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PINEAPPLE CULTIVATION GUIDE

KAES

MICRONESIA PLANT PROPAGATION RESEARCH CENTER
KOSRAE AGRICULTURAL EXPERIMENT STATION
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Cover Photograph
Pineapple (*Ananas comosus* cv. Hawaiian thorn-less) at the Kosrae demonstration Plot.

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NOTES

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PREFACE

Agriculture is an important industry that could greatly help in the economic development and growth of Micronesian countries, namely, the Federated States of Micronesia (FSM) and the Republic of the Marshall Islands (RMI).The current agricultural programs remain mostly on a subsistence level in the Micronesian region. FSM is made up of 607 small islands that are spread over a million square miles of the Western Pacific Ocean, with a total land area of only about 271 square miles. The RMI, with a total land area of only 70 square miles, is a nation of low-lying coral atolls that are scattered over three fourth of a million square miles of the central Pacific Ocean.

Frequent natural calamities in form of wave surges, salt water flooding, and drought; along with a lack of sustainable agricultural practices in these Micronesian countries have created a sharp decline in local food production, and an enormous trade imbalance. Very little food is produced at the local level. Most of the food items available at local markets are imported. High shipping costs, along with long transportation times make these imported food items very expensive, unaffordable and inconsumable for average local people. Even after paying high-prices, fresh produce is hardly available. The scarcity of fresh nutritious food has resulted in high rates of malnutrition and vitamin A deficiency, making it crucial to develop sustainable agriculture management systems in the Micronesian region. Educating and training local farmers in the sustainable agricultural production of fruit crops, such as pineapple, that could be grown successfully in island conditions, could greatly contribute in improving food self-sufficiency and overcoming nutritional deficiency in Micronesia.

Pineapple (*Ananas comosus* L. Merrill), the most economically significant plant of the Bromeliaceae family, is one of the most important horticultural crops in the tropical and sub-tropical regions of the world. Mainly grown for fresh and canned fruit and juice, pineapple is the only source of bromelain enzyme that is used in pharmaceuticals and as a meat-tenderizing agent. Popular for its delicious triploid fruit, pineapple is esteemed for its pronounced flavor and nutritive elements. The fresh fruit is very low in saturated fat, cholesterol and sodium. It is also a good source of dietary fiber, thiamin, pyridoxine, copper, and vitamin C and manganese.

This extension publication is intended to provide local farmers and producers with guidelines for the sustainable, climate-smart and organic commercial cultivation of pineapple. It is our hope that this publication will provide current and potential farmers and producers with practical information that will assist them in sustainable cultivation and increased commercial production of pineapple and thereby, lead to improved health and better economic status of local people in the Micronesian region.

Figure 14 Pineapple (*Ananas comosus* cv. Hawaiian): Research trials at Kosrae Demonstration Plot (a); pineapple flowering (b); pineapple fruit development (c) and ripe pineapples (d)

Figure 15 Pineapple (*Ananas comosus* cv. Hawaiian thorn-less): Research trials at Kosrae Demonstration Plot (a); pineapple flowering (b); pineapple fruit development (c) and ripe pineapple (d)

12. Storage

To ensure that normal ripening progresses during and after storage, harvested pineapples should be stored at a temperature between 44-46°F, 80-90% relative humidity with adequate air circulation. A temperature of 40°F and below causes chilling injury and breakdown in pineapples. At best, pineapples may be stored for no more than 4-6 weeks. There is a possibility that storage life might be prolonged by dipping the fruits in a wax emulsion containing a suitable fungicide. Irradiation also extends the shelf life of half-ripe pineapples by about one week.

Figure 13 Pineapple (*Ananas comosus* cv. Kosraean): Research trials at Kosrae Demonstration Plot (a); pineapple flowering (b); pineapple fruit development (c) and ripe pineapples (d)

CONTENTS

INTRODUCTION

The pineapple (*Ananas comosus* L. Merrill) is a perennial, monocotyledonous plant of the Bromeliaceae family. It is an economically significant fruit crop grown worldwide in the tropics for its edible terminal composite fruit consisting of coalesced berries. The fruit of the plant, also called pineapple, is a delicious fruit that has been celebrated for centuries for its distinct and unique taste, miraculous health benefits and medicinal properties. Pineapple is a rich source of many vitamins, and minerals, including copper, potassium, calcium, magnesium, manganese, vitamin C, thiamin, pyridoxine, beta-carotene, and folate, as well as soluble and insoluble fiber and anti-inflammatory enzyme bromelain. The consumption of ripe pineapples improves the respiratory, digestive and immune systems. It cures coughs and colds, strengthens bones, improves oral health, boosts eye health, increases heart health and blood circulation, reduces inflammation, fights off infections and parasites, prevents cancer, and also helps in losing weight (Szalay, 2014).

