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EVALUATION OF NEW BANANA GERMPLASM IN SOUTH FLORIDA

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Abstract. **Banana has been grown in Florida for over 100 years, and continues to rank as one of the most important tropical fruits that are grown in southern portions of the state. Commercial production faces several obstacles, the most important of which are poor soils, low winter temperatures and diseases, in particular fusarium wilt. From 1996 to 1998, the performance of 35 new dessert and cooking accessions was evaluated under South Florida conditions. Their agronomic characteristics and resistance to fusarium wilt were determined in field studies at the Tropical Research & Education Center (TREC) of the University of Florida, and the appearance and taste of their fruit were evaluated by informal taste panels. Four of seven dessert and four of eight cooking clones resisted fusarium wilt and produced high yields of acceptable fruit. Some of the most popular and productive clones were susceptible to fusarium wilt and are not recommended for production in areas that have a history of this disease. The relative merits of the best clones are discussed below.**

Banana, *Musa* spp., has been produced commercially in Florida for well over 100 years (Stambaugh, 1952). The earliest plantings extended as far north as Jacksonville and as far south as Miami Beach. Many of the plantations were highly successful, and fruit were shipped as far away as the Bahamas and Chicago. Profits from some operations were used to establish early citrus plantations in the state. Although the volumes of fruit that were produced and the areas that were devoted to production during the early years are not known, Stambaugh's (1952) record of an ". . . enterprise . . . worth millions. . . ." in an area between Bartow and Winter Haven in 1925 suggests that some of these plantings were large.

Although Stambuagh (1952) suggested that Florida banana producers could compete with the tropical export trades, it is unlikely that this has ever been possible. The Cavendish clones that are currently used by the trades can be produced more efficiently and less expensively in tropical America than in Florida. Rather than compete for Cavendish-based markets, Florida producers grow other cultivars. In general, these cultivars produce fruit that are appreciated in Florida and other states for their different tastes or cooking qualities. Production is now centered in southeastern Miami-Dade County where about 140 hectares produce fruit valued at over \$2½ million year^{-1} (Crane, 1997; Degner et al., 1997).

Currently, two cooking cultivars, 'Bluggoe' (known locally as 'Burro' or 'Orinoco') and 'Hua Moa' ('Hawaiiano'), and two dessert cultivars, 'Mysore' and 'Silk' ('Apple' or 'Manzano'), are most important in Miami-Dade. Each of these clones is less than ideally adapted to conditions in southern Florida. 'Bluggoe', 'Hua Moa' and 'Silk' are susceptible to fusarium wilt, a lethal disease that is now widely spread in the area. 'Hua Moa' is also intolerant of low temperatures, and is affected by post-harvest problems (e.g., finger rot caused by *Lasiodiplodia theobromae*) and a yield-decline phenomenon that may be caused by nematodes (Ploetz, unpublished). Although 'Mysore' possesses good resistance to fusarium wilt, clones of the cultivar in South Florida are infected with banana streak virus (BSV).

In 1995, 37 new dessert and cooking accessions were introduced for evaluation in South Florida. This paper describes the performance of these clones from 1996 to 1998 at the University of Florida's Tropical Research & Education Center (TREC) in Homestead. A preliminary description of this work was published previously (Ploetz and Benscher, 1996).

Materials and Methods

Most accessions in Table 1 originated in the International Transit Center (ITC) at the Katholieke Universiteit in Leuven, Belgium. The ITC collection is the largest in vitro assemblage of banana germplasm in the world and is supported by the International Network for the Improvement of Banana and Plantain (INIBAP). Five accessions were from the Queensland Department of Primary Industry (QDPI) in Maroochy, Australia.

Accessions were multiplied via tissue culture in Dr. Mike Smith's QDPI laboratory in Maroochy. In the fall of 1995, the micropropagated germplasm was shipped, under APHIS permit, from QDPI to TREC. Upon receipt, plantlets were removed from vials, their roots washed to remove tissue culture medium, and transplanted in Speedling trays (1" cells) filled with microwaved, commercial potting mix (Reliable Peat, Miami). Plantlets were hardened off under Cool-White fluorescent lights in the laboratory for 2 days before they were moved to a shade house. After 2 months, they were transplanted in 1-gallon polybags filled with potting mix.

Two accessions, 'Niyarma yik' and 'Rimina', a Fe'i banana, were cold sensitive and killed in the shade house when temperatures fell to 2 C during the winter of 1995/1996. Thus, they were not included in studies that are described below.

