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BLACK PEPPER CULTIVATION GUIDE

KAES

MICRONESIA PLANT PROPAGATION RESEARCH CENTER
KOSRAE AGRICULTURAL EXPERIMENT STATION
COOPERATIVE RESEARCH AND EXTENSION
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Cover Photograph
Close-up view of processed black peppercorns (*Piper nigrum* cv. Srilanka) and harvested from the Kosrae demonstration plot.

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To promote sustainable black pepper cultivation in the region, an integrated research, outreach and education project entitled, 'Black pepper micropropagation for elite seedling production: Comparison of local practices and commercial cultivation methods' was financially supported by the United States Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA). This project is of great significance, as it is specifically designed to develop black pepper micropropagation and nursery management systems to produce and ensure the year-round availability of identical, disease-free and high-quality planting material. The objectives of the project include: finding alternative supports to overcome the limitations caused due to shortage of tree ferns, determining appropriate fertilizer type and doses, along with the development and publication of a commercial black pepper cultivation guide appropriate for Micronesia.

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NOTES

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PREFACE

Agriculture is an important industry and it could greatly help in bringing food self-sufficiency and increasing the economic development and growth of the Micronesian region. The Federated States of Micronesia (FSM) is made up of 607 small islands spread over a million square miles of the Western Pacific Ocean, with a total land area of only about 271 square miles. However, current agricultural programs in the country are mostly on a subsistence level, and economic development is largely dependent on the outside world. Serious damage caused by natural calamities such as wave surges, salt water flooding, and drought, continually pose challenge for local farmers. Moreover, a lack of technical know-how and a changing life style and food habits of islanders causing an increase in the consumption of imported foodstuff have led to an overall decline in local agricultural production.

One recent example of such decline in agricultural production is the ceasing of local production of black pepper in Micronesia. Black pepper (*Piper nigrum* L.), a flowering vine of Piperaceae family, is valued for its dried berries called peppercorns, which are used as a spice and for medicinal purposes. Native to the humid jungles of the Malabar Coast of Southwestern India, the plant is cultivated in the tropics worldwide. Black pepper is considered an important cash crop in the Pacific, specifically in Micronesia. Black pepper from Pohnpei, FSM is regarded as a relatively rare commodity of exceptionally high quality. The "Pohnpei Pepper", a pepper product that was unique to Pohnpei was marketed successfully from Pohnpei for a short time. However, its production was ceased before the commercial potential of the product could be tapped fully. Therefore, a research project aiming to foster sustainable black pepper cultivation practices in Micronesia was developed to support local farmers and enhance agricultural productivity of black pepper in the region.

Traditionally in Micronesia, the trunks of two cultivars of a large native tree fern (*Cyathea nigricans*) are used as supports for black pepper cultivation. However, the short life-span of these tree ferns, along with the rapid decline in their population due to increasing use of the tree trunks for construction is becoming a limitation for commercial black pepper cultivation in the region. Considering the extremely limited availability of traditional tree fern supports and their short lifespan,

non-living supports such as reinforced cement-concrete standards have been specifically designed and constructed at the pilot site, to support the vines of fully acclimatized black pepper plants in the field. In addition, raised beds, which ensure perfect water drainage, organic fertilizers for soil amendment along with organic mulching, and automatic fertilizer injectors which provide perfect nutrition, were used for the establishment and maintenance of black pepper plantations.

This extension publication is intended to provide local farmers and producers with guidelines for sustainable, climate-smart and organic commercial cultivation of black pepper. 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 black pepper production in Micronesia, ultimately leading to improved health and better economic status of local people.

harvested, processed and conserved in brine (salt water, vinegar, citric acid).

b. Black pepper

Black peppercorns are produced when mature green berries are harvested, processed and dried.

c. White pepper

White peppercorns are produced when ripe yellow-orange berries are harvested, processed and dried.

Figure 17 Processing of black pepper: Harvested drupes of black pepper from the Pohnpei demonstration plot (a); processing of black pepper at Kosrae Agricultural Experiment Station (b); processed white peppercorns (c); and processed black peppercorns (d)

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.

11. Harvesting

Drupes that are almost mature with all green berries can be picked to process as green pepper. Drupes with one or two berries beginning to turn yellow can be picked to process into black pepper. To process into white pepper, drupes should be fully mature, with one or two ripe yellow-orange berries on each drupe. Drupes should be picked selectively and harvesting rounds should be carried out frequently throughout the year. Harvested drupes of pepper should be handled hygienically, collected and transported in clean and closed baskets for the processing in peppercorns (International Pepper Community, 2008).