Considering the commercial importance of pineapple, an interdisciplinary project on the sustainable commercial cultivation of pineapple in Micronesia has been developed. The project is integrating and employing multiple latest tools and technologies such as plant biotechnology, horticulture, microbiology, plant physiology and plant pathology, for the sustainable, climate-smart and organic cultivation of pineapple. The project activities include: in vitro multiplication for producing uniform elite, disease-free pineapple plantlets on mass-scale; greenhouse acclimatization of the multiplied plantlets; top and side-dressings for uniform fertilizer application; the application of organic fertilizers to provide essential nutrients and maintain beneficial soil microorganisms; and appropriate site-specific and climate-smart horticultural, plant physiological and integrated pest and disease management practices.

In vitro multiplication protocols of traditionally-preferred local pineapple cultivars (*Ananas comosus* cv. Kosraean, and *Ananas comosus* cv. Hawaiian) in Micronesia, have been developed and are being utilized for the multiplication and production of elite, uniform and disease-free pineapple plantlets. An efficient nursery management system has also been standardized for the acclimatization of these thousands of tissue culture multiplied plantlets. These disease-free

consumption because the conversion of starch into sugars takes place rapidly only a few days before full maturity.

Figure 12 Sustainable commercial cultivation of pineapple at Kosrae Demonstration Plot: Disease-free seedlings production on mass-scale (a); research trails of sustainable commercial cultivation at Kosrae Demonstration Plot (b, c) and harvested pineapples (*Ananas comosus* cv. Kosraean) from Kosrae Demonstration Plot (d)

11. Ratoon Crops

The plant crop after harvest can be retained as ratoon crop for two more years. After the harvest of the plant crop, chopping the side leaves of the mother plant should be done for easy cultural operations. The suckers retained should be limited to one or two per mother plant. Excess suckers, if any, should be removed. The development of the first ratoon sucker begins when the first crop is harvested after 15-22 months of planting. Plant nutrients are applied and if needed, insect and pest control chemicals are also applied. The second crop is harvested 32-36 months after the initial planting. The same practices are repeated if the crop is kept for a second ratoon, and third crop is harvested 40-44 months after the initial planting. Then the field is cleared to minimize carryover of pests and diseases.

Ants (Associated with mealybugs)	*Pheidole megacephala*, *Iridomyrmex humilis*, *Solenopsis geminata*
Symphylids	*Scutigerella sakimurai*, *Hanseniella unguiculata*

10. Harvesting

In Micronesia, pineapple fruits are harvested 4-7 months after flower initiation or after 15-22 months of planting. Fruit is harvested by bending it over by hand and twisting to remove it from the stalk. Pineapple (*Ananas comosus* cv. Hawaiian) fruit is ripe when the individual eyes become flattened and glossy, and when shell color turns yellow-red or yellow-orange from dark greenish-purple. Pineapple (*Ananas comosus* cv. Kosraean) fruit is ripe when the individual eyes become flattened and glossy, and when shell color turns yellow to yellow-orange from dark-green. Color development for both cultivars starts at the base and moves toward the top. Harvesting before ripening increases postharvest storage life, although harvesting when ripe is preferable for best fresh fruit quality for immediate

Figure 11 Introduction of pineapple (*Ananas comosus* cv. Kosraean, and *Ananas comosus* cv. Hawaiian) in the Republic of the Marshall Islands – Majuro: Pineapple plants plated in 3-gallon pots (a, b), vigorous and healthy vegetative growth of pineapple plants in pots (c) and pineapple fruit development in the potted plants (d)

seedlings are being utilized for the sustainable commercial cultivation of pineapple in the Micronesian region.

