TARO PRODUCTION IN PALAU

AURORA G. DEL ROSARIO
NELSON M. ESGUERRA
THOMAS TARO

COLLEGE OF MICRONESIA 1977

PALAU COMMUNITY COLLEGE

The College of Micronesia Land Grant offers its programs and activities to all persons regardless of race, color, sex, national, origin, age, disability, gender, religion, political beliefs, sexual orientaion, marital or family status, and is an Equal Employment Opportunity Employer and provider. College of Micronesia Land Grant and the United States Department of Agriculture (USDA) cooperating in furtherance with the Cooperative Extension Work Act of September 29, 1977 as amended.

College of Micronesia, Dr. Singeru Singeo,
Executive Director

Authors :

Aurora G. Del Rosario, Ph.D., Researcher. Palau Community College Cooperative Research and Extension. P.O. Box 9 Koror, Palau 96940

Nelson M. Esguerra. Ph,D. Entomologist. 3rd A St., Abi Abi Drive Sunvalley Subdivision. V. Rama Avenue, Cebu City 6000, Philippines

Thomas Taro. Vice President Palau Community College Cooperative Research and Extension. P.O. Box 9, Koror, Palau 96940

TARO PRODUCTION IN PALAU

AURORA G. DEL ROSARIO
NELSON M. ESGUERRA
THOMAS TARO

College of Micronesia
Palau Community College
December, 2015

College of Micronesia Land Grant Programs

ISBN 978-982-98055-2-2

Tittle: Taro Production in Palau

USP Library Cataloguing in Publication Data

Del Rosario, Aurora G.
Taro production in Palau / Aurora G. Del Rosario,
Nelson M. Esguerra and Thomas Taro.
Kolonia, Pohnpei : College of Micronesia Land Grant Programs, 2015

92p. ; 23 cm,

ISBN 978-982-098055-2-2

1. Taro--Palau. 2. Taro--Varieties--Palau. 3. Taro--Diseases and pests--Palau.
4. Taro--Climatic factors--Palau. I. Esguerra, Nelson M. II. Taro, Thomas. III. Tittle.

SB211.T2D45 2015
633.6809966--dc23

MESSAGE

Taro farming is being done by Palau women. Based on their experiences, they were able to segregate varieties of taro and even given appropriate Palauan names for each variety. On the other hand, the research staff at the Palau Community College Cooperative Research and Extension has developed improved ways of growing taro and even increases survival of taro plantings through proper management techniques.

All the information on successful and profitable taro farming is in this report. You will find the information useful in growing your own taro planting.

Singeru Singeo
Executive Director
College of Micronesia

MESSAGE

The emphasis for agricultural research at the Palau Community College Research and Development Station is to find ways to improve the yield of taro both planted on upland and lowland conditions. Through the years the taro germplasm collection of Palau has been maintained and conserved at the Research and Development Station. The distinct features of these local and introduced taro varieties are described in this report. Best management practices for successful taro production have become available. Also, proper pest management techniques have been developed for taro and other crops as well. A cost and return analysis shows that taro production is a profitable enterprise.

This report summarizes best production techniques to ensure successful taro production. It is worth reading and can be adopted easily be farmers.

Patrick U. Tellei, Ed.D.
President
Palau Community College

CONTENTS

Page

Page

LIST OF FIGURES

Figure **Page**

Figure **Page**

Figure **Page**

Figure **Page**

LIST OF TABLES

Table **Page**

ACKNOWLEDGEMENTS

We wish to thank the Palau Community College and the College of Micronesia for funding the printing of this book to make possible for the information in this book to come to light.

We also wish to acknowledge Dr. Singeru Singeo, Executive Director of the College of Micronesia, Dr. Patrick Tellei, Ed.D., PCC President, Ms. Anita R. Suta, former Vice President of Palau Community College Cooperative Research and Extension, and the women farmers of Palau for their support, and encouragement in our research activities in the conservation and maintenance of the taro germplasm at the Research and Development Station in Ngermeskang Ngaremlengui.

We extend our gratitude to the Pacific Adaptation to Climate Change (PACC), the Australia Agency for International Development (AusAID) and the Secretariat of the Pacific Community (SPC) for their support in our research on Palau Adaptation to Climate Change.

We are also grateful to the expert editorial assistance of Ms. Alice Arejola of the University of the Philippines Los Banos.

The comments and suggestions of Ms. Faustina Rehuher and Ms. Julie Tellei is also deeply appreciated.

We also thank the staff of the PCC Cooperative Research and Extension who have worked hard in conducting the research, maintenance, conservation, and documentation of the taro germplasm collection at the R & D Station: Felix Sengebau, Itwong Ngiraikelau, Maria Teruzi, Franson Oiterong, Leory Fritz, Siliang Michael, Dalton Thomas, Lyndon Masami, Kazue Joseph, Johnny Denae, Connie Madrangchar including the former staff of PCC-CRE : Geraldine Rengiil, Benjamin Ueda, Rosendo Skang, Lavenda Osima, Leilani Senior, Wilma Tmechur, Sue Ikertang , Clyde Yaliwelimar, Tyler Tellei, Ruskey Remoket, Rehabeam Madlutk, Dilyaur Franz, Elsengel Recheked.

INTRODUCTION

Taro, *Colocasia esculenta* (L.) Schott (sweet taro / *dait* / *kukau*) is an important staple food in Palau and in the Pacific Islands. It is used in many customary practices and social events. Taro is very important not only for food security but as a pride in the family.

Originally, taro production in Palau was principally done on a subsistence level for family use, for traditional customs and for the local market. It is grown in all the states of Palau in the main island of Babeldaob. With the current increase in population and demand for taro, 61% of the production is now designated for the market , while 26% are for household and 17% are for traditional customs. A survey in 1996 showed that 695 farmers produced 924,366 lbs of taro valued at $600,838 (Del Rosario, 2003). Due to its cultural and social significance, taro production in Palau has increased in price from $0.65/lb in 1996 to $0.75/lb in 1998 and $1.00/lb in 2001. However, there has been a decline of taro production by 3.5% per year from 2002 to 2012 (PACC Technical Report 2, 2013). Current prices for uncooked taro is $1.50 to $ 1.75 per pound while cooked taro is $ 1.75 to $ 2.00 per pound (Rehuher and Tellei, Personal Communication).

THE TARO PLANT

Taro is a perennial herbaceous plant that grows up to 2 meters in height. The leaves are peltate with the petiole attached to the leaf near the center with pointed leaf tips and rounded basal lobes. The petioles extends up to 2 meters in length rising up in whorls from the apex of the corm and vary in color from light greenish yellow to dark red depending on the variety.

The inflorescence is a spadix surrounded by a bract-like spathe consisting of two unequal parts and the flowers are unisexual. The lower green pistillate flowers are found at the base of the spadix usually up to 5 cm with sterile aborted flowers located above. This is followed by staminate flowers toward the end of the spadix. The fruits are small ellipsoid berries. However, not all taro plants flower naturally.

The roots are mainly on the soil surface, fibrous and adventitious. The corm is a large underground starchy stem, oblong to globular in shape

with diameters up to 20 cm and weighing up to 1 kg. Colors vary from white to purple, red or yellow.

All parts of the plant contain calcium oxalate raphides responsible for the itchy characteristic which can be destroyed by cooking to render them edible.

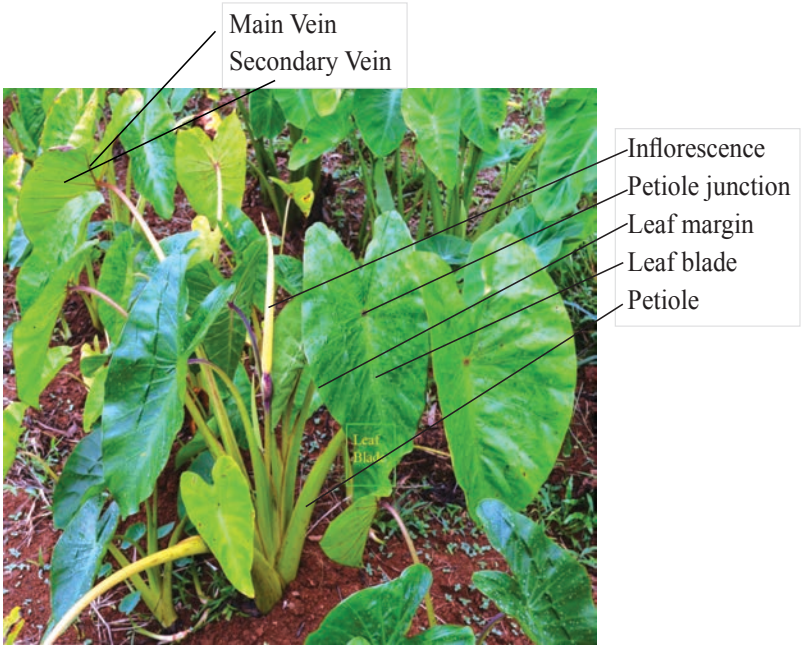

Fig. 1. The taro plant

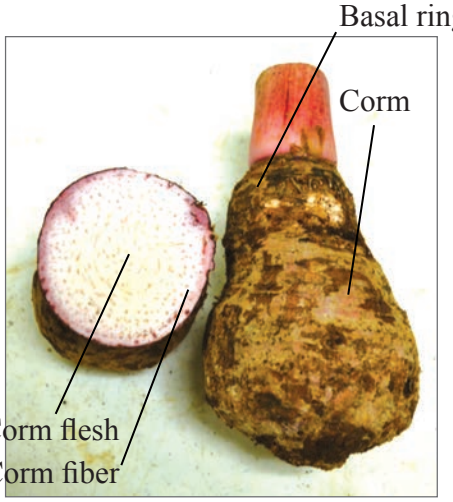

Fig. 2. Taro corm

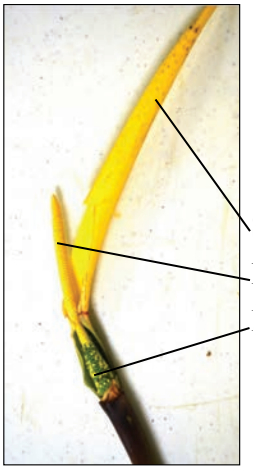

Fig. 3. Taro inflorescence

Taro is a rich source of carbohydrate, fiber, calcium and phosphorus. The leaves also contain high amounts of B carotene, total vitamin A and ascorbic acid. On the other hand, the petioles also have appreciable amounts of B-carotene, total Vitamin A, calcium and phosphorus (FNRI, 1997). In addition taro contains Vit E - 3.9 mg, folate-25 ug, magnesium 36.9 mg; potassium 639 mg; and selenium 1.2 ug (USDA).