Cultivar evaluation trial. On 20 May 1996, 35 accessions were planted in a completely randomized design in a field at TREC (Table 1). Each accession was replicated seven times, and a replicate consisted of a pair of plants. Rows were planted on raised beds, about 0.2 m in height, that were aligned from east to west and 4.5 m apart. Within rows, plants were separated by 2.5 m. Irrigation of this and the fusarium wilt experiment that is described below was conducted as needed, and fertilization followed standard recommendations for the area.

Beginning 4 months after planting, suckering and height of the accessions were recorded on a monthly basis. Ultimate-

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Table 1. Cultivar, genome and accession codes for new banana accessions and the experiments in which they were included.

		Accession codes[b]	Experiments in which a cultivar was included[c]			
Cultivar[a]	Genome	ITC/QDPI/PNG	Cultivar	0120	0124	01210
Pamoti on	AA	1229/576/-	X	X	X	X
Pisang jari buaya	AA	0312/577/-	X	X	X	X
Pisang lemak manis	AA	1183/578/-	X	X	X	X
Pisang mas	AA	0653/579/-	X	X	X	X
Rose	AA	0712/574/-	X	X	X	X
Señorita	AA	1230/580/-	X	—	—	—
Veinte cohol	AA	1031/582/-	X	—	—	—
Kunnan	AB	1034/583/-	X	X	X	—
Ney poovan	AB	-/398/-	X	X	X	—
Ney poovan	AB	0459/584/-	X	X	X	—
Inarnibal	AAA	0477/563/-	X	X	X	X
Pisang nangka	AAA	1062/585/-	X	X	X	X
Williams	AAA	0570/587/-	X	X	X	X
Yangambi km5	AAA	1123/586/-	X	X	X	X
Kofi	AAB	0912/355/310	X	-	-	-
Kumunamba	AAB	0824/337/195	X	X	X	X
Pisang Ceylon	AAB	0650/589/-	X	X	X	X
Popoulu	AAB	0335/588/-	X	X	X	-
Prata anã	AAB	0962/590/-	X	X	X	X
Walha	AAB	1033/592/-	X	X	X	X
Silk (sport)	AAB	1222/591/-	X	X	X	X
Sugar	AAB	-/404/-	X	X	X	X
Bluggoe	ABB	-/261/-	X	X	X	X
Ducasse	ABB	-/256/-	X	X	X	X
Dwarf kalapua	ABB	0812/368/171	X	X	X	—
Kluai namwa khom	ABB	0526/593/-	X	X	X	X
Kandrian	ABB	0803/367/148	X	X	X	X
Saba	ABB	1138/594/-	X	X	X	X
Pelipita	ABB	0472/564/-	X	X	X	X
Pelipita	ABB	-/595/-	X	—	—	—
FHIA02	AAAA	0505/597/-	X	X	X	X
FHIA17	AAAA	1264/599/-	X	X	X	X
FHIA23	AAAA	1265/600/-	X	X	X	X
FHIA01	AAAB	0504/596/-	X	X	X	X
FHIA03	AABB	0506/598/-	X	X	X	X

[a]Cultivars names are those given by the original donor. Inarnibal is known elsewhere as Pisang Berlin, Pisang Ceylon as Mysore, Sugar as Silk, Walha as Raja puri, Ducasse as Pisang awak, Kluai namwa khom as Dwarf Pisang awak, and FHIA 01 as Goldfinger.
[b]Accession codes are, in order, those for: the International Transit Center (ITC) in Lueven, Belgium; the Queensland Department of Primary Industries (QDPI) in Maroochy, Australia; and germplasm obtained during a *Musa* collecting mission in Papua New Guinea (PNG) that was sponsored by the International Board for Plant Genetic Resources (IBPGR, now known as IPGRI).
[c]Cultivar = cultivar evaluation trial conducted with all 35 introductions. In screening trials for resistance to fusarium wilt, representative Florida isolates from VCGs 0120, 0124 and 01210 were used to individually infest soil in which the indicated cultivars were planted.

ly, the number of suckers that were produced in a mat 1 year after planting and height at fruiting (distance in meters from the base of the stem to the top of the peduncle) were determined for each accession. Once accessions fruited, cycling time (the number of days that elapsed between planting and harvest) and bunch weight (weight in kg of all hands in a bunch without the raceme) were also recorded. Informal panels at TREC evaluated the appearance and organoleptic qualities of fruit from the experiment and on a subjective 1-4 scale where 4 = excellent and 1 = poor.

