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Field Evaluation of Tissue-Cultured Banana in the Northern Mariana Islands

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ABSTRACT

Bananas are widely grown in the Commonwealth of the Northern Mariana Islands and are an important food crop for domestic consumption. The objective of the present study was to evaluate new varieties of banana (tissue-cultured) in the local soil and climatic conditions of the Commonwealth. The study was conducted during 2007 to 2010 seasons at the Northern Marianas College-Cooperative Research, Extension and Education Services experimental farm in As Perido, Saipan. The number of suckers/mat, plant height, bunch weight, number of hands/bunch, stem diameter, color, and maturity were determined. Mean suckering rate/mat ranged from 4.0 to 6.6 during the initial harvesting cycle. 'Robusta', 'Dwarf French Plantain' and 'FHIA17' varieties were recorded as dwarf (180 cm tall) and 'Saba', 'Daru', 'Yawa2' were the tallest varieties (360 cm). 'High Noon' observed the longest cycling time (15.7 months) compared to 'Pesang ceylon' (12.5 months). Bunch weight was varied considerably with accession, ranging from 7 kg for 'Pesang ceylon' to 25 kg for 'Robusta'. Girth or stem diameter of the pseudostem was also significantly different among varieties. 'Daru', 'Yawa2' and 'Saba' demonstrated the largest diameter, 90.2, 90.0 and 89.0 cm, respectively. 'Yawa2' produced a high number of fruits (fingers), 142/bunch. The susceptibility of the varieties to yellow or black Sigatoka and Panama (Fusarium wilt) diseases was assessed based on visual evaluation of disease severity. Results indicate that all introduced varieties, cooking or dessert, performed well under the soil and climatic conditions of the CNMI.

Keywords: CNMI, *in-vitro*, propagation, variety trials, yield

Abbreviations: CNMI, Commonwealth of the Northern Mariana Islands; **CePCT**, Center for Pacific Crops and Trees; **CREES**, Cooperative Research, Extension and Education Service; **CSREES**, Cooperative State Research, Extension and Education Service; **NMC**, Northern Marianas College; **SPC**, Secretariat of the Pacific Community; **TC**, Tissue Culture; **USDA**, United States Department of Agriculture

INTRODUCTION

Bananas and plantains are cultivated in over 100 countries throughout the tropical and sub-tropical regions of the world and grown over 10 million ha, with an annual production of around 88 million metric tones, of which approximately one third is produced in each of the African, Asia-Pacific and Latin America and Caribbean regions (Sharrock and Frison 1999). *Musa* sp. cultivars vary greatly in plant height, fruit size, plant morphology, fruit quality and disease and insect resistance (Ayala-Silva *et al*. 2009). Banana and plantain are popular fruit throughout the tropics and are a good source of potassium while low in sodium (Ramcharan and George 1999).

Bananas are widely grown in the Commonwealth of the Northern Mariana Islands (CNMI) and are an important food crop for domestic consumption. Export of bananas to the neighboring island of Guam is increasing and the market is expected to expand. There is also a growing market for banana products, which command a premium price in niche markets. Over a dozen cultivars of banana are grown in the CNMI, which vary greatly in plant and fruit size, morphology, fruit quality, disease and insect resistance (Nandwani 2010).

This paper describes variety trials of banana conducted over three years, from 2007 to 2010, in the Northern Mariana Islands. Tissue-cultured plants of 14 new varieties were introduced into the CNMI from the Center for the Pacific Crops and Trees (CePaCT), Secretariat of the Pacific Community, Fiji. Variety trials and field evaluation experiments were conducted at the As Perdido Agriculture Experiment Station of the Northern Marianas College-Cooperative Research, Extension and Education Service (NMC-CREES) in Saipan. The objective of the research was to investigate the adaptability of new varieties to local soil and climate conditions of the CNMI. All 14 new varieties were evaluated for their superior agronomic characters such as high yielding, disease and pest resistance, growth and taste. All new varieties, cooking and dessert (eating), completed three crop cycles successfully.