Three pilot sites in the Micronesian region, specifically in the Federated States of Micronesia and the Republic of Marshall Islands, are being developed as demonstration plots to carry out research, and showcase, outreach and education activities of the project to encourage and promote sustainable commercial pineapple production among local farmers in the region. Recommendations for sustainable pineapple production are being provided through training workshops, hands-on trainings, farm visits, and field days. The project is providing opportunities for income generation and profitable self-employment to the participating farmers. In addition, it is serving as an excellent example to encourage other farmers and rural communities in successfully adopting the sustainable, climate-smart and organic commercial pineapple production practices.

Figure 1 Kosrae Agricultural Experiment Station

PINEAPPLE CULTIVATION

1. Climatic Conditions

Native to the American tropics, the cultivation of pineapple is limited to low elevations between 30°N and 25°S. The plant is drought tolerant and produces fruit under yearly precipitation rates ranging from 25 to 150 inches, depending on the cultivar, location and degree of

Figure 2 Pineapple demonstration sites: Location of Micronesia in the Pacific Ocean (a); Republic of the Marshall Islands - Majuro (b); Federated States of Micronesia - Pohnpei (c) and Federated States of Micronesia - Kosrae (d)

a. Diseases

Disease	*Pathogen*
Heart and root rot	*Phytophthora cinnamomi*
Heart rot	*Phytophthora parasitica*
Root rot	*Pythium* spp.
Black rot	*Ceratocystis paradoxa*
Butt rot	*Thielaviopsis paradoxa*
Fruitlet core rot	*Penicillium funiculosum*, *Fusarium mondiforme* var. *subglutinans*
Pink disease of fruit	*Acetomonas* spp.
Pineapple wilt	Probably virus
Yellow spot virus	Wilt virus
Bacterial diseases	*Erwinia carotovora*, *Erwinia chrysanthemi*
Nematodes	*Meloidogyne* spp., *Rotylenchulus reniformis*

b. Insect pests

Insect Pests	*Scientific Name*
Scales	*Diaspis bronwliae*, *Melanaspis bronwliae*
Thrips (Vectors of yellow spot virus)	*Thrips tabaci*, *Frankliniella occidentalis*
Mites	*Steneotarsonemus ananas*, *Dolichote-tranychus* (or *Stigmacus*) *floridanus*
Mealybugs	*Dysmicoccus brevipes*, *Dysmicoccus neobrevipes*

ensuring sustainable pineapple production. Phytosanitary measures, such as physical removal of pests, affected plant parts, and of infected plants (virus-infected plants, severely disease-infected or pest-infested plants, including plants affected by wilt) is important to control the incidents.

Common pests infesting vegetative propagules (crowns, slips, suckers) are mealybugs, scale and pineapple red mites. In addition to these pests, the diseases termed heart rot, root rot, fruit rot and butt rot may be major problems when handling, storing or planting fresh materials. Occurrence of these could be minimized by using tissue culture multiplied disease-free pineapple seedlings.

Nematodes, symphylids, mealybugs and wilt affect pineapple plants during the vegetative cycle, while heart rot, root rot, black rot, and butt rot affect pineapple fruits approaching maturity. Nematode infestation by *Meloidogyne* spp. causes the main problem on conventional pineapple plantations. Therefore, proper care should be undertaken.

Rodents feed on fruit and small leaves of crowns and thereby damage the fruit and the crown. Ripened or almost ripe fruits that are not harvested are popular targets of rodents. They also feed on the young fruit causing severe wounds, scarring and perforations that will eventually be rejected at the packing station by the quality control inspectors due to the poor appearance.

Pigs feed on pineapple fruit after removing the fruit from plants. In addition to eating fruit, pigs can injure a large number of plants by eating the hearts of young plants.

Organic plant products and biocontrol agents such as neem oil, neem cake, hot-chilies solutions and recommended predators for insect pests control may be used. Agrochemicals for control of pests and diseases may be used only when all other measures have been exhausted. Chemicals used should comply with the state regulators. Application of chemicals should follow recommended practices and these should be applied only under the supervision of qualified professionals.

atmospheric humidity. With a temperature range of 65-95°F as the most favorable temperature, the plant can be grown throughout the year in Micronesia. Altitude has an important effect on the flavor of the fruit, and between 4500 and 5700 feet, the flavor is most suitable for canning.