Fusarium wilt resistance. Resistance of most of the accessions to fusarium wilt was determined in a separate field study (Table 1). Three different populations or vegetative compatibility groups (VCGs) of the fusarium wilt pathogen, *Fusarium oxysporum* f. sp. *cubense*, are known in South Florida, VCGs 0120, 0124, and 01210 (Ploetz and Pegg, 1999). Accessions were tested against a representative isolate from each VCG by individually infesting planting holes with cornmeal sand cultures of the isolates at planting (May-June, 1996). External evaluations of disease severity were made four times in 1997 and 1998 on a subjective 1-5 scale where 1 = healthy and 5 = dead.

Results and Discussion

In general, the banana germplasm that is described in this paper had not been grown before in South Florida. In fact, four of the ITC accessions, 'Kofi', 'Kumunamba', 'Dwarf kalapua' and 'Kandrian', were collected in Papau New Guinea in the late 1980s and had not been grown previously in the Western Hemisphere (Arnaud and Horry, 1997). Fourteen other accessions were either new in the hemisphere or were found previously only in the collection of the Fundación Hondureña de Investigación Agrícola (FHIA) in La Lima, Honduras ('Pamoti on', 'Pisang jari buaya', 'Pisang lemak manis', 'Rose', 'Señorita', 'Veinte cohol', 'Inarnibal', 'Pisang nanka', 'Yangambi km 5', 'Popoulu', 'Kunnan', 'Ney poovan' 398 and 584, and 'Kluai namwa khom'). Although cultivars that are represented by most of the remaining accessions had been grown before in South Florida, the specific accessions had not and often possessed important traits. For example, all of the ITC accessions were indexed for the three most important *Musa* viruses, namely banana bunchy top virus, cucumber mosaic virus and BSV. 'Pisang Ceylon', the 'Mysore' clone that was included in these studies, is the only accession of this cultivar that is known to be free of BSV.

Banana is a tropical crop that originated in southern and Southeast Asia (Simmonds, 1962). It performs best in areas with deep alluvial soils, consistent rainfall, and warm year-round temperatures. None of these conditions are met in subtropical South Florida. Freezing temperatures are not uncommon during the winter in South Florida and high winds, that damage leaves and cause lodging in plants with bunches, occur during the spring and fall. Furthermore, the area has poor soils and a highly seasonal pattern of rainfall. Thus, it was assumed at the outset of this work that some of the introductions would not perform well.

Low temperatures during the winter of 1995/1996 killed 'Niyarma yik' and 'Rimina'. Two other accessions, 'Pisang mas' and 'Yangambi km 5', were also cold sensitive and damaged severely before they were established in the field experiments.

One of the risks that are inherent in the use of tissue-culture plantlets is the development of somaclonal mutations during micropropagation. Most of these mutations are deleterious and are not evident until plants mature. In the present study, two examples of somaclonal mutations were observed in the tissue-cultured material that was used to establish these experiments. One plantlet of 'Pisang jari buaya' was a color chimeric mutant that was identified at planting, but did not appear to affect fruit production. In contrast, all plantlets of the 'Williams' accession were found to be dwarf off-types when they produced fruit. In general, these plants were at least 50% shorter than normal 'Williams' and produced smaller than normal bunches and fingers (data not shown). Since the 'Williams' accession was a mutant, it was not considered when evaluating relationships between accession ploidy and genome and the traits that are discussed below.

Cultivar evaluation trial. Mean suckering rate ranged from 3.6 to 11.6 per mat during the first year (data not shown). Suckering generally decreased as the ploidy of clones increased, with diploids exhibiting a significantly higher rate than triploids or tetraploids (respectively, 7.34 versus 5.56 and 4.82; $P < 0.05$; data not shown). Vakili (1967) noted the same relationship when he compared BB diploids with autotetraploids he produced with the diploids and colchicine. No clear relationship existed in the present study between suckering rate and genome.

Height at fruiting and cycling time also varied significantly among the clones. 'Kandrian' was about two meters taller than the shortest clones, and cycling time varied by more than a factor of two, with 'Kumunamba' producing fruit within 372 days of planting and 'Kandrian' doing so in 826 days (data not shown). Neither trait was significantly correlated with ploidy or genome.

Bunch weight was profoundly influenced by accession, ploidy and genome. Bunch weight ranged from 0.8 kg for 'Pisang mas' to 14.4 kg for 'Kandrian', and was significantly lower for diploids than for triploids and tetraploids (data not shown).