Table 1. Nutritional Value Of Taro

Component	Nutritional Content			
	Boiled Tuber**	Boiled Tuber*	Leaves*	Petiole*
Edible Portion	100%	69%	100%	100%
Water		73.4 g	88 g.	96.2 g
Energy	147 kcal	104 kcal	48 kcal	14 kcal
Protein	0.7 g.	1.5 g.	1.4 g.	0.2 g.
Fat	0.1 g.	0.1 g.	0.4 g.	0.1 g.
Carbohydrate	45.7 g.	24.4 g.	9.7 g.	3.2 g.
Crude Fiber	6.7 g.	(2.2 g.)	0.6 g.	0.3 g.
Ash	0.82 g.	0.6 g.	0.5 g.	0.3 g.
Calcium	23.8 mg.	3.7 mg.	72 mg.	33 mg.
Phosphorus	100 mg.	41 mg.	28 mg.	11 mg.
Iron	1.0 mg.	0.7 mg.	0.4 mg.	0.4 mg.
Retinol		0	0	0
B-Carotene		5 ug.	4000 ug.	125 ug.
Total Vitamin A	111 IU	1 ug.	667 ug.	21 ug.
Thiamine	0.1 mg.	0.08 mg.	0.02 mg.	0.01 mg.
Riboflavin	0.04 mg.	0.01 mg.	0.08 mg.	0.01 mg.

* FNRI . 1997. The Philippine Food Composition Tables. DOST. Manila. Philippines

** USDA

TARO PRODUCTION SYSTEMS IN PALAU

Taro is planted continuously throughout the year. In Palau, there are three principal systems of growing taro, namely the wetland ***mesei, dechel*** and upland ***sers.***

1. MESEI

Most taro in Palau are grown in ***mesei,*** a wetland taro production system, where the taro is grown in paddy-like system with channels and dikes for water control. The taro patches are arranged very skillfully and thoughtfully near mangrove swamps which surround the island. The taro patch is the main source of staple food (***ongraol***) for the families. The ***mesei*** is inherited through maternal and paternal lineage and sometimes through marriage.

The ***mesei*** are found in valley bottoms near sea level where water cannot drain freely into streams or the ocean. The various fields are irrigated by running water from a nearby elevated area and resemble rice terraces wherein one is always slightly higher than the next. The planting areas are usually long and narrow or could be irregular in shape. They are separated from each other by small embankments with paths. Narrow water channels are found next to these paths and sometimes on them. The fields have been laid out long time ago by fore parents, probably designed and constructed by men from the whole village.

The taro is planted in very deep soil which have poor drainage. It is formed by organic material derived from decomposed and partially decomposed fresh water marsh vegetation and overlying alluvium washed from upland soils. The surface layer is dark brown or a very dark grayish brown muck about 86 cm deep. It has a high water table from 30 cm above the surface to 14 cm below the surface year round. Various plants and trees are grown on the dikes.

Weeds are first removed from the taro patch and the weeds are placed in a pile. The top 15 cm of the soil is turned over by hand and placed in another pile. The weeds are then placed in the hole followed by bundles of green manure. Then the top six inches of the soil is placed back in the hole and smoothened out. This is done in several sections of ***bluu*** which is mostly use nowadays and the path for water between the sections is laid out. Other sections of the mesei such as ***uars, ulecharo, uleboil*** and ***orak*** have functions for customary ceremonies. In the ***mesei***, planting materials are set

out at a spacing of 60 x 60 cm and then mulch usually consisting of banana leaves or other leafy materials are put in place to prevent growth of weeds, conserve moisture and nutrients.

Fig. 4. Turning the soil manually

Fig. 5. Planting the taro and immediately covering with leaf mulch

Fig. 6. Newly planted wetland taro patch

Fig. 7. Established taro in wetland area

2. DECHEL

Dechel is normally for planting giant swamp taro (***brak***) and taro (***dait***) is planted in between but may differ from place to place. The ***dechel*** system of planting is practiced in places adjacent to upland areas, near streams or the shoreline. The soil is very deep and poorly drained and formed from alluvium washed from upland soils dominantly from volcanic rock. The surface is covered with a mat of undecomposed and partially decomposed grasses and sedges 10 cm thick. The surface layer is a dark grey mucky silt loam and the underlying material is olive and grey to greenish grey silty clay loam. Permeability of ***dechel*** soil is moderately slow. In ***dechel***, the soil is damp or wet but there is much less water than the ***mesei.***

The land is usually cleared of weeds first . A long narrow shovel or stick is used to make holes 60 x 60 cm apart. The taro planting material is placed inside the hole, and the surrounding loose soil is stepped on. Mulch

Fig. 8. Making holes and planting taro in ***dechel***

Fig. 9. Taro plants growing in ***dechel***

3. SERS

Another production system where taro can be grown profitably in upland areas is known as ***sers***. There are many upland areas suitable for taro production on Palau. These ensure the availability of taro corms as food for the populace even when taro planting in the *mesei* become unfit for production due to climate change and salt water intrusion.

The ***sers*** plantings are grown on higher and drier ground. The soil is deep and well drained. The surface layer is a dark brown silt loam. The upper 10 cm of the subsoil is brown silty clay loam and the next 56 cm is yellowish red to a strong brown silty clay. Permeability of the soil is moderately rapid; runoff is slow to rapid, depending on the slope of the area.

Land Preparation

The land is initially cleared of weeds and bushes by slashing and burning. The taro is planted in holes which are prepared using a stick, pick ax or rotavator. In areas which have been previously grown with other crops, the soil is cultivated manually or plowed with a tiller as rows or mounds are made.

Newly established areas for planting taro on upland areas are cleared of shrub and vegetation. Since most of the soils on Palau are acidic, lime is applied by broadcasting at 750 kg/ha before rototilling This allows the lime to be mixed in the soil. In rototilling, rows are made 1 meter apart.

Fig. 10. Liming and rototilling the field for planting taro in upland area

Planting Materials

Setts. Planting materials of taro are ***setts*** (top of corm and base of stems), suckers and stolons. The roots and fiber are scraped off the corm with the use of a crescent shaped knife (*ngark*) and the leaf blades are cut leaving 30 cm of the petiole above the corm. The cut surfaces of the planting materials are allowed to dry or may be replanted immediately. In Palau planting materials are dipped in 10% chlorox solution or salt / ocean water prior to planting to kill disease-causing microorganisms and insect pests.

Fig. 11. Cutting the corm from the shoot with the use of a *ngark*

Fig. 12. Taro planting materials

Fig. 13. Dipping planting materials in 10% Chlorox solution

Tissue Cultured Planting Materials Taro planting materials can also be obtained from tissue cultures which have been propagated in the laboratory. Tissue culture plants are small plantlets grown in artificial medium in sterile container. It is a rapid way of mass propagating taro plants. The plants obtained are uniform and disease-free. Plantlets are acclimatized in the greenhouse prior to planting them in the field.

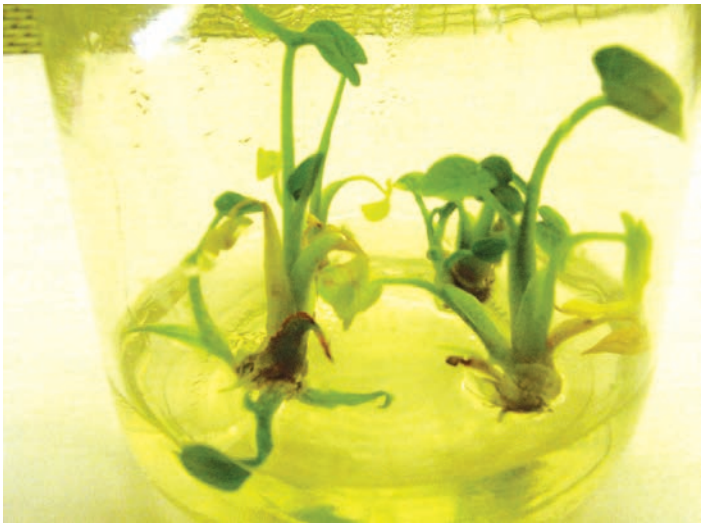

Fig. 14. Taro tissue culture in artificial medium

Fig. 15. Taro plantlets acclimatized in the greenhouse prior to field planting

Distance of Planting

A planting material is inserted into the ground at a depth of 10 to 15 cm. The distance between planting holes is about 60 cm. The base of the planting material is covered with soil then pressed around the base of seedling to keep the plant upright.

Weed Control

Manual weeding is done by using a hoe or scythe. The weeds are removed in between plants and between rows. Weeds near the base of the plants are handpulled. Once the leaf canopy closes, weeding is no longer done.

Fig. 16. Manual weeding of taro

Fertilization

One month after planting, a handful of compost or manure and a handful of inorganic fertilizer (10-30-10) are placed about 7 cm around the base of each plant and then covered with soil.

Fig. 17. Applying compost and fertilizer

INSECT PESTS OF TARO AND THEIR CONTROL

There are four major insect pests attacking taro in Palau. These are the cluster caterpillar, taro hornworm, melon aphid and taro leafhopper.

1. Cluster caterpillar, *Spodoptera litura* (Fabr.)

It occurs throughout Micronesia except on the island of Kosrae. It is a highly polyphagous species feeding on many plants such as taro, tomato, eggplant, corn and others.

Fig. 18. Larvae of the cluster caterpillar

The eggs are laid by the female moth at the underside of leaves and are covered with a buff of hairs from the body of the moth. The newly hatched larvae found in taro are blackish green with yellowish stripes The mature caterpillars feed by scraping the tissues and making holes on the leaves of taro. Mature larvae fall to the ground and pupate a few centimeters below the soil surface. The moth is thick set, grayish brown with marking on the forewings. The lifecycle is completed in almost two months.