Cavendish and plantain are the local varieties of banana grown for domestic consumption and export to neighboring islands. CNMI's tropical climate is ideally suited for the production of banana. However, the crop is affected by a host of factors including an increase in the incidence of pests and diseases, weeds, soil infertility, poor and lack of availability of planting materials, limited genetic diversity, natural disasters, animal damages, sea water intrusion into the basal water lens (Nandwani 2010). The number of farms growing bananas increased from 87 in 2002 to 119 in 2007; however, production declined from 98,248 kg in 2002 to 66,791 kg in 2007 (CNMI Census of Agriculture 2009).

MATERIALS AND METHODS

The NMC-CREES Crop Production team periodically visited the field on the three islands of the CNMI (Saipan, Rota and Tinian) to survey local banana varieties. Samples of fruits, suckers and flowers (male buds) were brought to Saipan and identified with the assistance of the community, extension agents, or by sending pictures to regional experts.

The field trials were conducted at the As Perdido farm in Sai-

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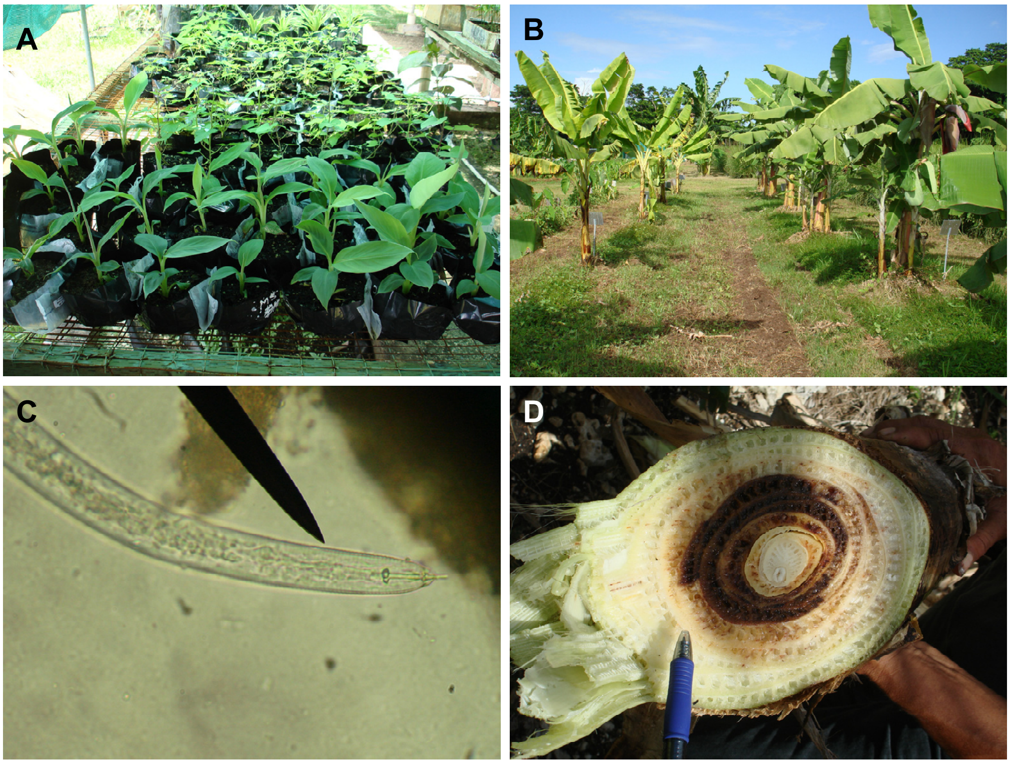

Fig. 1 (**A**) Tissue culture banana plants in the nursery (2 weeks). (**B**) Banana variety trials field plot at the As Perdido farm. (**C**) Banana nematodes (*Radopholos* sp.). (**D**) Pseudostem infected with *Fusarium wilt* (Panama disease).

pan. The soil is volcanic in nature with limestone and calcareous deposits. It consists of a well-drained soil, rich in organic matter (5-6%) with a pH ~6.2-7.5, depending upon the area. Average annual precipitation is approximately 1500 mm with wet season generally lasting from June to November and the dry season lasting from December to May.