To determine a clone's relative productivity over time, a harvest index (HI) was used. It was calculated as:

$$HI = \frac{BW}{CT} \times 100,$$

where BW = bunch weight in kg, and CT = cycling time in days. Harvest indices ranged from 0.1 for 'Pisang mas' to 2.7 for 'Popoulu'. Twenty-two clones had HIs greater than 1, an arbitrary level of acceptable productivity in this study. No diploid AA accession approached this level of productivity, corroborating previous conclusions about the poor performance of clones with this genome (Stover and Simmonds, 1987). Interestingly, both accessions of 'Ney poovan', an AB diploid, had HIs that approached or exceeded ratings for many triploids and tetraploids in the study (Table 2; data not shown). As a group, triploids had higher, but not significantly different, indices than tetraploids (respectively, 1.27 versus 1.2).

In taste tests conducted at TREC, clear preferences were evident among the dessert clones, 21 of which were sampled enough times to allow statistical analyses of the ratings. Of these, the 398 accession of 'Ney poovan' from QDPI had the highest rating (3.79 out of a possible 4), and 10 of the remaining clones had mean ratings of 3 or higher (good to excellent taste). Only nine of the 21 clones had a mean appearance rating of 3 or greater.

Too few cooking bananas were evaluated to allow statistical analyses of these data. However, 11 of 20 that were tested had mean ratings of 3 or higher.

Fusarium wilt resistance. Resistance to fusarium wilt was evaluated for most of the clones that were included in the cultivar trial (Table 1). To date, the results indicate that some of the highest yielding and best tasting clones are susceptible to one or more of the populations of *F. oxysporum* f. sp. *cubense* that are found in South Florida (Table 2). The highly rated 'Silk' sport from Tanzania is susceptible to at least two of the VCGs in this study, 0124 and 01210, and the productive and highly rated accession of 'Bluggoe' ABB is susceptible to VCG 0124. 'Popoulu', another highly rated cooking banana and the most productive clone in the field trial, is susceptible to VCG 0120.

Recommended clones for South Florida. Although most of the accessions that were evaluated displayed at least one meritorious characteristic in these trials, only seven dessert and eight cooking clones produced reasonably high yields of accept-

Table 2. Summary of acceptability, yield performance and susceptibility to fusarium wilt of the highest rated accessions[a].

Cultivar	Taste: Dessert	Taste: Cooking	Harvest Index	Susceptible to fusarium wilt?
Ney poovan 398	3.79	—	1.2	?
Ney poovan 584	3.05	—	1.4	?
Kofi	—	3.8	1.1	not tested
Kumunamba	—	3.67	1.5	no
Pisang Ceylon	3.11	—	1.0	no
Popoulu	—	3.33	2.7	yes
Silk (sport)	3.29	—	1.0	yes
Bluggoe	—	3.4	1.4	yes
Kluai namwa khom	—	3.0	1.0	?
Kandrian	—	3.33	2.0	no
Saba	3.13	3.43	1.9	no
Pelipita 595	—	3.0	1.3	?
FHIA01	3.19	—	1.3	no
FHIA02	3.07	—	1.1	no
FHIA17	3.29	3.0	1.3	no

[a]Only clones with mean taste ratings of 3 or higher and harvest indices of 1 or higher are included in this table.
[b]Susceptibility is based on preliminary results with these clones through 1998. Accessions marked with a "?" have either been shown to be susceptible to fusarium wilt in previous incubator studies ('Ney poovan' and 'Kluai namwa khom') or another accession of the same cultivar ('Pelipita' 564) was susceptible in the fusarium wilt field trial.

able fruit (i.e., harvest indices of 1 or higher and 3 or higher in taste tests) (Table 2). Unfortunately, three of the dessert clones ['Ney poovan' 398, 'Ney poovan' 584 and 'Silk' (sport)] and three of the cooking clones ('Popoulu', 'Bluggoe' and 'Kluai namwa khom') that met these standards were either susceptible to fusarium wilt in the field trials or have succumbed to the disease in previous incubator studies (Ploetz, unpublished). Another acceptable clone, 'Pelipita' 595, was not tested in the fusarium wilt field experiment, but may be susceptible to isolate A10 (VCG 01210) since another introduction of the cultivar, 'Pelipita' 564, was affected. These clones are not recommended for production in areas that have a history of fusarium wilt, but could be used in other areas. Certainly, the excellent flavor of 'Ney poovan' 398 and outstanding productivity of 'Popoulu' suggests that these clones could become commercially important in South Florida despite their major flaw of susceptibility.