Farmers usually collect larvae from the leaves and crush them.
They also spray Malathion at the recommended rate once a week when infestation sets in.

2. Taro hornworm, *Hippotion celerio* (Linn.)

The taro hornworm can be found throughout Micronesia. The female moth lays yellowish white eggs singly on the underside of the taro leaves. The larvae which are also yellowish turn green as they mature. The mature larvae feed voraciously on the leaves of taro sometimes consuming a single leaf. When the leaves mature, the larvae fall to the ground and pupate a few centimeters below the surface of the soil. Sometimes, a brown form of the larva occurs. The pupa is ash brown. The adult is light brown, the forewings of which are elongated with oblique outer margins and with metallic bands. The moth is active at night to look for nectars of flowers and to lay eggs on the host plant. The life cycle takes more than a month.

The taro hornworm is a serious insect pest of dryland taro. One way of controlling it is by plowing the field every planting season to expose the pupae of the hornworm to the elements and predators.

Farmers usually hand collect the larvae and then crush them. Sometimes farmers spray taro with Malathion at the recommended rate to kill the larvae feeding on the leaves.

Fig. 19. Larva of taro hornworm

3. Melon aphid, *Aphis gossypii* (Glover)

The melon aphid can be found throughout Micronesia. It is known to feed on kava, cucumber, taro, melon and legumes, Siam weed, mile-a-minute weed and eggplant. It is known to transmit 40 virus diseases of plants including dasheen mosaic and cucumber mosaic viruses.

The melon aphids on taro are black green. When feeding on other plants such as Siam weed, mile-a minute weed and cucumber, they are yellowish green and much smaller in size.

Adult aphids are 2 to 3 mm long with black heads and cornicles. Each female aphid reproduces 60 to 100 nymphs after 20 to 30 days. The nymphs look like adults except that they are smaller. The life cycle is completed in 2 weeks. Aphids are usually found on the undersurface of the leaf and are responsible for the curling of young taro leaves.

Predatory coccinellid beetles and syrphid fly maggots feed on melon aphids.

A wasp parasitoid, *Aphidius colemani*, which came from Hawaii was introduced to Palau in 2006 to control the melon aphids on taro. Since then, the melon aphid has no longer been considered a serious threat to taro production.

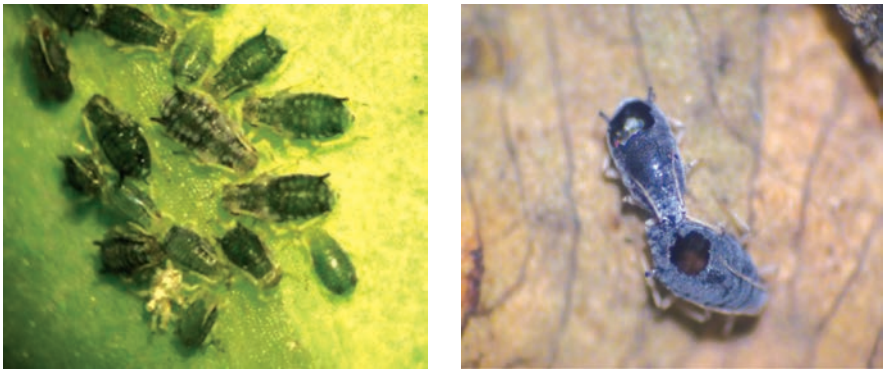

Fig. 20. Close up of melon aphids on taro (left) and exit holes on mummified black melon aphid caused by *Aphelinus* sp. (right).

4. Taro leafhopper, *Tarophagus colocasiae* (Matsumura)

Both nymph and adult leafhopper suck the sap from leaves and petioles of taro. When the population is high, the damaged leaves become brown especially along leaf margins. The plant looks dirty and sickly producing small and hard to cook corms at harvest. In some South Pacific island countries, the leafhopper transmits a dreaded disease called *Alomae bobonae* disease.

Female adult leafhoppers insert their eggs into slits cut with the ovipositor on the petiole and petiole bases and midrib of a leaf. The life cycle takes more than a month. Both nymph and adult leafhoppers congregate in groups on the underside of leaves and petioles but sometimes also on upper surfaces of leaves. When the population is high fully winged form of adults may be formed to facilitate movement from one plant to another. The adult leafhopper is dark brown with a whitish patch on the thorax. Newly hatched nymphs assume a dull white color.

The mirid bug, *Cyrtorhinus fulvus* Knight, is an important natural enemy of the taro leafhopper. It originally came from the Philippines brought to Hawaii in 1947 to control the taro leafhopper. The mirid bug was brought to Micronesia also to control the taro leafhopper. Unfortunately, because of slow transportation during that time, the mirid bugs got established only on Pohnpei. Nymphs and adult bugs prey on the eggs of the taro leafhopper.

Fig. 21. Damage caused by taro leafhoppers (left) and close up of taro leafhoppers (right).

The yellow colored, sometimes greenish nymphs move fast once disturbed, while adults are winged and can fly from plant to plant searching for leafhopper eggs. The life cycle is completed in more than a month. A pile of dry leaves and twigs is burned close the affected taro plants as the smoke drive away the insects.

DISEASES OF TARO AND THEIR CONTROL

There are two important diseases of taro in Palau. These are the taro corm rot and the taro leaf blight.

1. Taro corm rot, *Pythium* sp.

The corm rot, locally known as *obei*, is an important disease of taro. It is caused by the fungus, *Pythium* sp. The fungus attacks the roots causing the developing corms to rot and die. The leaves collapse and the plant dies. On mature plants the corm rot attacks at the base and sides making the corms soft, mushy, and smelly.

Fig. 22. Taro corm rot in *mesei*

There are a number of ways to control the incidence of corm rot:

- Fallowing or no planting in the same area for one to three years.
- Applying a handful of wood ash and a handful of lime reduce the incidence of corm rot infection on young plants.
- Push down the infected plant and put ashes, koranges (*Barringtonia racemosa*), leaves and fruits, and cover with soil.

- Dipping planting materials overnight in either Captan or Ridomil at 1 kg/ha before planting also reduce the incidence of corm rot.

- Five varieties of taro have consistently been found to have lower incidence or resistance to corm rot. These varieties are Erderid, Homusted, Ngetmadei, Renged and Dungersuul.

The recommended control practice is to apply lime to the area every planting season. It is applied on top of the soil before rototilling the soil. By doing this, the lime is mixed with the soil. Chicken manure is applied in each hole at planting time. Even susceptible varieties like Ngesuas and Ochab were successfully grown. It seems that by applying lime at every land preparation increases the soil pH thus reducing the incidence of corm rot to low level. Applying chicken manure allow the beneficial microorganisms to grow preventing build-up of pathogenic microorganisms.

2. Taro leaf blight, *Phytophthora colocasiae* Rac.

The disease which commonly occurs in Micronesia is caused by the fungus P. *colocasiae*.

The first sign of the disease is a small circular brown speck on the upper leaf surface and water soaked below. The spots enlarge and become irregular in shape and turn dark brown with yellow margin. The characteristic feature of the disease is a clear yellow to red liquid which oozes from the center of the spots and becomes dark brown and hard when dry. Night time temperatures of 20 to 22 ℃ and 100 % relative humidity with light rains or dew in the morning increase its severity.

Fig. 23. Lesions on leaves caused by taro leaf blight

Control of the disease can be done in several ways:

- Collection of diseased taro leaves in the morning, then placing them in trash bags and burn.

- Leaves of planting materials should be removed or cut before planting as these can be a source of spores of the disease.

- Soaking the planting materials in 10% chlorox solution overnight. By doing so, the disease causing microorganisms in the planting materials are killed.

- Planting two or three different varieties in the taro patch.

- Use of taro leaf blight resistant varieties such as Ngesuas, Ngeruuch, Homusted and Kerdeu. Hybrids of taro developed at the University of Hawaii and in Samoa are also resistant to the disease. These hybrids are Paakala, Palehua, Pauakea, Samoa 115, Samoa 116 among others.

- Spraying taro with either Ridomil or Dithane M 45 or Maneb fungicides at 1 kg/400 liters of water should be done as symptoms appear on the leaves. Second spraying should be done 7 days after. Latron at 1 ml/4 liters of solution is added to allow sprays to stick to hard-to-wet leaves of taro.

Fig. 24. Samoa 115, a taro leaf blight resistant hybrid.

HARVESTING

Taro is harvested usually from 7 to 9 months after planting when the leaves shrink to only 2 to 3 leaves per plant. The soil around the plant is loosened using a hoe or knife. Once loosenend, the plants are pulled from the soil. The corm is cleaned by scraping off the soil and roots using a crescent-shaped knife locally known as *ngark*. The shoot which is used as planting material is removed and leaf blades are cut leaving 30 cm of the petiole above the corm. The corms are collected and placed in a harvest basket for home consumption or for sale in the market.

Fig. 25. Harvesting taro in *dechel*

Fig. 26. Collecting harvested taro

Fig. 27. Cleaning harvested taro

Fig. 28. Harvested taro ready for the market

Economics of Taro Production

This is an attempt to show the profitability of wetland taro production in 21 *bluu* (blocks / squares) in a typical village setting for 7-8 months based on the following assumptions:

- Each *bluu* measures 12ft x 12 ft
- 49 plants are planted in each *bluu*
- Hired labor for each 8-hour working day is paid at $20.00/day
- 80% of planted taro / *dait* are harvestable after 7-8 months = 39 mother corms / *bluu*
- 30% of harvested mother corms are for home consumption and local customs = 11 mother corms / *bluu*
- One mother corm weighs 1lb.
- 18 lbs of baby corms are harvested per *bluu* which can be made into 15 pcs *belsich* (pounded cooked taro and rolled into 6-inch tubes) x 21 *bluu* = 315 pcs *belsich* (200 pcs sold and 115 pcs for home consumption)
- *Belsich* can be sold at $ 2.00 each tube
- One mother plant produces 4 suckers / stolons, that is 39 x 4 = 156 suckers / *bluu*
- 39 mother plants + 156 suckers = 195 planting materials / *bluu*
- Planting materials produced = 195 plants / *bluu* x 21 *bluu* = 4095 *dait*
- *Demok* can be prepared from the taro leaves and can be sold at $ 1.00 per cup. *Demok* is a soupy mixture of shredded taro leaves, coconut milk with tuna or mackerel or crab. It is seasoned with salt and pepper.
- 20 cups of *demok* can be prepared from taro leaves per *bluu* x 21 *bluu* = 420 cups of *demok* (50% for sale and 50% for home consumption)
- 20 cups of *chelang* can be prepared from taro petioles per *bluu* x 21 *bluu* = 420 cups of *chelang* (50% for sale and 50% for home consumption). *Chelang* is a soupy mixture of pieces of taro petioles with coconut milk and sugar.