12. Processing, Drying and Storage

To ensure high quality, threshing of green pepper berries from the drupes is done manually in Micronesia. Separated green pepper should be washed in clean water to remove field dirt, insects or other contaminants that may be present. Washed cleaned pepper should be soaked for 1 to 2 minutes in water of 194^{o}F temperature to eliminate contaminants. Soaking in hot water would also facilitate drying and improve the appearance of the dried peppercorns. In Micronesia, solar dryers and electric dehydrators are used because of frequent rain and extremely high relative humidity. Black peppercorns should be dried to a moisture level of 10% for long storage. To avoid the loss of volatiles in peppercorns, drying must not be done at temperatures above 131^{o}F.

13. Texture and Color

Different harvesting times and processing techniques could result in various colors and textures of peppercorns (Naturland, 2001).

a. Green pepper

Green peppercorns are produced when almost mature green berries are

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Figure 15 Biotic stresses: Minor diseases affecting black pepper production in Micronesia: Sooty mold (a); scales (b); lichen white stem patch (c) and damage by caterpillars (d)

Figure 16 Bio-insecticide and bio-fertilizers: Neem oil (a); neem cake (b); hot chilies (C) and *Rhizobia* spp. (d)

Organic plant products and biocontrol agents such as neem oil, neem

Figure 13 Biotic stresses: Major diseases affecting black pepper production in Micronesia: *Anthracnose* disease (a); root rot (b) and slow decline (c, d)

Figure 14 Biotic stresses: Minor diseases affecting black pepper production in Micronesia: White thread blight (a); bacterial lead blight (c) and red rust (d)

INTRODUCTION

Black pepper (*Piper nigrum* L.) a flowering vine of Piperaceae family, is valued for its dried berries called peppercorns, which are used as a spice and for medicinal purposes. Native to the humid jungles of the Malabar Coast of Southwestern India, the plant is cultivated in the tropics worldwide. In Micronesia, it is gaining commercial importance as an important cash crop because of premium price. Traditionally, the trunks of two cultivars of large native tree fern (*Cyathea nigricans*) are used as supports for black pepper cultivation. However, short life-span of these tree ferns along with the rapid decline in their population due to increasing use of tree trunks for construction, is becoming a limitation for commercial black pepper cultivation in the region.

An in vitro multiplication protocol for locally preferred and commercially important black pepper cultivar *Piper nigrum* cv. Srilanka was developed and utilized for the multiplication and production of elite, uniform and diseases-free black pepper plantlets in Micronesia. An efficient nursery management system was also standardized for the acclimatization of hundreds of plantlets into uniform and diseases-free seedlings for sustainable commercial cultivation.

In Micronesia, traditionally, the trunks of tree fern (*Cyathea nigricans*) are used as living supports for commercial black pepper vines. These large native tree ferns are important sources of wood and are used for traditional house construction, as well as supports for commercial black pepper cultivation. Out of the two cultivars of the tree ferns that are traditionally recognized, one which produces a red staining juice is preferred over the other cultivar, which produces a greyish juice. The increasing construction in Pohnpei, along with the short life span of the desired tree ferns has resulted in drastic reduction in their lowland population. With newer roads now providing access to several inland locations, the upland populations of tree fern are also threatened (People and Plants of Micronesia, 2014).

Considering the increasing demand for commercial black pepper cultivation and the extremely limited availability of traditional tree fern supports, non-living supports such as reinforced cement-concrete standards have been specifically designed and constructed at the pilot site to support the vines of fully acclimatized black pepper plants in the field. Standards of reinforced cement-concrete (6 inch length, 6

inch width in octagonal shape and 13-15 feet height) were constructed and used as a support for each plant. In addition, raised beds, which ensure perfect water drainage, were used for the establishment of black pepper commercial plantations. To provide perfect nutrition and maintain these plantations, organic fertilizers, along with organic mulching and automatic fertilizer injectors were used for soil amendment.

Thus, this 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 commercial cultivation of black pepper in Micronesia. The

project team is utilizing plant biotechnological techniques such as in vitro multiplication for uniform black pepper plantlet production, greenhouse acclimatization of multiplied black pepper plantlets for elite, disease-free seedling production, automatic fertilizer injectors for uniform fertilizer application, and organic fertilizers to provide essential nutrients and maintain beneficial soil microorganisms along with appropriate site-specific and climate-smart horticultural, plant physiological and integrated pest and disease management practices.

Figure 11 Biotic stresses: Major diseases affecting black pepper production in Micronesia: *Phytophthora* rot (a); *Anthracnose* disease (b) and slow decline (c, d)

Figure 12 Biotic stresses: Major diseases affecting black pepper production in Micronesia: *Anthracnose* disease (a, b); slow decline (c) and stunted disease complex (d)

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 vine.