The land was cleared of trees, shrubs, grasses and rocks at the farm. Fertilization and cultural practices were performed as recommended for banana production in general (Robinson and de Villiers 2007). Fertilizer doses (16:16:16) were hand-spread except when basal dressings were incorporated during land preparation. Applications in practice are often concentrated within a circle of 1.0-1.5 m diameter around the pseudo-stem, or (after flowering) in a crescent shape around the daughter plants.

Tissue-cultured plants of 14 new varieties were obtained from the Centre for Pacific Crops and Trees (CePaCT) of the Secretariat of the Pacific Community (SPC), Fiji in 2007. Hardening and transplantation of tissue-cultured plants upon receipt of shipment from the center was described by Nandwani (2010).

At the As Perdido farm, well-hardened plants (**Fig. 1A**) were planted at a 180-cm within-row spacing and a 330-360 cm distance between rows (**Fig. 1B**). Each replication of variety contained three plants. Planting holes of 150 × 150 × 150 cm were dug and a layer of topsoil (ACE hardware, Saipan) was placed into the planting hole and the hole was refilled with soil after planting. The plots were weeded with lawn mowers, and neem leaf extract was applied as needed to control insect pest and diseases.

Preparation of neem extract for insect pest control

Fresh, young, green and tender leaves collected from field-grown neem (*Azadirachta indica*) trees growing at the As Perdido farm, Saipan. One-pound of leaves was washed, cleaned, dried and blended in a blender with water (1 liter). The extract was covered with cotton cloth for three days after which the extract was filtered to obtain a clear liquid. This liquid was diluted 1:3 (extract: water) and two tablespoon of dishwashing soap (Joy, Joeten, Saipan) were added. The extract was applied to plants three times/week.

The experimental field was microirrigated weekly and standard fertilization practices (16: 16: 16, NPK) were used for the duration of the field evaluations. Plants were labeled and tagged. Data was recorded on flower emergence, plant height, pseudostem diameter (thickness), number of suckers produced by each plant, color of pseudostem and petiole. Yield measurements and assessments of bunches were made on all plants. Fruit bunches were harvested when the fingers were green and reached maturity (width). Number of hands, fingers/hand, and bunch weight were recorded at the time of harvest. Yields were based on fresh bunch weights and reported yields were cumulative for the replicates. The field plot was scouted by an entomologist and data on disease and insect pest infestation was recorded. The susceptibility of the varieties to yellow or black Sigatoka and Panama (Fusarium wilt) diseases was assessed based on visual evaluation of disease severity. Harvested plants were cut at the ground level and the largest sucker was retained to grow the ratoon crop and for the second cycle of fruiting in each variety. Accessions were randomized, replicated three times with replications being single plants. Variety, origin, genome/ploidy level and accession numbers, synonyms and usage for cooking bananas are shown in **Table 1**.

Management of experimental field

Dead leaves from the field were periodically removed. One or two strong suckers were kept for ratooning and weeding on a regular basis with a hoe. Infected leaves were pruned to reduce the amount of inoculum of leaf disease. Dried and diseased leaves were cut once a month and leaves with less than 50% affected, were trimmed. Fruit bunches appeared at the top of the plant in about 9-10 months. Then, male buds were cut off at the end of the bunch after bunches began to mature. Fruits were bagged to protect from pest damage and injuries. This was done when the last hand in the bunch had fully emerged. Bunches were covered with perforated plastic to keep out diseases from infecting fingers. Fruit bunch-bearing plants were supported with a forked pole (propping) and mulch was added around the plant with mowed grass, leaves, etc.

RESULTS AND DISCUSSION

The 14 introduced varieties were highly significant for all traits measured. The means of all accessions were compared; most accessions were statistically different from one another for most of the traits measured.

Mean suckering rate/mat ranged from 4.0 to 6.6 during the initial harvesting cycle. Height at fruiting and cycling

Table 1 Growth characteristics of introduced varieties in the CNMI.