Table 2. Cost and Return Analysis of Taro Production

Item	Cost ($)
I. Farm Expenses	
A. Labor	
Clearing / cutting grass (2 Working Days, WD)	40.00
Turning the soil / *mesalou*	
(4 persons x 2 WD = 8WD)	160.00
Collecting *ramk*	
(4 persons x 2 WD = 8WD)	160.00
Planting (2 persons x 2 WD= 4 WD)	80.00
Weeding and clearing waterways	
(2 persons x 2 WD = 4 WD)	80.00
Harvesting and cleaning taro	
(4 persons x 2 WD = 8 WD)	160.00
Subtotal	**680.00**
B. Supplies and Materials	
Planting materials (49 *dait* x 21 *bluu* =	
1029 plants x $ 0.25 / *dait*)	257.25
Fuel and oil for cutting grass and collecting ramk	50.00
4 pcs scythe / *kamang*	100.00
Gloves	10.00
Subtotal	**417.25**
Grand Total Expenses (A + B)	**1,097.25**
II. Projected Harvest of Taro	
A. Cash Income	
28 lbs corms / *bluu* sold in market x 21 *bluu*	
= 588 lbs x $1.50/lb	882.00
200 pcs *belsich* x $2.00 / pc	400.00
210 cups of *demok* x $1.00 / cup	210.00
210 cups of *chelang* x $1.00 / cup	210.00
2500 *dait* planting materials x $ 0.25	625.00
Sub total	**2,327.00**
Net Income = Total Cash Income Less Total Expenses	**1,229.75**

Table 2 (cont'd.)

Item	Cost ($)
B. Non-Cash Income	
11 lbs corms / *bluu* for home & custom	
X 21 *bluu* = 231 lbs x $ 1.50 / lb	346.50
115 pcs *belsich* x $2.00	230.00
210 cups of *demok* x $1.00	210.00
210 cups of *chelang* x $1.00	210.00
Planting materials for next planting =	
1500 *dait* x $0.25	375.00
Total Non-Cash Income	**1,371.50**
Total Revenue = Net Income + Total Non-Cash Income	**$ 2,601.25**

This analysis show that the farmer can get cash income by marketing the products derived from the wetland taro patch such as the taro corms, *belsich, demok, chelang,* and *dait* or planting materials. These can cover up for the expenses for labor and materials incurred during the production period and still get a net income from the farm equivalent to $1,229.75.

Aside from these, the farmer is still able to provide food for the family and customs which is summarized as non-cash income of $1,371.50, thus giving a total revenue of $2,601.25.

TARO VARIETIES IN PALAU

LOCAL VARIETIES

Palau is rich in diversity of taro germplasm because it is the main staple food of the local population. Palauan farmers are known to collect and plant a mixture of different varieties of taro in their farms at any given time. Taro in Palau is known to be resistant to various pests and diseases such as taro leaf hopper and taro leaf blight. Palauan taro varieties have been responsible for the recovery of the other Pacific island countries from the devastating leaf blight infection (1994) which have wiped out the taro industry in Samoa. It has been extensively used in the breeding for disease resistant hybrids.

There has been no known documentation of the local taro varieties in Palau. The different varieties of taro are described following the taro descriptors of the International Plant Genetic Resources Institute (1999). This is an attempt to describe and record the distinguishing characteristics and differentiate each of the Palauan and introduced taro varieties.

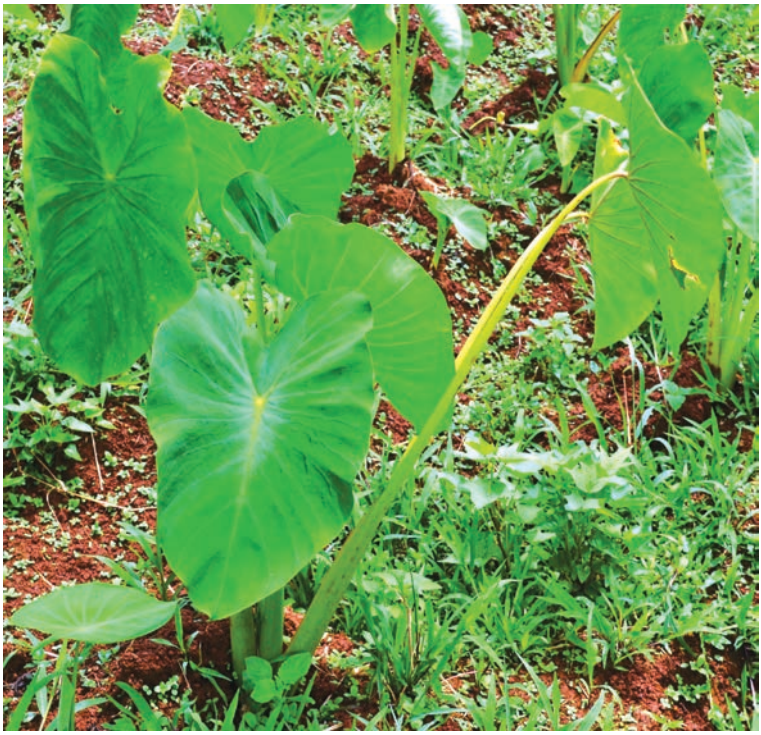

Fig. 29. Dilisor

This variety is 50-100 cm in height with 6-10 stolons. The leaves have green leaf blade and green leaf margin with no petiole junction. The main vein is green in Y pattern extending to secondary veins. The petioles are green with white petiole basal ring. The corm is dumb bell with white corm cortex and light yellow fiber. Maturity is 7 - 9 months. Average corm weighs 250 grams. The tuber is sweet and sticky when cooked.

Fig. 29 a. Dilisor corm

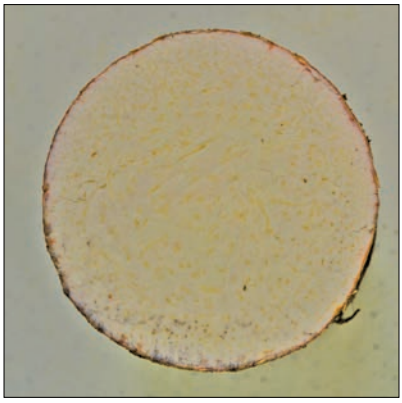

Fig. 30. Dirraousch

The plant is 50-100 cm in height with 6-10 stolons. The leaf blade is green with purple leaf margin and purple petiole leaf junction. The main vein is red in Y pattern extending to secondary veins. The petiole is red from base to top with pink basal ring. The corm is round shape with pink flesh and white flesh fiber. Maturity is 7-8 months and average corm size is 400g. The tuber is bland and starchy when cooked.

Fig. 31. Dirratengadik

This variety is 50-100 cm in height with 11-20 stolons. The leaf blade is dark green with purple leaf margin and purple petiole junction. The main vein is whitish in Y pattern extending to secondary veins. The petioles are purple at the top and green at the base with pink basal ring. The corm is dumb bell with pink flesh and white fiber. Maturity is 7-8 months and average corm weight is 380grams. The tuber is bland and starchy when cooked.

Fig. 31 a. Dirratengadik plants and corms

Fig. 32. Dirrubong

This variety is 50-100 cm in height with 6-10 stolons. The leaf is green with purple leaf margin and red petiole junction. It has purple main vein in Y with pattern extending the secondary veins. The petioles are purple from base to top with red basal ring. The corm is round with white flesh and yellow fiber. Maturity is 10-12 months, Average corm weight is 420 g. The tuber is bland and starchy when cooked.

Fig. 32 a. Dirrubong corms

Fig. 33. Dois

This is a short taro plant < 50 cm in height with 1-5 stolons. The leaves are dark green with purple leaf margin and purple petiole junction. The main vein is purple in Y pattern extending to secondary veins. The petiole is purple from top to base with red basal ring. The corm is dumb-bell shaped with white flesh and light yellow fiber. Maturity is 7 months and average corm weight is 153 g. The cooked tuber is sweet and sticky.

Fig. 34. Dungersuul

This is a tall taro plant (> 100 cm in height) with 6-10 stolons. The leaf blade is green with green leaf margin and yellow petiole junction. The main vein is green in Y pattern extending to secondary veins. The petiole is green at the top and light green at the base with pink basal ring. It has dumb-bell shaped corm with white flesh and light yellow fiber. Maturity is 7-9 months and average corm weight is 406 g. The cooked tuber is sweet and starchy.

Fig. 34 a. Dungersuul plants corms

Fig. 34 b. Dungersuul corm

Fig. 35. Dung Ra Terrekakl

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with red leaf margin and yellow petiole junction. The main vein is yellow in Y pattern extending to secondary veins. The petiole is green from base to top with pink basal ring. The corm is intermediate dumb-bell with pink flesh and pink fiber. Maturity is 7-9 months and average corm weight is 500 g. The cooked tuber is sweet and sticky.

Fig 35 a. Dung Ra Terrekakl corm

Fig. 36. Erderid

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is dark green with yellow leaf margin and red petiole junction. The main vein is white in Y pattern extending to secondary veins. The petiole is green from base to top with red basal ring. The corm is intermediate round with pink flesh and yellow fiber. Maturity is 7-9 months and average corm weight is 385 g. The cooked tuber is sweet and sticky.

Fig 36 a. Erderid plants and corms

Fig. 37. Esuuch

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with red leaf margin and yellow petiole junction. The petiole is green from base to top with pink basal ring. The corm is intermediate dumb bell with pink flesh and pink fiber. Maturity is 7-9 months and average corm weight is 340 g. The cooked tuber is sweet and sticky.