Figure 10 Abiotic stresses affecting black pepper production in Micronesia: Salt spray (a); salt water intrusion (b); high temperature (c) and excessive rainfall (d)

10. Insect-Pests and Diseases

Nematode infestation by *Meloidogyne* spp. causes the main problem on conventional pepper cultivations. Soil-borne fungi are the most significant cause of disease to black pepper. They possess a wide spectrum of hosts and can affect practically all of the crop types. Therefore, constant and frequent scrutiny is necessary to identify any incidence of disease or pest 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 to maximize productivity and minimize crop loss. Phytosanitary measures, such as physical removal of pests, affected plant parts, infected plants (virus-infected plants, severely disease-infected or pest-infested plants, including plants affected by *Phytophthora* spp. or slow decline or yellow wilt) are important to control the incidents.

Figure 1 Kosrae Agricultural Experiment Station

BLACK PEPPER CULTIVATION

1. Climatic Conditions

Black pepper (*Piper nigrum* L.) originates from tropical, warm, humid latitudes, where temperatures of 77°F and 80-120 inches annual rainfall predominate. Evenly distributed rainfall is ideal. Supplemental irrigation is necessary in dry, low-rainfall areas. Due to its tropical climate and adequate rainfall, pepper can be grown throughout the year in Micronesia.

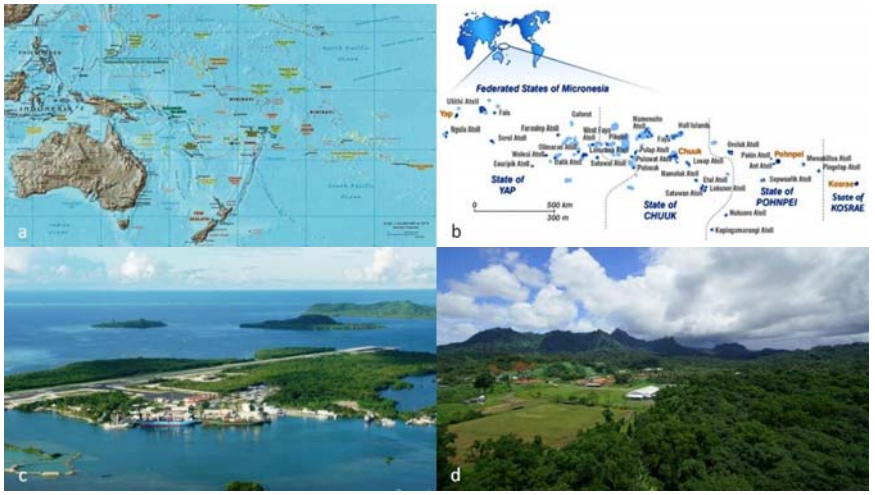

Figure 2 Black pepper demonstration sites: Location of Micronesia in the Pacific Ocean (a); Federated States of Micronesia (b); Pohnpei State (c) and Kosrae State (d)

2. Soil Characteristics

Black pepper can be grown on a wide range of soil types, but best results are obtained on deep, well drained soils with good water holding capacity. The best soil characteristics are sandy loam clay to clay loam with adequate essential plant nutrients and high organic content. Suitable soil pH is between 5.0 to 6.5. A slope not exceeding 10-15^{o} is recommended for better soil conservation, easier harvesting and farm management.

3. Field Preparation

Soil preparation for black pepper is similar to that for most dry land crops such as corn. Existing vegetation is turned under with a moldboard or disc plow, or by spading. Most soils benefit from adding compost at this stage. During cultivation, phosphate 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

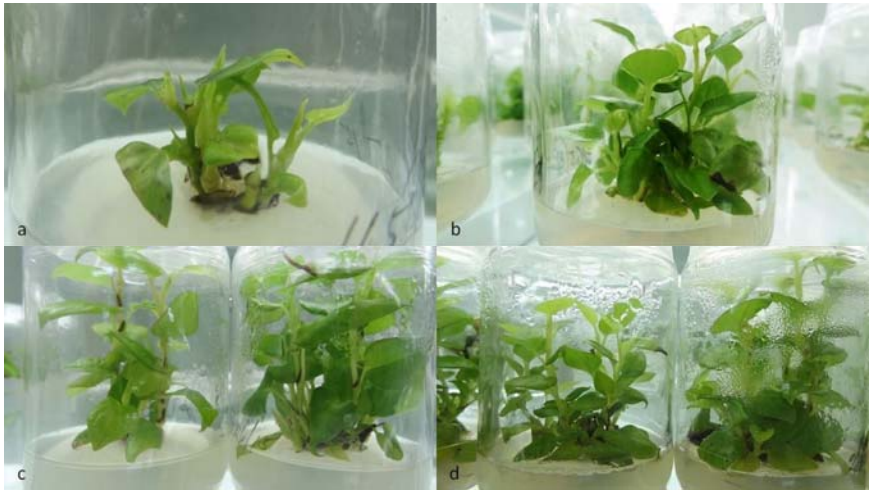

Figure 3 In vitro multiplication of black pepper at Kosrae Agricultural Research Station: Black pepper culture establishment (a); black pepper multiplication (b); rooting in black pepper multiple shoots (c) and complete black pepper plantlets (d)