2. Soil Characteristics

A well-drained, sandy loam with a high content of organic matter is best for pineapple cultivation. The soil should be friable for a depth of at least 2 feet with a pH within a range of 4.5 to 5.5. Alkaline soils should be treated with sulfur and consistent application of organic fertilizers to achieve the desired pH level. Pineapple plants would not survive waterlogging and if there is impervious subsoil, drainage must be improved. Sandy, red loam, clay loam and gravelly soils usually need organic enrichment.

3. Field Preparation

The field preparation for pineapple is similar to that for most dry land crops. The land should be well prepared at the outset because the pineapple is shallow-rooted and easily damaged by post-planting cultivation. Existing vegetation should be turned under with a moldboard or disc plow, or by spading. Most soils benefit from adding compost at this stage. During soil preparation, potassium fertilizer can also be added, if required. After turning, leave the soil for a few days to allow for decomposition, and then break soil clods by harrowing or rotovating or, with a hoe or rake in small gardens. After the soil has been pulverized, the surface should be smoothed in preparation for pineapple planting. Addition of organic fertilizer such as compost improves tilth, increases soil potassium, and may improve micronutrient availability. If the soil is imperfectly drained, beds at least 10-15 inches high should be formed. If nematodes are present in the soil, it should be sterilized, fumigated, or treated with a nematicide. Fumigation of the soil contributes to high quality and high yields.

4. Preparation of Planting Materials

Traditionally pineapple has been propagated through crowns, slips, suckers and ratoons that are prepared or obtained from the mother plants. Selected planting materials should come from preferred

varieties that are disease and pest resistant, and vigorous and high

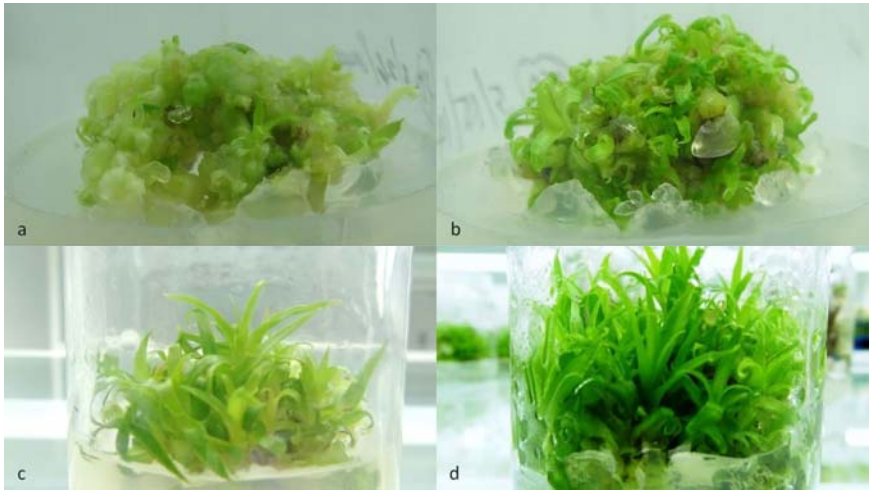

Figure 3 In vitro multiplication of pineapple at Kosrae Agricultural Research Station: Pineapple culture establishment (a); pineapple multiplication (b); rooting in pineapple multiple shoots (c) and complete pineapple plantlets (d)

Figure 4 Mass-scale in vitro multiplication of traditionally-preferred commercially-important local pineapple cultivars (*Ananas comosus* cv. Kosraean, and *Ananas comosus* cv. Hawaiian) (a, b, c d)

8. Weed Control

Pineapple grows slowly, especially in the first 3-4 months after planting. Growth can be greatly slowed by competition from weeds. Yield losses can exceed 50% in extreme cases. Weeds may also serve as 'reservoirs' and reproduction sites for certain pests such as mealybugs, symphylids, nematodes, etc. Weed control is, therefore, essential and must be performed preventatively to minimize their spread and growth. Eradicate weeds by hand pulling or cultivating with a hoe. After the crop has attained the maximum vegetative stage, the lush foliage will shade out weed growth, and cultivation for weed control should be minimized to avoid injuring the roots. When necessary, limited weeding by hand may be carried out in the inter-spaces and around the base of the plant. Weeds can be controlled by black plastic or organic mulch.