Fig. 38. Homusted

This variety is a tall taro (> 100 cm) with 1-5 stolons. The leaf blade is dark green with purple leaf margin and purple petiole junction. The petiole is purple from base to top with purple basal ring. The corm is dumb-bell intermediate with pink flesh and white fiber. Maturity is 7-9 months and average corm weight is 333 g. The cooked tuber is sweet and sticky.

Fig. 38 a. Homusted corm

Fig. 39. Kerdeu

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with green leaf margin and no petiole junction. The leaf main vein is green in Y pattern. The petiole is green at the base and purple at the top with pink basal ring. The corm is intermediate round with pink flesh and white fiber. Maturity is 7-9 months and average corm weight is 450 g. The cooked tuber is sweet and sticky.

Fig. 39 a. Kerdeu plants

Fig. 39 b. Kerdeu corm

Fig. 40. Kirang

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with green leaf margin and purple petiole junction. The main vein is pink in V pattern. The petiole is purple at the top and green at the base with pink basal ring. The corm is intermediate dumb bell with pink flesh and pink fiber. Maturity is 7-9 months and average corm weight is 650 g. The cooked tuber is sweet and sticky.

Fig. 40 a. Kirang plants

Fig. 40 b. Kirang corm

Fig. 41. Meltalt

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with green leaf margin and green petiole junction. The main vein is white in Y pattern. Petiole color is green from base to top with pink basal ring. The corm is round, intermediate with pink flesh color and yellow fiber. Maturity is 7-9 months and average corm weight is 280 g. The tuber is bland and starchy when cooked.

Fig. 42. Merii

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with purple leaf margin and pink petiole junction. The main vein is purple in Y pattern extending to secondary veins. The petiole is purple from base to top with purple basal ring. The corm is intermediate round with pink flesh and yellow fiber. Maturity is 7-8 months and average corm weight is 450 g. The cooked tuber is bland and starchy.

Fig. 42 a. Merii corm

Fig. 43. Miuako Ngkeklau

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is dark green with red leaf margin and red petiole junction. The main vein is pink in Y vein pattern extending to secondary veins. The petiole is purple from base to top with pink basal ring. The corm is long dumb-bell shape with white flesh and pink fibers. Maturity is 7-8 months and average corm weight is 370 g. The cooked tuber is sweet and sticky.

Fig. 44. Miuako Ouberburs

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with green leaf margin and without petiole junction. The main vein is green in Y vein pattern. The petiole is green at the base and purple at the top with white stripe and pink basal ring. The corm is intermediate dumb-bell shape with white flesh and light yellow fibers. Maturity is 7-8 months and average corm weight is 380 g. The cooked tuber is bland and sticky.

Fig. 45. Ngemekeang

This variety is 50-100 cm in height with 1-5 stolons. The leaf blade is green with purple leaf margin and purple petiole junction. The main vein is purple in V pattern. The petiole is purple at top and green at the base with white basal ring. The corm is intermediate cylindrical shape with white flesh and light yellow fibers. Maturity is 7-8 months and average corm weight is 425g. The cooked tuber is sweet and sticky.

Fig. 46. Ngertmau

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with yellow leaf margin and yellow petiole junction. The main vein is white in Y pattern extending to secondary veins. The petiole is light green from base to top with purple basal ring. The corm is intermediate round shape with white flesh and yellow fibers. Maturity is 7-8 months and average corm weight is 400 g. The cooked tuber is bland and starchy.

Fig. 47. Ngeruuch

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is green with yellow leaf margin and yellow petiole junction. The main vein is yellow in Y vein pattern. The petiole is green from base to top with white basal ring. The corm is intermediate dumb-bell shape with light yellow flesh and yellow fibers. Maturity is 7-8 months and average corm weight is 380 g. The cooked tuber is bland and starchy.

Fig. 47 a. Ngeruuch plants and corms

Fig. 48. Ngesuas

This variety is 50-100 cm in height with 11-20 stolons. The leaf blade is green with purple leaf margin and purple petiole junction. The main vein is purple in Y pattern extending to secondary vein. The petiole is purple from base to top with red basal ring. The corm is intermediate cylindrical shape with pink flesh and pink fibers. Maturity is 7-8 months and average corm weight is 400 g. The cooked tuber is sweet and sticky.

Fig. 48 a. Ngesuas plants and corms

Fig. 49. Ngetmadei

This variety is 50-100 cm in height with 6-10 stolons. The leaf blade is dark green with red leaf margin and red petiole junction. The main vein is purple in Y pattern extending to secondary veins. The petiole is purple from base to top with pink basal ring. The corm is long dumb-bell shape with pink flesh and pink fibers. Maturity is 7-8 months and average corm weight is 450 g. The cooked tuber is sweet and sticky.

Fig. 49 a. Ngetmadei corm

Fig. 50. Ochab

This variety is 50-100 cm in height with 11-20 suckers. The leaf blade is dark green with yellow leaf margin and red petiole junction. The main vein is white in Y pattern. The petiole is green from base to top with pink basal ring. The corm is long cylindrical shape with white flesh and light yellow fibers. Maturity is 7-8 months and average corm weight is 357 g. The cooked tuber is bland and starchy.

Fig. 50 a. Ochab plants and corms

Fig. 51. Ochelochel

This variety is 50-100 cm in height with 11-20 suckers. The leaves are green with green leaf margin and yellow petiole junction. The main vein is white in Y pattern. The petiole is green from base to top with red basal ring. The corm is intermediate conical shape with pink flesh and white fibers. Maturity is 7-8 months and average corm weight is 400 g. The tuber is bland and starchy when cooked.

Fig. 51 a. Ochelochel plants and corms

Fig. 52. Ordiil

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with green leaf margin and no petiole junction. The main vein is green in pattern extending to secondary vein. The top 1/3 of the petiole is purple and the base is green with white basal ring. The corm is intermediate dumb-bell shape with white flesh and light yellow fibers. Maturity is 7-8 months and average corm weight is 388 g. The cooked tuber is sweet and sticky.

Fig. 53. Okelang Becheleleu

This taro is > 100 cm in height with 11-20 stolons. The leaves are green with red leaf margin and red petiole junction. The main vein is red in Y pattern. The top of petiole is purple and the base is green with red basal ring. The corm is long dumb-bell shape with white flesh and light brown fibers. Maturity is 7-8 months and average corm weight is 750 g. The cooked tuber is bland and starchy.

Fig. 53 a. Okelang Becheleleu plants and corms

Fig. 54. Renged

This variety is 50-100 cm in height with 6-10 stolons. The leaves are dark green with red leaf margin and purple petiole junction. The main vein is purple in Y pattern extending to secondary veins. The petiole is purple from base to top with purple basal ring. The corm is long dumb-bell with white flesh and pink fiber. Maturity is 7-8 months and average corm weight is 370 g. The cooked tuber is sweet and sticky.

Fig. 55. Terebkul

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with green leaf margin and red petiole junction. The main vein is yellow green in Y pattern extending to secondary veins. The petiole is light green from base to top with red basal ring. The corm is short dumb-bell with pink flesh and brown fiber. Maturity is 7-8 months and average corm weight is 402 g. The cooked tuber is bland and starchy.

Fig. 56. Terrekakl

This variety is 50-100 cm in height with 6-10 stolons. The leaves are dark green with purple leaf margin and green petiole junction. The main vein is white in Y pattern extending to secondary veins. The top 1/3 of petiole is green from base to top with pink basal ring. The corm is long and conical shape with white flesh and light yellow fiber. Maturity is 7-8 months and average corm weight is 450 g. The tuber is sweet and sticky when cooked.

Fig. 56 a. Terrekakl plants

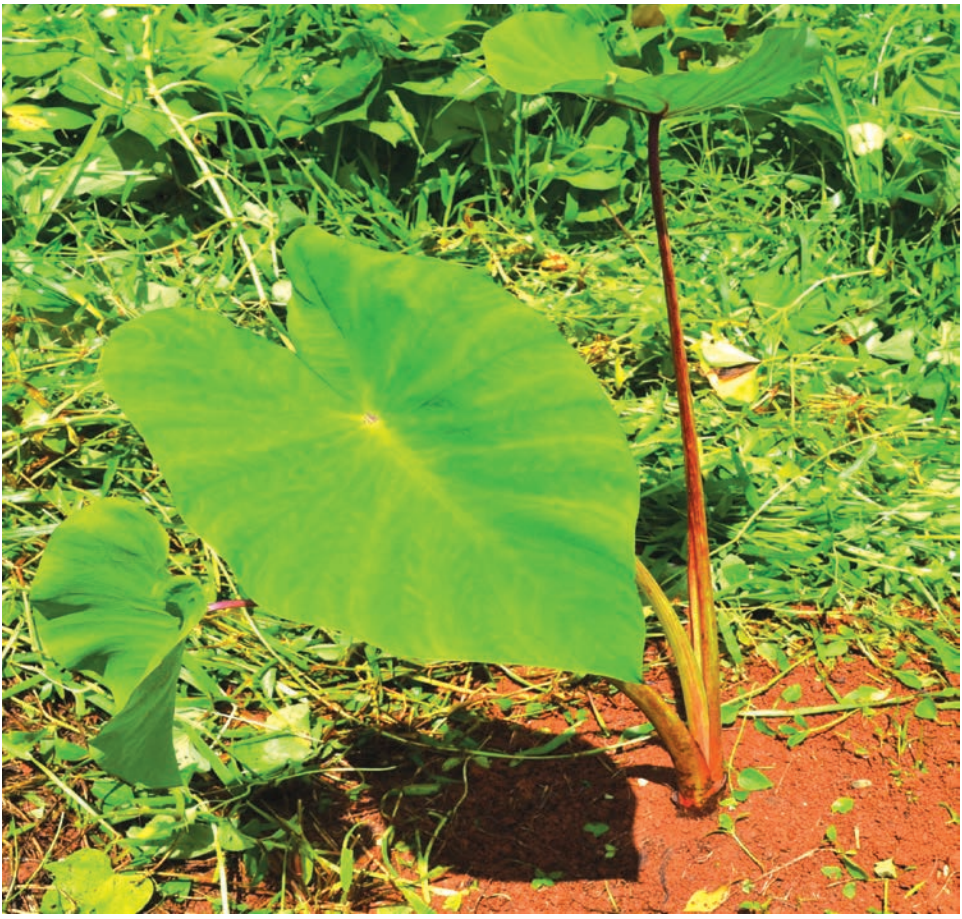

Fig. 57. Thomas

This taro is 50-100 cm in height with 6-10 stolons. The leaves are green with red leaf margin and white petiole junction. The main vein is pink with variegation in Y pattern extending to secondary veins. The petiole is purple from base to top with purple stripe and red basal ring. The corm is intermediate dumb-bell with white flesh and yellow fiber. Maturity is 7-8 months and average corm weight is 500 g. The tuber is sweet and sticky when cooked.

