Plant propagation in the Micronesian region: challenges and measures for sustainable production©

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Abstract

This paper reports on plant propagation of select staple and cash crops in the Micronesian region. While discussing various climatic, socio-economic and technical issues that limit agricultural production, the paper emphasizes the feasibility of plant tissue culture techniques for sustainable plant propagation in the region. The findings include development of successful in vitro plant propagation methods and field transfer techniques for regional cultivars of banana, taro, cassava, sweet potato, pineapple, and black pepper. Plant propagation systems developed for crops at the Micronesia Plant Propagation Research Center serve as a foundation for establishing sustainable agriculture practices and attaining food self-sufficiency in Micronesia.

INTRODUCTION

Agriculture is an important industry and it could greatly help in the economic development and growth in the Micronesian region. Micronesia, lying just on the Equator, enjoys a tropical climate with relatively even, warm temperatures throughout the year. Rainfall is generally plentiful reaching up to 330 in. of rain per year. Nevertheless, drought conditions do occur periodically throughout the Micronesian region, especially when the El Niño condition moves into the western Pacific. At these times groundwater supplies even dwindle to emergency proportions. Tropical typhoons constitute an annual threat, particularly to the low-lying islands. Increasing climate variability has resulted in harsh weather calamities in the form of wave surges, salt water flooding and drought that continually pose challenges for the local farmers who struggle to attain food self-sufficiency by growing crops on their small household farms.

The common food crops in the region include: breadfruit, banana, taro, cassava, yam, sweet potato, pineapple, and citrus. The cash crops include: black pepper, kava, coconut, coffee, and noni. Limited farming, occurring mostly in the form of small farms developed at individual family level with inadequate access to appropriate agricultural resources and trained professional advice along with the frequent climate surges in the region, render the agricultural production of these crops insufficient for supporting the island communities.

Even though Micronesia is free of major insects, pests and pathogens, crop yield is not sustainable in the region. Continued use of traditional planting materials such as suckers, runners and cuttings without any decontamination or revival for years, and lack of knowledge of phytosanitary measures has resulted in pathogen accumulation in locally grown crops. The possibility of procuring seedlings is often obscure because of cost ineffectiveness. Moreover, the quarantine measures are very strict and entry of any planting material is strictly prohibited. Thus, the non-availability of disease-free and elite seedlings has become one of the major bottlenecks in quality production of vegetatively propagated staple and cash crops in the Micronesian region.

Considering the difficulty to maintain disease-free parental stocks in the tropical islands, plant tissue culture is increasingly being appreciated as a potential means of germplasm preservation and production of elite and disease-free planting materials on a mass scale. The Micronesia Plant Propagation Research Center (MPPRC) plays a vital role in germplasm collection, in vitro multiplication, distribution, and conservation of economically

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important staple and traditional medicinal and cash crops in the region. Directed under the United States Department of Agriculture Land-Grant Program, the MPPRC is the only North-Pacific regional facility that is actively engaged in plant biotechnology research, extension and outreach in the region. This paper will share the impact and outcomes of some of the major research projects that are successfully undertaken by the MPPRC and have served as the foundation for developing sustainable agriculture practices in the region.

MATERIALS AND METHODS

Plant material

Healthy explants of traditionally-preferred regional cultivars and selected salt tolerant cultivars of banana (*Musa* species), taro (*Colocasia esculenta* L. Schott and *Cyrtosperma merkusii* H. Schott), cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas* L. Lam.), pineapple (*Ananas comosus* L. Merrill) and black pepper (*Piper nigrum* L.) were collected from the field and were thoroughly washed with running tap water prior to surface sterilization by immersion in 70% ethanol followed by a treatment with 2% sodium hypochlorite solution with 5 drops of Tween 20. Apical and/or axillary meristems were excised from sterilized explants for in vitro culture establishment.

Culture medium

Murashige and Skoog (1962) medium (MS medium) supplemented with different concentrations and combinations of growth regulators was used as a basal medium for establishing aseptic cultures of all crops. All media contained 0.8% agar and 3% sucrose. The pH was adjusted to 5.8 prior to autoclaving.

Micropropagation

Aseptic cultures of all collected cultivars were established for multiplication on MS medium supplemented with different concentrations and combination of cytokinins such as thidiazuron (TDZ), 6-benzylaminopurine (BAP) and 6-furfurylaminopurine (KIN) and auxins such as 2,4-dichlorophenoxyacetic acid (2,4-D), indole 3-acetic acid (IAA) and 1-naphthaleneacetic acid (NAA). MS media augmented with IAA or without any growth regulator were used to induce rooting in multiple shoots. Each experiment was replicated three times with minimum 30 replicates per treatment. Complete plantlets were transferred onto sterilized potting mix for acclimatization in the greenhouse for 1-4 months. Completely acclimatized plants were transferred in the screen house where they were kept until field transfer. A one-way analysis of variance was used to determine the level of significance between experimental treatments in all crops. Statistical significance of the results was determined using the least significant difference (LSD) test by Tukey (1953) at 5% level of significance.

RESULTS AND DISCUSSION

Micropropagation methods were developed or optimized for banana (5 µM BAP - Verma, 2008, 2009, 2010), taro (5 µM TDZ or 5 µM IAA and 7.5 µM BAP - Verma, 2008, 2010, 2013; Verma and Cho, 2010), cassava (1 µM BAP), sweet potato (5 µM KIN - Verma, 2008, 2010, 2013), pineapple (9 µM BAP or 2 µM NAA), and black pepper (8 µM BAP or 3 µM IAA)(Figures 1A, B, D, G, I, J, and N). Disease-free and elite seedlings of traditionally-preferred regional cultivars and salt tolerant cultivars of some crops were produced in bulk quantities to ensure the year round availability of high quality planting material. More than 95% survival rate was observed for all crops after 8 weeks of acclimatization in the greenhouse. Acclimatized plants exhibited healthy growth in the nursery where they were kept until field transfer (Figures 1C, K and O). Upon transfer of fully acclimatized plants into the field, healthy and vigorous growth was observed (Figures 1H and L) and excellent and healthy yield was obtained after harvest (Figures 1E, F, H, L, and M).

Figure 1. Taro micropropagation (A and B), taro acclimatization (C), sweet potato micropropagation (D), harvested sweet potatoes (E and F), black pepper micropropagation (G), black pepper cultivation (H), banana micropropagation (I), cassava micropropagation (J), cassava acclimatization (K), banana cultivation (L), harvested pineapples (M), pineapple micropropagation (N), and pineapple acclimatization in greenhouse (O).

Development of successful micropropagation methods of various food and cash crops at the MPPRC reaffirms that tissue culture is of great advantage for mass propagation of vegetatively propagated crops for which traditional breeding methods are time-consuming and disease-free planting materials are in short supply. Advantages of in vitro propagation include: a high plant multiplication rate, physiological uniformity, the availability of disease-free material throughout the year, and safe and rapid dissemination of new salt tolerant plant germplasm (Food and Agriculture Organization, 2010; Verma, 2013).

CONCLUSION

Development of in vitro multiplication methods for traditionally preferred regional cultivars of banana, taro, cassava, yam, sweet potato, pineapple and black pepper through projects run by the MPPRC provide an effective rapid method of plant propagation in the Micronesian region where procuring disease-free seedlings is a major hurdle for sustainable agriculture production. In vitro propagation of these staple food and cash crops through tissue culture provides an excellent advantage over traditional propagation methods and serves as a first step towards developing sustainable agricultural practices to ensure food

self-sufficiency in the Micronesian region.

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