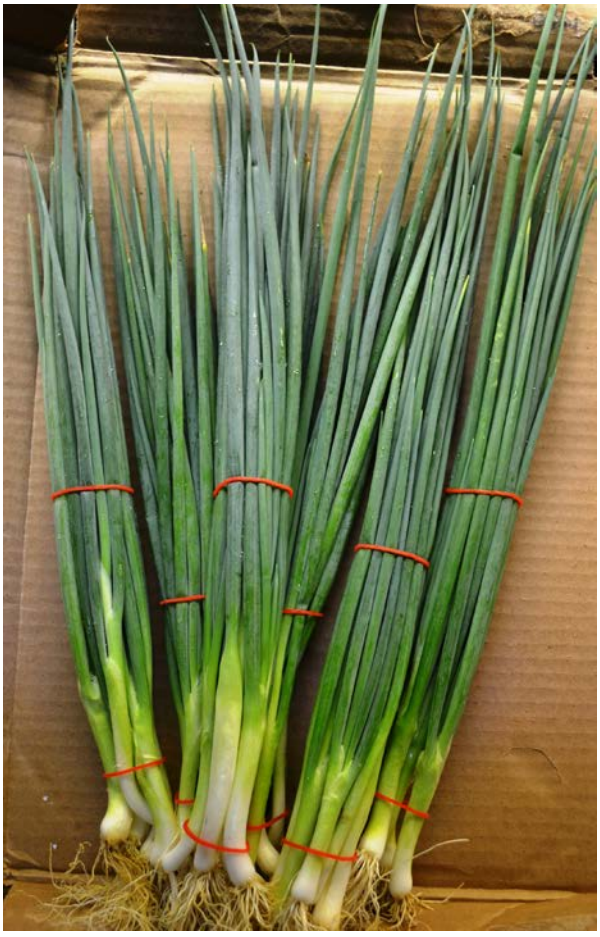

Fig. 45. Green onions ready for the market.

Green onions are high in B carotene, total Vitamin A, calcium and phosphorus.

Varieties

Seeds of green onions variety Bunching Onion come from Taiwan and the Philippines. Seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared of weeds and shrubs. Lime is applied on the soil by broadcasting. Rototilling is done and 1 meter bed is established by using a hoe and spade. Once beds are formed, shallow lines are made across the bed

Distance Of Planting

Each shallow line on top of the bed is spaced 10 cm from each other. On each shallow line, a hole spaced 7 cm apart is made. On each hole 2 to 3 seeds of green onions are placed and covered with soil. Manure and fertilizer are applied between shallow lines and covered with soil.

Irrigation

Watering of seedlings are done if it is not raining. One half teaspoon of urea is added to a gallon of water, mixed thoroughly and sprinkled to the seedlings using a sprinkling can.

Weed Control

The weeds between plants and between shallow lines are carefully pulled by hand.

Pest Control

In Palau, the plants are seldom attacked by insects. Sometimes, onion thrips can be a problem. If this happens, the plants are sprayed with either Malathion or Diazinon at recommended rates to reduce infestation.

Harvesting

At harvest time the plants are carefully pulled from the soil with the use of a knife. Harvested green onions are cleaned with water before selling them to the market .

Fig. 46 . Green onions in the field.

11. CHILI PEPPER

Chili peppers are commonly grown for its hot fruits, which are used as spice. The leaves are eaten as vegetables. Hot peppers are perennials with varying structures. They can be herbaceous or shrub-like but are generally branching with green-brown stems and simple oval leaves. The plant produces flowers with 5 petals which are usually white in color. Chili pepper plants are commonly grown as annuals with fruit being harvested for one growing season.