Fig. 57 a. Thomas corm

Fig. 58. Ungil Dil

This taro is > 100 cm in height with 6-10 stolons. The leaves are dark green with purple leaf margin and purple petiole junction. The main vein is purple in Y pattern. The petiole is purple from base to top with red basal ring. The corm is intermediate dumb-bell with white flesh and brown fiber. Maturity is 7-8 months and average corm weight is 350g. The cooked tuber is sweet and sticky.

Fig. 58 a. Ungil Dil corm

Fig. 59. Urungel

This variety is 50-100 cm in height with 6-10 stolons. The leaves are dark green with red leaf margin and red petiole junction. The main vein is purple in Y pattern extending to secondary veins. The petiole is purple from base to top with basal ring. The corm is short dumb-bell with white flesh and purple fiber. Maturity is 7-8 months and average corm weight is 210 g. The cooked tuber is bland and starchy.

Fig. 59 a. Urungel corms

Fig. 60. Ulechem

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with yellow leaf margin and yellow petiole junction. The main vein is yellow in Y pattern. The petiole is green from base to top with red basal ring. The corm is intermediate and cylindrical with purple flesh and light yellow fiber. Maturity is 7-8 months and average corm weight is 410 g. The cooked tuber is bland and starchy.

Fig. 60 a. Ulechem corm

INTRODUCED TARO VARIETIES

Palau has been a member of the Pacific Agricultural Plant Genetic Resources Network (PAPGREN). As such, Palau thru the Palau Community Collage Cooperative Research and Extension (PCC-CRE), has been able to acquire new taro germplasm and hybrids from the Center for Pacific Crops and Trees (CePaCT) of the Secretariat of the Pacific Community (SPC). This is also one of the benefits that Palau gets as a member of the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Under this program, the PCC-CRE has been able to repatriate to Palau the different taro varieties that were used in the breeding program in Hawaii and in Samoa to develop hybrids that would be resistant to the taro leaf blight infection. In addition, PCC-CRE also became recipients of the products of these hybridization programs of Hawaii and Samoa.

We have retained the names of these accessions and hybrids as we have received them from CePaCT. These are some of the hybrids and lines that were introduced to Palau from 2006. We have evaluated them and they were found to be well adapted and acceptable to the local community.

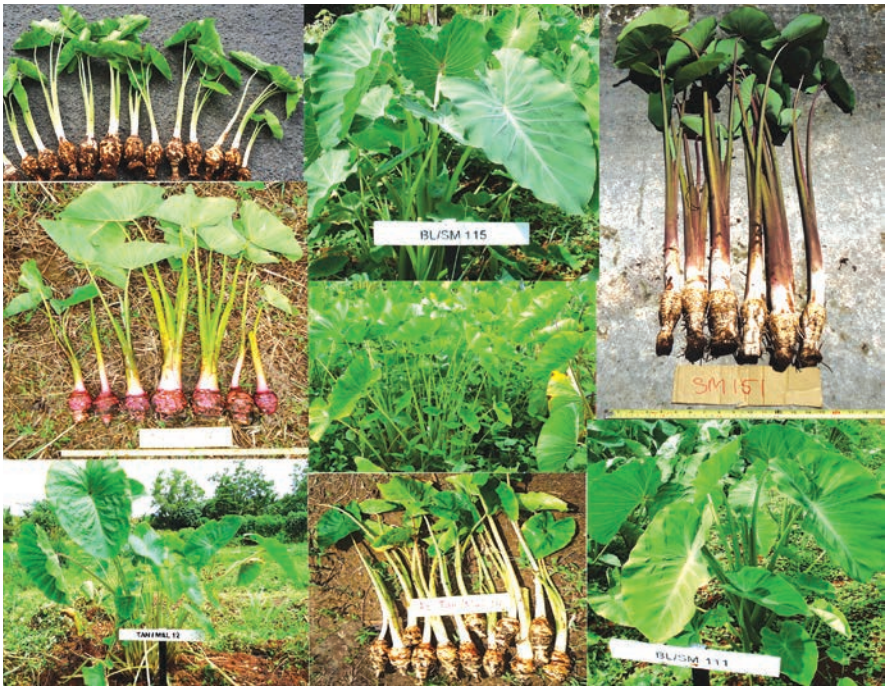

Fig. 61. Hawaii 12 / BC 99-6

This taro is 50-100 cm in height with 6-10 suckers. The leaves are dark green with fleck variegation, yellow leaf margin and small purple petiole junction, The main vein is yellow in Y pattern. The petiole is green from base to top with purple basal ring. The corm is long, conical with pink corm and red fiber. Maturity is 7-8 months and average corm weight is 366 g. The cooked tuber is bland and starchy.

Fig. 62. Hawaii 26 / BC 99-11

This taro is 50-100 cm in height with 6-10 suckers, The leaves are dark green with green leaf margin and small purple petiole junction. The leaf vein is pink in V pattern. The petiole is green from top to base with purple basal ring. The corm is intermediate elliptical with pink flesh and pink fiber. Maturity is 7-9 months and average corm weight is 340 g. The cooked tuber is sweet and sticky.

Fig. 62 a. Hawaii 26 corm

Fig. 63. Hawaii 37 / Paakala

This taro > 100 cm in height with 1-5 suckers. The leaves are green with green leaf margin and small yellow petiole junction. The main vein is whitish in Y pattern. The petiole is light green from top becoming green at the base with pink basal ring. The corm is long dumb-bell with pink flesh and white fiber. Maturity is 7-8 months and average corm weight is 950 g. The cooked tuber is sweet and sticky.

Fig. 64. Samoa 10

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with purple leaf margin and purple petiole junction. The leaf main vein is whitish in V pattern. The top 1/3 of the petiole is purple and green base with white stripe and white basal ring. The corm is intermediate dumb-bell yellow flesh and white fiber. Maturity is 7-9 months and average corm weight is 325 g. The cooked tuber is sweet and sticky.

Fig. 64 a. Samoa 10 corm

Fig. 65. Samoa 12

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with purple leaf margin and medium purple petiole junction. The main vein is red in Y pattern, The petiole top is purple and green base with red basal ring. The corm is intermediate dumb-bell with pink flesh and red fiber. Maturity is 7-8 months and average corm weight is 428 g. The cooked tuber is sweet and sticky.

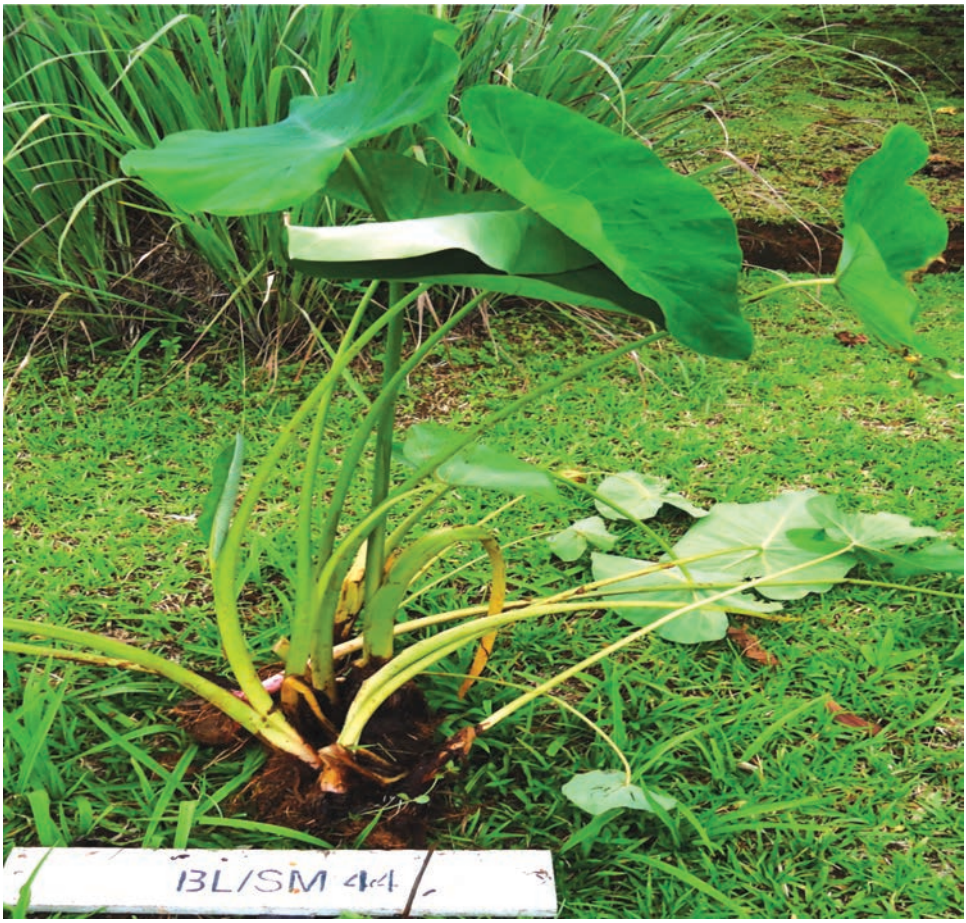

Fig. 66. Samoa 44

This variety is 50-100 cm in height with 6-10 stolons. The leaves are green with green leaf margin and medium red petiole junction. The leaf main vein is green in Y pattern. The petiole is green from top to base with pink basal ring. The corm is intermediate dumb-bell with white flesh and yellow fiber. Maturity is 7-8 months and average corm weight is 540 g. The cooked tuber is bland and starchy.