Variety	Plant height (cm)	Girth (stem diameter) (cm)	Maturity* (months)	Pseudostem color and number of leaves	Color of petiole channel
Saba	12’5”	89.0	15.5	Green w/brown spot, 9	Light brown
Robusta	5' 9"	60.1	15.0	Light green and brown spots, 10	Light red
Dwarf French Plantain	5’6”	50.7	15.2	Red-brown with spots stem, 8	Dark red
High Noon	7' 8"	70.1	15.7	Green-brown stem, 9	Light red
FHIA 02	8’	62.0	14.0	Green-brown with spots (light red when young), 9	Light red at the edge
FHIA 03	9' 1"	70.4	13.5	Green, 10	Light red
PA12.03	6' 5"	60.9	13.0	Green-brown (red when young) stem, 10	Light red at the edge
Pacific Plantain	7'	70.8	13.7	Red stem, 8	Red
FHIA 17	5' 2"	40.6	14.2	Light green/brown, 7	Dark red
Daru	13' 9"	90.22	15.0	Green w/brown spot below petiole stem, 11	Light brown
Yawa 2	12' 10"	90.0	13.7	Green w/brown spot below petiole, 10	Light brown
Pisang ceylan	9'	50.4	12.5	Gold brown with spots (red when young), 8	Light red at the edge
FHIA 21	10’	50.3	13.2	Light green-brown, 8	Dark red stripes
Williams	7' 5"	50.5	14.0	Light brown with dark brown spots, 8	Light red

*Maturity period (months) is when fruit bunch harvested (0.2, 0.5 and 0.7 values represents 1, 2, and 3 weeks after full month).
**Flowering to harvesting is about 3 months

Table 2 Yield characteristics of introduced varieties in the CNMI.

Variety	No. of hands/ bunch (mean)	Bunch weight (LB) (mean)	No. of fingers/ bunch (mean)	Ratoon (months)	Suckers/mat (mean)
Saba	8	35	128	8	4.6
Robusta	12	55	102	4	6.6
Dwarf French Plantain	5	35	60	5	4.3
High Noon	7	25	80	5	6.3
FHIA 02	9	50	78	5	4.0
FHIA 03	7	45	92	6	4.6
PA12.03	5	21	53	4	5.3
Pacific Plantain	6	43	31	7	5.6
FHIA 17	11	42	85	5	5.3
Daru	8	52	123	8	6.3
Yawa 2	10	35	142	9	6.6
Pisang ceylan	7	15	65	5	4.0
FHIA 21	8	18	84	5	4.3
Williams	8	16	63	5	5.3

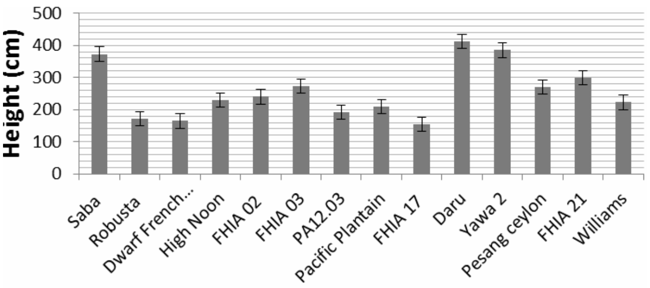

Fig. 2 Plant height of banana varieties.

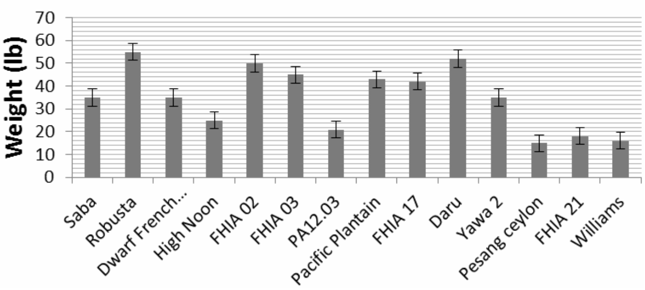

Fig. 3 Fruit bunch weight of banana varieties.