Table 21. Nutritional Value of Chili Pepper

Component	Nutritional Content	
	Fruits	Leaves
Edible Portion	89 %	100%
Water	72.2 g.	86.8 g
Energy	75 k cal	52 k cal
Protein	4.8 g.	1.8 g.
Fat	2.2 g.	0.3 g.
Carbohydrate	9.0 g.	10.5 g.
Crude Fiber	1.4 g.	0.5 g.
Ash	11.8 g.	0.6 g.
Calcium	65 mg.	87mg.
Phosphorus	89 mg.	16 mg.
Iron	2.3 mg.	1.7 mg.
B-Carotene	4207 ug.	2030 ug.
Total Vitamin A	701 ug.	338 ug.
Thiamine	0.31 mg.	0.09 mg.
Riboflavin	0.25 mg.	0.08 mg.
Niacin	1.8 mg.	0.6 mg.
Ascorbic acid	69 mg.	5 mg.

The fruit of chili pepper contains high amounts of B-carotene, total vitamin A, phosphorus and calcium, while the leaves have high amounts of B-carotene, total Vitamin A and calcium.

Fig. 47. Fruits on chili pepper plant

Varieties

Seeds of chili pepper varieties Sinigang, and Spicy Chili pepper come from Taiwan and the Philippines. Seeds are available at some stores in Palau.

Land Preparation

The area to be planted has to be cleared of weeds and shrubs. Once cleared, lime is applied by broadcasting it on top of the soil. Rototilling is done immediately to mix the lime with the soil. Rows are made 1 meter apart. On each row planting holes are made 60 cm from each other. On each hole, a handful each of manure and complete fertilizer are applied and covered with soil.

Planting Materials

Seeds of chili pepper are grown first in small plastic bags with soil. They are watered daily to hasten seedling emergence. Hardening of seedlings are done for one week by exposing them under the sun and by restricting watering. After one week of hardening, the seedlings are ready for transplanting in the field.

Two seedlings are placed in each hole and pressing the soil at the base of the seedlings.

Irrigation

Watering of seedlings is done if it has not been raining to prevent wilting of seedlings and also finally preventing their death.

Fertilization

At flowering time, a handful each of manure and complete fertilizer are applied in a hole made 10 cm away from base of the plants. The holes are then covered with soil.

Weed Control

Weeds near the base of the plants are pulled carefully by hand while weeds in between plants and between rows are removed using a hoe.

Pest Control

The chili whitefly, *Aleurotrachelus trachoides*, infests leaves of chili pepper. Their honeydews encourage growth of sooty molds making the leaves black. Farmers usually spray Diazinon at the recommended rate to kill the nymphs and adults that aggregate on the underside of leaves.

Fig. 48. Whitefly infestation on chili pepper leaves

Harvesting

As soon as chili pepper fruits are mature, they can be harvested by pulling them carefully from the plant. The fruits are placed in harvest baskets and then placed in plastic bags for sale in the market.

Fig. 49. Chili pepper fruits ready for selling in the market

12. TOMATO

Tomato plants are vines, typically growing 180 cm (6 ft) or more above the ground if supported, although erect bush varieties have been bred, generally 100 cm (3 ft) tall or shorter. Indeterminate types are "tender" perennials, dying annually in temperate climates, although they can live up to three years in a greenhouse in some cases. Determinate types are annual in all climates.

Tomato grow as a series of branching stems, with a terminal bud at the tip that does the actual growing. When that tip eventually stops growing, whether because of pruning or flowering, lateral buds take over and grow into other, fully functional, vines.[63]
Tomato vines are typically pubescent, meaning covered with fine short hairs. These hairs facilitate the vining process, turning into roots wherever the plant is in contact with the ground and moisture, especially if the vine's connection to its original root has been damaged or severed.

Most tomato plants have compound leaves. The leaves are 10–25 cm long, odd pinnate, with five to 9 leaflets on petioles,[65] each leaflet up to 8 cm long, with a serrated margin; both the stem and leaves are densely glandular-hairy. Their flowers, appearing on the apical meristem, have the anthers fused along the edges, forming a column surrounding the pistil's style. Flowers in domestic cultivars tend to be self-fertilizing. The flowers are 1–2 cm across, yellow, with five pointed lobes on the corolla; they are borne in a cyme of three to 12 together.