Fig 66 a. Samoa 44 plants

Fig. 67. Samoa 111

This taro is > 100 cm in height with 6-10 suckers. The leaf is yellow green with yellow margin and no petiole junction. The main vein is green in Y pattern. The petiole is light green from top to base with yellow green basal ring. The corm is intermediate and conical with white flesh and white fiber. Maturity is 7-8 months and average corm weight is 500 g. The cooked tuber is bland

Fig. 67 a. Samoa 111 plants and corms

Fig. 68. Samoa 114 / Salelologa

This taro is > 100 cm in height with 6-10 stolons. The leaves are green with yellow margins and green petiole junction. The main vein is green in Y pattern. The petiole is green from top to base with red basal ring. The corm is intermediate and round with white flesh and brown fiber. Maturity is 7-8 months and average corm weight is 400 g. The cooked tuber is bland and starchy.

Fig. 68 a. Samoa 114 corm

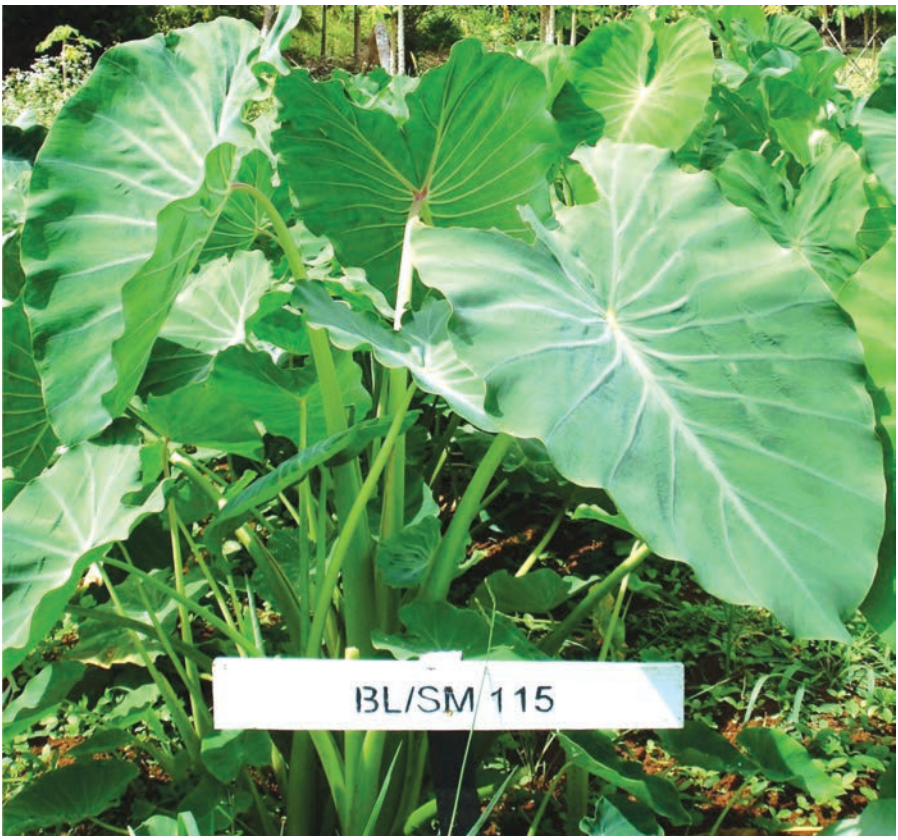

Fig. 69. Samoa 115 / Malaela

This variety is 50-100 cm in height and 6-12 suckers. The leaves are green with yellow margin and small yellow petiole junction. The main vein is whitish in Y pattern extending to secondary veins. The petiole is light green from base to top and white basal ring. The corm is intermediate conical with white flesh color and light yellow fiber. Maturity is 8-10 months and average corm weight is 550 g. The cooked tuber is bland and starchy.

Fig. 70. Samoa 116 / Manu

This taro variety is 50-100 cm in height with 6 to 10 stolons. The leaves are green with purple leaf margin and medium purple junction. The main vein is red in Y pattern extending to secondary veins. The top of petiole is purple and becoming green towards the base with pink basal ring. The corm is intermediate conical with white flesh and pink fiber. Maturity is 7-8 months and average corm weight is 1000 g.

Fig. 70 a. Samoa 116 plants and corms

Fig. 71. Samoa 128 / Nu'utele 2

This taro is 50-100 cm in height with 6 to 10 stolons. The leaves are green with purple leaf margin and purple petiole junction. The main vein is purple in Y pattern. The petiole is purple at the top becoming green towards the base with pink basal ring. The corm is intermediate round with white flesh and white fiber. Maturity is 7-8 months and average corm weight is 550 g. The cooked tuber is bland and starchy.

Fig. 71 a. Samoa 128 plants and corms

Fig. 72. Samoa 151

This taro variety is > 100 cm in height with 11-20 suckers. The leaves are dark green with red leaf margin and large purple petiole junction. The main vein is purple in Y pattern. The petiole is purple at the top becoming green towards the base with white basal ring. The corm is long and elliptical with white flesh and light yellow fiber. Maturity is 10-12 months and average corm weight is 750 g. The cooked tuber is bland and starchy.

Fig. 73. Indonesia 14

This taro is 50-100 cm in height with 11-20 suckers. The leaves are dark green with purple leaf margin and large purple petiole junction. The main vein is purple in Y pattern. The petiole is purple from base to top with red basal ring. The corm is conical with white flesh and white fiber. Maturity is 10-12 months and average corm weight is 650 g. The cooked tuber is sweet and sticky.

Fig. 73 a. Indonesia 14 plants and corms

Fig. 74. PNG 3

This taro is 50-100 cm in height with 6-10 stolons. The leaves are green with purple leaf margin and large yellow petiole junction. The main vein is pink in Y pattern. The petiole is green at the top becoming red towards the base with red basal ring. The corm is intermediate dumb-bell with pink flesh and red fibers. Maturity is 7-9 months and average corm weight is 620 g. The cooked tuber is sweet and sticky.

Fig. 75. Malaysia 12

This taro variety is 50-100 cm in height with more than 20 suckers. The leaves are green with red leaf margin and purple petiole junction. The leaf main vein is white in I pattern. The petiole is green from top to base with white basal ring. The corm is intermediate, elliptical and branched with yellow flesh and white fiber. Maturity is 7-9 months and average corm weight is 163 g. The cooked tuber is sweet and sticky.

Fig. 75 a. Malaysia12 plants and corms

Fig. 76. Malaysia 14

This variety is 50-100 cm in height with 11-20 suckers. The leaves are green with green leaf margin and no petiole junction color. The leaf main vein is white in I pattern. The petiole is green from top to base with white basal ring. The intermediate corm is dumb-bell in shape with yellow flesh and white fiber. Maturity is 7-9 months and average corm weight is 350 g. The cooked tuber is sweet and sticky.

Fig. 76 a. Malaysia 14 plants and corm

Sea Level Rise and Salt Water Intrusion

The Pacific island countries are among the most vulnerable nations in the world to the impacts of extreme weather events. One of the most adverse effect of climate change is increase in air and ocean temperature which have an impact on precipitation, sea levels, winds, tides and other key climatic conditions. As ocean temperatures rise, thermal expansion of ocean waters leads to rise in sea levels causing loss of land, coastal erosion and increased salt water intrusion (Solomon et al., 2007). In the Pacific Islands, the impact of climate change is likely to be more severe and are likely to include food insecurity concerns resulting from reduced food production due to salt water intrusion and soil salinity, excessive rainfall, increased flooding and soil erosion. The mean sea level trends at Malakal in Palau since 1969 has been about 0.2 + 1.8 cm/decade , or a total change of 0.6 + 5.8 cm (Shea, 2001).

The Second National Communications to the UNFCCC for Palau point to three main issues of critical importance namely, drought, intense rainfall and frequent storms, and sea level rise. El Nino brings drought-like conditions to Palau and La Nina higher than average rainfall with more intense and more frequent storms. In 1998, 236 taro patches in 19 states were assessed by the PCAA, IESL and NEMO Office. In these cases crops were seriously affected and consequently, livelihoods of the population (Bishop,R., 2001). Furthermore, as a result of sea level rise, salt water

Fig. 77. Extreme high tide and salt water intrusion into wetland taro patch.

Fig. 78. Salt water intrusion in lowland taro patch during high tide.

inundation is a serious problem that is plaguing farmers especially taro farmers that use the lowlands close to coastal areas. In Palau, there are several taro patches that are being affected by salt water especially during high tide. Even though agriculture in Palau is relatively small scale, contributing only 6.2% of the GDP, there are a lot of small scale taro farms dispersed around the main island of Babeldaob (Bells and Daniels, 2007).

Upland and Lowland Farm Areas in Palau

Upland and lowland farm areas in Palau is 255.1 hectares. Of these, 76 hectares are lowland (*mesei*) areas. A survey conducted by PALARIS showed that 21% equivalent to 16.4 hectares of the total lowland (mesei) areas experience salt water intrusion. This greatly affects food security since these lowland areas are devoted principally to taro production.

Table 3. Upland and lowland farm areas in Palau

State	Upland (Sers)	Area Sq Meters	Lowland (Mesei)	Area Sq Meters	Lowland Salt H20 intruded	Area Sq. Meters
Babeldaob						
Aimeliik	63	400,156.29	20	26,521.29	7	11,290.13
Airai	115	402,785.85	47	83,580.89	13	22,421.78
Koror	71	238,639.42	102	141,223.08	7	6,800.40
Melekeok	34	160,791.72	52	49,701.13	7	27,013.07
Ngaraard	9	55,692.65	78	37,099.93	2	348.58
Ngarchelong	31	53,231.96	64	25,027.83	3	9,379.27
Ngardmau	21	34,394.38	39	32,323.27	3	6,530.05
Ngaremlengui	70	148,462.35	27	18,843.83	3	11,227.06
Ngatpang	36	62,860.18	6	7,837.71	1	2,042.73
Ngchesar	32	185,145.82	34	73,495.29	4	4,894.49
Ngiwal	10	12,813.81	25	24,181.66	20	29,462.03
Total	492	1,754,974.43	494	519,835.91	70	131,409.59
Outer Islands						
Peleliu	24	23,956.04	62	94,523.99	7	6,745.55
Southwest	4	1,900.06	8	115,309.35	1	21,680.53
Angaur	5	8,690.27	1	2,042.73	1	4,028.08
Kayangel	2	573.78	20	29,462.05	2	333.00
Grand Total	**527**	**1,790,094.58**	**585**	**761,174.03**	**81**	**164,196.75**

Prevention of salt water intrusion. In 1998, salt water intrusion associated with abnormally high tides caused extensive damage to taro patches and traditional food supply throughout Palau (Bishop, 2001). Highest tides in Palau normally occur from September through October and every few years some low lying taro patches will experience some damage due to salt water intrusion. But as early as August 1998, large areas of low lying and inadequately maintained taro patches were inundated with salt water (Bells and Daniels, 2002). Salt water in taro patches is detrimental to the growth of taro resulting in crop losses as high as 75 to 100 percent. As a result of this, most farmers have abandoned their taro patches, thus losing production areas.