growth. Black pepper requires good soil fertility. In the first year, organic fertilizers such as compost may be applied at the rate of 4-6 lbs along with 0.25 lbs of inorganic fertilizer such as 12:2:14 Nitrogen, Phosphorus, and Potassium (NPK), plus micro-elements at the interval of 3 months. In the second year, organic fertilizers may be applied at a rate of 8-10 lbs along with 0.50 lbs. of inorganic fertilizer such as 16:16:16 NPK, plus micro-elements at the interval of 3 months. In the third year and onwards, organic fertilizers may be applied at a rate of 10-12 lbs along with 1.0-1.5 lbs of inorganic fertilizer such as 12:12:17 NPK, plus micro-elements at the interval of 3 months.

To apply compost or organic fertilizers, scrape the soil surface around the circumference of the canopy. Apply the fertilizer along with the organic fertilizers with the recommended dosage and then cover it with soil taken from the inter-spaces. Ensure sufficient moisture availability during fertilizer application.

Figure 9 Abiotic stresses affecting black pepper production in Micronesia: Extreme temperature (a); strong wind (b); high salinity (c) and excessive rainfall (d)

9. Weed Control

Black pepper is susceptible to weed competition, especially during the first 8-12 months after planting, when the leaf canopy is being formed. During this time, control weeds by hand pulling or cultivating with a

done 4-6 months after planting. The next pruning is done when the vines are about a year old, and the last pruning when the terminal shoots have reached the top of the standards.

7. Irrigation

Often grown in areas with high rainfall, black pepper is generally a rain fed crop. Black pepper plantations 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 results, maintain soil moisture at or near field capacity (moist but fully drained) throughout the growing period.

8. Fertilizer Application

Soils should be analyzed for nutrition status to determine nutrient requirements for growth and productivity of black pepper vines. 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

Figure 8 Perfect fertilizer application management: Automatic fertilizer injector (a); liquid fertilizer application to each plant at regular intervals (b and c) and healthy and vigorous black pepper vine vegetative growth (d)

Figure 4 Acclimatization of black pepper plantlets and disease-free seedlings production: Acclimatization of black pepper plantlets (a, b); disease-free acclimatized black pepper seedlings in nursery (c) and disease-free seedlings distribution (d)

black pepper planting. Black pepper can be planted on ridges, in furrows, or on flat ground.

4. Preparation of Planting Materials

Traditionally black pepper has been propagated through cuttings that are prepared from main plants. The cuttings consist of the upper 5-7 nodes segments. Selected planting materials should come from varieties that are disease and pest resistant, vigorous and high yielding, with good productivity with respect to the final product. In the recent years, owing to the advantages of disease free planting material along with uniformity in growth and higher yields, the use of tissue cultured plantlets as the planting material for black pepper has become increasingly popular among the farmers.

5. Standards and Planting

Traditionally in Micronesia, the trunks of the tree fern (*Cyathea nigricans*) are used as living supports for commercial black pepper vines. Considering the extremely limited availability of traditional tree fern supports and their very short lifespan, non-living supports such as

reinforced cement-concrete standards are a good alternative. Standards should be planted well before planting black pepper at a depth of 2.0-3.0 feet. The planting pits should have a depth of 1.5 feet and a radius of at least 1.5 feet from the standard. Prior to planting, the soil should be amended adequately with organic fertilizers such as compost. Disease-free seedlings should be planted in prepared pits at the onset of a rainy day or in the evening. Young vines should be tied loosely to the support and shaded with suitable plant material.

Considering the frequent and heavy rains, and poor drainage in the Micronesian region, the black pepper seedlings are recommended to be planted in rows on raised beds. The plants should be spaced in the rows at 8.0 feet apart and a 10 feet wide alley is to be maintained between rows.

Figure 5 Reliable supports, proper drainage and soil health management: Raised beds for proper water drainage (a); durable reinforced cement-concrete standards to support black pepper vines (b); black pepper planting pits 1.5 feet radius from the standard and 1.5 feet deep (c) and amended soil filled around standards (d)

6. Pruning

A couple of rounds of pruning should be carried out during the vegetative phase of vine growth. Initial pruning of terminal shoots is

Figure 6 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)

Figure 7 Healthy and vigorous black pepper vines - One year old after planting (a); black pepper vine pruning (b); black pepper flowering (c); and ready to harvest drupes of black pepper (d)