PLANT TISSUE CULTURE SEEDLING PRODUCTION AND SUSTAINABLE COMMERCIAL BLACK PEPPER CULTIVATION IN THE MICRONESIAN REGION

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Context:

This project is funded by USDA NIFA Distance Education Grant, DEG # 2016 - 70004 - 25867. The College of Micronesia-FSM (COM-FSM) in collaboration with the College of Micronesia Land Grant Program (COM LGP) is producing it. The term RLO is the acronym for *reusable learning object*. It is basically a course developed for a quick reference to current students in agriculture and related sciences; for use by agriculture extension agents, farmers and homemakers, interested individuals, and for lifelong learners. This RLO is posted on the College website and could be downloaded and used by interested individuals. By design, RLO is developed to provide quick and practical reference material in the areas of tropical agriculture and related sciences. Contents of a RLO includes, but are not limited to the following categories:

1. How to address existing issues in Food and Agriculture.
2. Preliminary Result of long term field experience
3. Results of completed field trails
4. Results of demonstration findings
5. Method demonstration findings
6. Local produce and Value-added
7. Health and nutrition survey activities and results
8. Plants and animal quarantine Issues
9. Others

Course Description

This course provides students with an understanding of the basic principles of sustainable commercial pepper cultivation in the Micronesian region such as climatic conditions, soil characteristics, field preparation, preparation of disease-free planting materials, standards and planting, fertilizer application, weed control, harvesting, processing, drying and storage, and texture and color. The course also covers the critical management practices required for field crop production in the Micronesian region to assist students in preparing for a career in agriculture or the agricultural sciences.

Program Learning Outcomes

The student will be able to:

1) Acquire basic concepts and principles of tropical agriculture focusing towards cultivation of pepper in a sustainable and commercial manner appropriate to the Micronesian region.
2) Demonstrate basic competencies in the management of land resources and sustainable pepper production.
3) Acquire basic skills, knowledge and attitude to manage a sustainable pepper production farm or work as agricultural professional.
4) Acquire a related scientific background that will allow transfer to a higher degree program related to tropical agriculture or the agricultural sciences.

Student Learning Outcomes

Upon successful completion of the course, students should be able to:

1) Demonstrate a basic understanding of crop establishment.
2) Describe diseases-free seedling production.
3) Describe aspects of crop management.
4) Explain plant growth and environmental conditions.
5) Demonstrate the knowledge of fertilizer management.
6) Manage planting materials and pepper plantations.

Course 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.

An in vitro multiplication protocol for locally preferred and commercially important black pepper cultivar *Piper nigrum* cv. Srilanka was developed at the Micronesia Plant Propagation Research Center 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.

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 black pepper 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.

Course Content

Climatic Conditions

Black pepper (*Piper nigrum* L.) originates from tropical, warm, humid latitudes, where temperatures of 77^{o}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.

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.

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

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.

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.

Pruning

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

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.

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 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.

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 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.

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.

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.

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.

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.

Texture and Color

Different harvesting times and processing techniques could result in various colors and textures of peppercorns

Green pepper

Green peppercorns are produced when almost mature green berries are harvested, processed and conserved in brine (salt water, vinegar, citric acid).

Black pepper

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

White pepper

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

Quiz

1) Black pepper seedlings are prepared before field planting. (True/False)

2) Black pepper plants need standards or supports to grow. (True/False)

3) Adequate drainage is needed in black pepper plantations. (True/False)

4) Black pepper plants don't need phosphate fertilizer. (True/False)

5) It is better to apply small quantities of fertilizer often, rather than to add a large quantity in one treatment in black pepper plantations. (True/False)

6) How often fertilizer application is suitable in Micronesia for black pepper?
    a. Monthly
    b. Quarterly
    c. Biannually
    d. Annually

7) What is best approach to make diseases-free pepper seedlings?
    a. Seeds
    b. Stem cutting
    c. Tissue culture
    d. Root cuttings

8) White peppercorns are produced when ……. berries are harvested, processed and dried.
    a. Any kind
    b. Green young
    c. Green mature
    d. ripe yellow-orange

9) Processed and dried peppercorns could be stored in dry place at room temperature for ……. years.
    a. Half
    b. One
    c. Three or more
    d. None

10) Organic plant products such as ……. Could be used for insect pests control in pepper plantations.
    a. neem oil
    b. neem cake
    c. hot-chilies solutions
    d. None of the above

Critical Thinking:

How can organic fertilizers be made efficiently on your islands or atolls by utilizing locally available resources and how you could store prepared organic fertilizers properly and utilized them to meet nutritional requirements of sustainable commercial black pepper cultivation?

References

1) Elevitch, C.R. (2011). *Specialty Crops for Pacific Islands*. Permanent Agriculture Resources Hawaii.
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3) Verma, V.M. (2018). *Black Pepper Cultivation Guide*. College of Micronesia Landgrant.