Main dike and secondary dike. It has been found that with the more frequent high tide occurring recently, dikes were insufficient to prevent salt water from coming into the taro planting area. Thus, there is a need to rehabilitate the dikes in these areas. Taro patches identified as pilot sites with salt water intrusion were in Ngimis, Ngatpang and in Ollei, Ngarchelong. The height of the main dike was increased to prevent salt water from coming in during high tide. Moreover, a strong secondary dike was constructed inside the taro patch to further protect the taro growing area.

Fig. 79. Flooding in Ngimis, Ngatpang, June, 2013

Fig. 80. Increasing the height of the main dike behind the summer house in Ngimis, Ngatpang

Fig. 81. Strengthening the secondary dike around the taro plantings to protect them from salt water, Ngimis, Ngatpang.

Fig. 82. Rehabilitation of the dike with sandbags, Ollei, Ngarchelong

With these remedial measures, it was found that:

- Salt water was coming into the taro patch through holes made by small crabs.
- There was a need to increase the height of the dike based on water level monitoring.
- The use of pipe is not recommended for drainage of water from the taro patch due to clogging with debris and dried leaves.
- Waterways and ditches should be regularly weeded and cleaned to ensure steady flow of water.

Thus, the following recommendations were adopted:

- Increase total height of main ditch to 5 ft and cover the main dike with rubber sheet lining held in place by sand bags
- Increase to 2 ft the depth of water ditch inside and outside the main dike
- Install a gate valve on the northern corner of the taro patch to prevent salt water from coming into the taro parch during high tide
- Construction of secondary dike inside the taro patch is an essential adaptation measure to prevent salt water from coming into the growing taro.

Fig. 83. Construction of the main dike with sand bags and rubber lining in Ollei, Ngarchelong

Fig. 84. Secondary dike constructed to protect the *mesei* in Ollei, Ngarchelong

Fig. 85. Gate valve (14-inch) installed at the northern corner of taro patch, in Ollei Ngarchelong, Dec. 2013.

Evaluation and search for salt tolerant taro varieties. Salinity is a constraint to agricultural production in some coral atoll islands in the Pacific where aroid taro is a staple food (Shannon and Grieve, 1999). On low elevation atolls, rainfall maintains a precarious fresh water lens, which is subject to salt water intrusion during drought or storms. Salinity has been shown to affect early growth and nutrient accumulation in taro (Hill, et al., 1998). Lack of tolerance to salinity may be a factor for declining interest in taro production in favor of imported food and for cultivation of swamp taro (*Cyrtosperma* sp.), another edible aroid that appears to have some salinity tolerance (Manner, 1993). This is seen in the predominance of *Cyrtosperma* in atoll islands such as Kayangel and Peleliu.

Some variability in tolerance among aroid genera (Manner, 1993) and within the genus *Colocasia* (Chang et al., 1984) has been observed. There are about 70 taro varieties being cultivated in taro patches all throughout Palau. Likewise, several varieties of taro hybrids have been introduced from the Secretariat of the Pacific Community Center for Pacific Crops and Trees (SPC-CePaCT) (Del Rosario, 2012).

Thirteen local varieties and 6 introduced varieties were evaluated for tolerance / susceptibility and performance in salt water intruded taro patches in Ngimis, Ngatpang and in Ollei, Ngarchelong. Based on survival and yield, the varieties Kirang, Dirrubong and Dungersuul were found to be salt tolerant as shown by their good survival and performance in salt water intruded taro patch (Del Rosario, 2014).

Fig. 86. Salt tolerant taro varieties Kirang (left), Dungersuul (middle) and Dirrubong (right)

REFERENCES

Bells, Y. and Daniels, E. 2002. First National Communication to the United Nations Framework Convention on Climate Change. Republic of Palau. 90 pp.

Bishop, R. 2001. A Preliminary assessment on damage assessment to taro patches. National Emergency Management Office. Republic of Palau.

Buncle, A. 2013. Informing climate-resilient development: the application of cost-benefit analysis (CBA) in the Pacific Adaptation to Climate Change (PACC) Programme: Experiences and lessons learned in the application of CBA to PACC demonstration projects. SPREP, Apia, Samoa 54 pp.

Chang, H., Siegel, B.Z. and Siegel, S.M. 1984. Salinity induced changes in isoperoxidases in taro, Colocasia esculenta. Phytochemistry 23:233-235

Del Rosario, A.G. , Sengebau, F. and Taro, T. 2014. Salt tolerant taro varieties in the Republic of Palau. Acta Horticulturae. In Press.

Del Rosario, A.G. 2012. Introduction, Evaluation and Identification of Disease and Pest Resistant Taro Hybrids in Palau.

Del Rosario, A.G. and Esguerra, N.M. 2003. Crop profile for taro in the Republic of Palau. PCC-CRE Publication 27/03 26 pp.

Esguerra, N.M. and Del Rosario, A.G. 2007. Economic Entomology in Micronesia. Palau Community College, 214 pp.

Esguerra, N.M. and Del Rosario, A.G. 2006. Control of taro corm rot (obei) in Palau. PCC-CRE Extension Bulletin No. 5. 2 pp.

Esguerra, N.M. and Del Rosario, A.G. 2007. Control of leaf blight disease of taro. PCC-CRE Extension Bulletin No. 6. 2 pp.

Esguerra, N.M. and Del Rosario, A.G. 2005. An insect enemy of the taro leafhopper. PCC-CRE Extension Bulletin No. 3. 2 pp.

Food and Nutrition Research Institute. 1997. The Philippine Food Composition Tables. Department of Science and Technology. Bicutan, Taguig, Metro Manila. Philippines

Hill, S., Abaidoo, R., Miyasaka, S. 1998. Sodium chloride concentration affects early growth and nutrient accumulation in taro. HortScience 33:1119-1135.

IPGRI. 1999. Descriptors for taro (*Colocasia esculenta*). International Plant Genetic Resources Institute, Rome, Italy.

Manner, H.I. 1993. Taro (*Colocasia esculenta* (L.) Schott in the atolls and low islands of Micronesia. Pp. 88-100. In: L. Ferentinos (ed) Proc. Sustainable Taro Cult in the pacific. 24-25 Sept 1992. Univ. of Hawaii. Honolulu.

Manner, H. and Taylor, M. 2011. Taro. In : Elevitch, C. (Ed.) Specialty Crops in the Pacific. Permanent Agriculture Resources, Holualoa, Hawaii. Pp. 431-464.

Marero, L.M. 2012. Taro as Food in Palau. Palau Community College. 78 pp.

Nyman, L.P., Gonzales, C.J. and Arditti, J. 1983. In vitro selection for salt tolerance of taro (*Colocasia esculenta* var. *antiquorum*). Ann. Bot. 51:229-236

Office of Environmental Response and Coordination. 2008. Palau Pacific Adaptation to Climate Change.

Office of Environmental Response and Coordination. 2007. Second National Communication to the United Nations Framework Convention on Climate Change. Republic of Palau. 90 pp.

Shea, E.L. 2001. Preparing for climate change – The potential consequences of climate variability and change. A report of the Pacific islands Regional Assessment Team. East West Center Honolulu. HI.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) 2007. Climate Change 2007: The Physical Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, United Kingdom and New York, NY USA.

Rehuher, Tina and Tellei, Julie. 2015. Personal Communication.

Wall, G. and Wiecko, A.T. 2012. Guam Taro Guide. University of Guam. 38 pp.

About the Authors

Dr. Aurora G. Del Rosario obtained her B.S. Agriculture, M.S. and Ph.D. degrees in Horticulture from the University of the Philippines at Los Banos, Laguna, Philippines. As an Associate Professor at U.P., she taught undergraduate and graduate courses in Horticulture aside from advising undergraduate and graduate students in their thesis research. She also conducted extensive research in coconut, banana, abaca and ornamental and medicinal plant tissue culture. Upon her retirement from the University in 1999, she joined the Palau Community College Cooperative Research and Extension as a Researcher working on Crop Production, Collection and Maintenance of the Root Crops Germplasm in Palau and development of Tissue Culture Technique for the rapid multiplication of taro, banana and other crops. She has done extensive research on the Evaluation of different taro varieties Adaptable under Palauan Environment, Introduction and Evaluation of Pest and Disease Resistant Taro Hybrids, Evaluation and Identification of Salt Tolerant Taro Varieties in Palau, Prevention of Salt Water Intrusion to Taro Patches in Palau. She has travelled extensively, attending conferences and presenting papers about her work on Horticulture.

Dr. Nelson M. Esguerra has extensive work experience in Crop Protection in Micronesia. For more than a decade since 1986 he was assigned at the College of Micronesia based on Pohnpei, covering the Republic of Marshall Islands and the Federated States of Micronesia, including low lying outer atolls. He moved to the Republic of Palau at the end of 1997 and worked as a Researcher at the Palau Community College Cooperative Research and Extension. His work dealt primarily on importing, rearing and releasing biological control agents for control of introduced pests and weeds. He spent many times traveling to remote islands of Micronesia introducing natural enemies of introduced pests and learning how people lived including their cultures and traditions. He holds both M.S. and Ph.D. degrees in Entomology from the University of Hawaii at Manoa, including a B.S. Agriculture degree from the University of the Philippines at Los Banos. He has written many publications including the recently printed book entitled "Economic Entomology in Micronesia" with Dr. A.G. Del Rosario as co-author.

Thomas Taro holds an M.A. Degree in Education from the San Diego State University. As Vice President of the Palau Community College Cooperative Research and Extension, he provides the needed leadership in implementing and coordinating the College of Micronesia Land Grant Programs in Palau.