Tomato fruit is classified as a berry. As a true fruit, it develops from the ovary of the plant after fertilization, its flesh comprising the pericarp walls. The fruit contains hollow spaces full of seeds and moisture, called locular cavities. These vary, among cultivated species, according to type. Some smaller varieties have two cavities, globe-shaped varieties typically have three to five, beefsteak tomatoes have a great number of smaller cavities, while paste tomatoes have very few, very small cavities. For propagation, the seeds need to come from a mature fruit, and be dried or fermented before germination.

Fig. 50. Tomato fruits still attached to the plant

Table 18. Nutritional Value Of Tomato

Component	Nutritional Content
Edible Portion	98 %
Water	93.6 g.
Energy	25 k cal
Protein	0.4 g.
Fat	0.1 g
Carbohydrate	5.6 g.
Crude Fiber	1.3 g.
Ash	0.3 g.
Calcium	13 mg.
Phosphorus	9 mg.
Iron	0.5 mg.
B-Carotene	255 ug
Total Vitamin A	42 ug.
Thiamine	0.03 mg.
Riboflavin	0.02 mg.
Niacin	0.3 mg.
Ascorbic acid	15 mg.

Tomato fruits contain B-carotene, ascorbic acid and total Vitamin A.

Varieties

Seeds of Cherry Tomato, Marimar and Malakas come from Taiwan and the Philippines. They are on sale at some stores in Palau.

Land Preparation

The area to be planted has to be cleared of weeds and shrubs. Lime is added to the area by broadcasting it on top of the soil. Rototilling is done immediately to mix the lime with the soil. At the same time, rows are established 1 meter apart.

Planting Material

Seeds of tomato are grown initially in small containers like paper cups with soil and manure. The cups are watered daily to hasten seedling emergence. Hardening of seedlings is done by gradually exposing them under the sun and by restricting watering. One week after hardening, the seedlings are ready to be transplanted to the field.

Distance Of Planting

Planting holes are made 60 cm apart on top of each row. On each hole, a handful each of manure and complete fertilizer are placed and then covered with soil. Two to three seedlings of tomato are planted in each hole. The base of the seedlings are then covered with soil.

Fertilization

At flowering, a handful each of manure and complete fertilizer are applied in holes made 10 cm away from the bases of the plants.

Irrigation

Watering the plant is done when there is no rain. This is done with the use of either a water hose or sprinkling can.

Weeding

Weeds growing near the bases of the plants are pulled by hands. Weeds in between plants and on rows are cut by using a hoe or scythe.

Pest Control

The tomato fruitworm is a pest of tomato. The larvae bored into the fruits and feed inside. Farmers resort to using Diazinon sprays at recommended rate to kill the worm.

Harvesting

Fruits become ripe with the occurrence of shades of orange and yellow on the fruit surface. Fruits are harvested by hand and placed in a basket. The fruits are washed and placed in plastic bags before taking them to the market.

13. WATERMELON

Watermelon, *Citrullus lanatus*, is a viny annual plant in the family Cucurbitaceae grown for its fleshy fruit. Watermelon vines are thin, grooved and covered in tiny hairs. Vines are branching and possess deeply lobed pinnate leaves. The plant produces solitary yellow flowers and a large spherical to oblong fruit. The fruit is a 'pepo' - a fleshy fruit protected by a thick leathery rind. The fruit is smooth, light to dark green in color and can be striped, marbled or solid green. The flesh of the fruit is usually red in color but some cultivars produce green, orange or white flesh and contains numerous seeds which are usually black or dark brown in color. Watermelon vines can reach a length of 3 m (10 ft) and as an annual, survives only one growing season.