time varied significantly among varieties (**Table 1**). Dwarf varieties around 180 cm tall were ‘Robusta’, ‘Dwarf French Plantain’ and ‘FHIA17’ (**Fig. 2**). ‘High Noon’, ‘FHIA 02’, ‘PA12.03’, ‘Pesang ceylan’ and ‘Williams’ had medium height (210-270 cm tall). ‘Saba’, ‘Daru’, ‘Yawa2’ were the tallest varieties and grew up to 360 cm in height. Cycling time varied from 15.7 months for ‘High Noon’ to 12.5 months for ‘Pesang ceylon’. Bunch weight varied considerably with accession, ranging from 7 kg for ‘Pesang ceylon’ to 25 kg for ‘Robusta’ (**Table 2, Fig. 3**). Girth or stem diameter of pseudostem was also significantly different among varieties. ‘Daru’, ‘Yawa2’ and ‘Saba’ demonstrated the largest diameter, 90.2, 90.0 and 89.0 cm, respectively. ‘FHIA 17’ had the least diameter, 40.6 cm. Mean total number of fingers (fruits) were highly significantly different for ‘Yawa 2’, ‘Saba’ and ‘Daru’ with 142, 128 and 123 total fruits, respectively. ‘Pacific Plantain’ produced the fewest number of fruits/bunch (31). Mean total number of hands/bunch was highly significant for ‘Dwarf French Plantain’ and ‘PA12.03’ demonstrated lowest number of hands with (5) followed by ‘Pacific Plantain’ (6), ‘Pisang Ceylan’ and ‘High Noon’ (7). ‘Robusta’ (12) and ‘FHIA 17’ (11) produced the highest number of hands/bunch. Important morphological characters, pseudostem color and color of petiole channel, were recorded for all 14 varieties. Most of the varieties had a green-brown pseudostem and a red-brown petiole. ‘Pacific Plantain’ had a distinguished dark red pseudostem with an all-red petiole channel. The number of leaves produced at flowering varied from 7 in ‘Robusta’ to 12 in ‘Daru’.

The advantages of *in vitro* micropropagation of banana include higher rates of multiplication, production of clean, or disease-free, planting material, and the small amount of space required to multiply large numbers of plants (Vuylsteke and Ortiz 1996). For ‘Giant Cavendish’, tissue-cultured plants generated clones with increased resistance to Fusarium wilt, strong wind, and heavier fruit bunches, and sweeter fruit (Hwang and Ko 2004). Micropropagated ‘Malbhog’ banana plants (*Musa paradisiaca*, AAB group) were genetically uniform (Roy *et al.* 2010). Kulkarni *et al.* (2006) successfully regenerated commercially important and endangered Indian banana cv. ‘Rajeli’ through multiple shoot formation and somatic embryogenesis. The effect of gamma radiation on micropropagated dwarf Cavendish banana resistant to race 4 Fusarium wilt was reported (Smith *et al*. 2006). Five varieties of cooking bananas were evaluated under calcareous soil and irrigation conditions in Florida (Ayala-Silva *et al*. 2009). Wairegi and van Asten (2010) conducted a study aimed to explore the possibility of increasing yield through the use of fertilizer and mulch, and to evaluate the benefits of these inputs across the major banana-producing regions in Uganda. Gaidashaovaa *et al*. (2010) reported the effect of toposequence-related variations in soil on banana yields, foliar nutrient status, and nematode impact. A comparative experiment on field performance of new banana varieties was conducted by Guo *et al*. (2011).

In the current study, all 14 varieties (cooking or dessert) performed well under the given soil and climatic conditions of the CNMI with minimal irrigation. The susceptibility to diseases such as black or yellow Sigatoka and Fusarium wilt recorded on visual observation (**Fig. 1C, 1D**). Nematode damage observed at miner level in some roots. The new varieties could be used as a source of cooking bananas, value-added products such as banana chips, gems, cookies or for ornamental use. Several hundred plants of new banana varieties are propagated *in-vitro* and distributed to the farming community throughout the CNMI.

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