9. Insect-Pests and Diseases

Constant and frequent scrutiny of pineapple plantation is necessary to identify any incidences of disease or pest in the crop at an early stage and to take immediate action to control them. Integrated pest and disease management principles need to be applied at all stages of cultivation to maximize productivity and minimize crop loss and for

Figure 10 Bio-insecticide and bio-fertilizers: Neem oil (a); neem cake (b); hot chilies (C) and *Rhizobia* spp. (d)

Figure 9 Organic-fertilizer and application: Hot-composting for reliable and faster decomposition of organic substrates (a); organic fertilizer finished compost ready for application (b) and organic fertilizer application as top dressing (c, d)

usually applied to the soil before planting and later by side dressing. Other nutrients, including K, are sometimes applied as foliar sprays or through the drip irrigation system, or by both methods, during the plant growth cycle. Fruit size and total yield have been enhanced by applying chelated Fe with N; also, where chlorosis is conspicuous, by accompanying N with foliar sprays of Fe and magnesium (Mg).

Pale yellow-green color of pineapple plants is acceptable during the first five months of planting in Micronesia, where the vegetative growth period is 12-15 months. Apply sufficient N to shift leaf color towards a darker yellow-green between 5-8 months and after 8 months, apply enough N to produce dark green plants.

To apply the fertilizer, scrape the soil surface around the circumference of the canopy and apply the fertilizer along with the organic fertilizers with the recommended dosage and then cover it with the soil taken from the inter-spaces. Ensure sufficient moisture availability during fertilizer application. All yellowing should be eliminated before floral initiation.

Figure 5 Mass-scale acclimatization of pineapple (*Ananas comosus* cv. Kosraean, and *Ananas comosus* cv. Hawaiian) plantlets (a, b); Acclimatized pineapple plants in the greenhouse (c) and ready for field transfer acclimatized and disease-free pineapple seedlings (d)

Figure 6 Acclimatization of pineapple plantlets at Pohnpei Agricultural Research Station (a); close-up view of acclimatized pineapple plant showing healthy and vigorous root growth (b) and field transfer of tissue culture multiplied disease-free pineapple seedlings at Pohnpei Demonstration Plot (c, d)

Figure 7 Acclimatization of pineapple plantlets at Majuro Agricultural Research Station (a); Acclimatization of pineapple plantlets at Majuro Demonstration Plot (b, c) and transfer of acclimatized pineapple plants in 3-gallon pots (d)

Figure 8 Proper drainage and soil health management: Raised beds preparation for proper water drainage for pineapple planting at Pohnpei Demonstration Plot (a); and healthy and vigorous pineapple vegetative growth in 2 months at Pohnpei Demonstration Plot (b, c, d)

yielding, with good productivity with respect to the final product. In recent years, owing to the advantages of disease-free planting material along with uniformity in growth and higher yields, the use of tissue culture multiplied seedlings as the planting material for pineapple has become increasingly popular among farmers. Tissue culture multiplied seedlings are planted when they are 15-18 months old.

5. Planting

Considering the frequent and heavy rains, and poor drainage in the Micronesian region, the pineapple seedlings are recommended to be planted in twin rows on raised beds. The plants should be spaced in the rows at 1.5-2.0 feet apart and staggered, not opposite, and with a distance of 3 feet between the two rows. A 6 feet wide alley is to be maintained between pairs of rows.

6. Irrigation

Pineapple is generally a rain fed crop grown and in areas with high rainfall it does not require irrigation if good water management is maintained. Pineapple plantations in Micronesia do not require irrigation under normal conditions, except perhaps during the initial establishment period or in drought prone areas. The plantations should not be allowed to become waterlogged for any extended length of time. For best crop establishment, maintain adequate soil moisture throughout the growing period.

7. Fertilizer Application

Soils should be analyzed for fertility status to determine nutrient requirements for the growth and productivity of pineapples. Pineapple requires good soil fertility. In a tropical climate, it is better to apply small quantities of fertilizer often, rather than to add a large quantity in one treatment. This makes the fertilizer application more profitable and prevents too rapid growth.

Pineapple has high requirements for fertilizer nitrogen (N), potassium (K) and iron (Fe), and relatively low requirements for fertilizer phosphorus (P) and calcium (Ca). Less fertilizer is required during the first five months after planting; requirements increase sharply afterward and peak at two to four months before floral initiation. P and Ca are usually banded in the plant line during bed preparation. K is