Table 23. Nutritional Value Of Watermelon

Component	Nutritional Content
Edible Portion	62 %
Water	92.3 g.
Energy	31 k cal
Protein	0.1 g.
Fat	0.2 g
Carbohydrate	7.2 g.
Crude Fiber	0.5 g.
Ash	0.2 g.
Calcium	8 mg.
Phosphorus	7 mg.
Iron	0.2 mg.
B-Carotene	100 ug
Total Vitamin A	17 ug.
Thiamine	0.02 mg.
Riboflavin	0.03 mg.
Niacin	0.2 mg.
Ascorbic acid	7 mg.

Watermelon is high in B-carotene and total vitamin A.

Fig. 51. Field planting of watermelon

Varieties

Seeds of watermelon varieties HV 186 and Yellow Baby come from the Philippines and Taiwan. Seeds are available at some stores in Palau.

Land Preparation

The area for planting is cleared first with weeds and other vegetation. Holes about 30 cm wide are established every 2 meters apart. A handful each of manure and inorganic fertilizer are placed in each hole and covered with soil.

Planting Materials

Seeds of watermelon are planted first in plastic bags with soil. The plastic bags are placed under the shade. Two to three seeds are placed in each plastic bag. Watering is done to facilitate seedling emergence. Hardening of seedlings is done by gradually exposing them under the sun and by restricted watering. One week after hardening the seedlings are ready for transplanting. Two to three seedlings are transplanted in each hole and the bases of seedlings are covered with soil.

Fertilization

A handful each of manure and inorganic fertilizer are applied at flowering. These are placed in a hole about 12 cm from the base of the plants.

Weed Control

Regular weeding by hand is done to remove weeds near the bases of the seedlings. The seedlings are allowed to crawl on the ground.

Pest Control

The orange cucumber beetle feeds on the leaves of watermelon. Farmers usually come to the field early morning to collect beetles and kill them by placing in a can with kerosene.

Harvesting

The fruit is mature once the underside of the fruit begin to turn yellow and the fruit peduncle begin to dry up. The fruits are harvested by hand using a small knife to detach them from the mother plant. They are stored inside the house to prevent rats from feeding on the fruits.

Fig. 52. Close up of watermelon fruits

II. INTERCROPPING

Intercropping has not been practiced in Palau. Intercropping maximizes land use and provides additional income to farmers.

Other intercropping concepts are being practiced already in many countries in Asia. Papaya for example is used as intercrop for perennial crops such as coconut and banana. Papaya can be used as the main crop with early maturing crops such as pineapple and ginger as intercrops. Upland taro can be used as intercrop for coconut, pineapple and papaya.

Fig. 53. Intercropping papaya with taro

III. PRICES OF LOCALLY PRODUCED ROOT CROPS, FRUITS AND VEGETABLES IN PALAU

COMMODITY	PRICE
Taro	$ 1.25 / lb
Sweet Potato	$ 0.75 / lb
Cassava (Peeled)	$ 5.00 / bag
Cassava (Ground)	$ 5.00 / bag
Sweet Corn	$ 1.45 / lb
Banana (Local)	$ 0.99 / lb
Papaya	$ 0.65 / lb
Soursop	$ 0.75 / lb
Pineapple (Local)	$ 1.00 / lb
Citrus (Kingkang)	$ 1.25 / pkg
Guava	$ 1.25 / lb
Dragon Fruit	
Long Beans	$ 1.00 / lb
Cucumber	$ 0.85 / lb
Okra	$ 1.00 / lb
Eggplant	$ 0.85 / lb
Radish	$ 0.95 / lb
Kangkum	$ 0.85 / lb
Pumpkin / Squash	$ 0.85 / lb
Chinese Cabbage / Nappa	$ 1.50 / bag
Bittermelon / Margoso	$ 1.05 / lb
Green Onions	$ 2.00 / bundle
Chili Pepper	$ 0.85 / pkg
Tomato	$ 2.50 / bag
Watermelon	$ 0.85 / lb

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