The remaining accessions in Table 2 are resistant to fusarium wilt, and appear to have potential in all production areas in Miami-Dade County. The dessert clones 'Pisang Ceylon', 'FHIA01', 'FHIA02' and 'FHIA17', and the cooking clones 'Kofi', 'Kumunamba', 'Kandrian' and 'Saba', are recommended for use in all areas in South Florida.

Literature Cited

Arnaud, E. and Horry, J. P. (eds.) 1997. *Musa*logue: A catalogue of *Musa* germplasm. Papua New Guinea collecting missions, 1988-1989. International Network for the Improvement of Banana and Plantain, Montpellier, France.

Crane, J. H. 1997. Tropical fruit crops acreage in Florida. Univ. Florida, Trop. Res & Ed. Ctr., Homestead. 1 pg.

Degner, R. L., Moss, S. D. and Mulkey, W. D. 1997. Economic Impact of Agriculture and Agribusiness in Dade County, Florida. FAMRC Industry Report 97-1. Fla. Agric. Market Research Center, Food and Resource Economics Dept. Univ. of Fla., IFAS, Gainesville, FL 32611.

Ploetz, R. C. and Benscher, D. 1996. Evaluation of new banana germplasm in South Florida. Info*Musa* 5:36.

Ploetz, R. C. and Pegg, K. G. 1999. Fusarium wilt. In: Jones, D. R. (ed.) Diseases of Banana and Abaca. CABI. Wallingford, UK. (In press)

Simmonds, N. W. 1962. The Evolution of the Bananas. Longmans, London. 170 pp.

Stambaugh, S. U. 1952. Bananas in Florida. Dept. Agric. Tallahassee. 77 pp.

Stover, R. H. and Simmonds, N. W. 1987. Bananas. 3rd ed. Longmans. London. 367 pp.

Vakili, N. G. 1967. The experimental formation of polyploidy and its effects in the genus *Musa*. Am. J. Bot. 54:24-36.

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CULTIVAR TREE GROWTH AND FRUIT QUALITY EVALUATION OF YOUNG CARAMBOLA (*AVERRHOA CARAMBOLA* L.) TREES

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Abstract. **A 0.47 ha carambola cultivar evaluation planting was established at the Tropical Research and Education Center (TREC), Homestead. Six single-tree replications of 13 sweet cultivars were planted in a completely randomized design during 1996. Cultivars evaluated include 'Arkin', 'Erlin', 'Cheng Chui', 'Wubentou', 'Miss', 'Waiwei', 'Pasi', 'Fwang Tung', 'Kajang', 'Kary', 'Sri Kembangan', 'B-10', and 'Lara'. Fruit from several nearby 'Golden Star' trees (tart type fruit) were also evaluated. Trees were not allowed to bear a crop during 1996 and fruit evaluation began during the summer of 1997. Commercial carambola producers and extension-research faculty participated in an informal taste test on 31 Oct 1997. Fruit were rated for sweetness, peel and internal flesh color, rib thickness, fruit size, and overall impression of the fruit. Mean °Brix was lowest for 'Cheng Chui' and 'Wubentou' and highest for 'B-10'. A majority of the producers rated 'Kary' (90%), 'Miss' (84%), 'Lara' (72%), 'B-10' (72%), 'Fwang Tung' (67%), 'Sri Kembangan' (67%), and 'Kajang' (55%) to be sweet and 79% rated 'Golden Star' as sour. In a rating for overall impression, 95%, 63%, 62%, 59%, and 56% of the producers rated 'Kary', 'B-10', 'Arkin', 'Sri Kembangan', and 'Lara' as good to very good, respectively. Most of the survey participants gave an overall rating of poor for 'Pasi' (93%), 'Erlin' (70%), 'Wubentou' (71%), and 'Cheng Chui' (53%).**

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Introduction and Review of Literature

Miami-Dade County's commercial carambola acreage in Florida is estimated to be 532 acres and worth $17.4 million dollars annually (Degner et al., 1997). An estimated additional 100 acres of carambola are grown in Lee and Palm Beach Counties.

Numerous carambola cultivars and seeds of various carambola types have been introduced to Florida and evaluated to various degrees (Campbell, 1970; Wagner et al., 1975; Campbell et al., 1985; Knight, 1989). Currently, the major carambola cultivar grown is 'Arkin' (~95%) followed by 'Kary' and 'B-10'. A number of cultivars have been introduced and evaluated but none have proved to be superior to 'Arkin' or warrant large scale planting.

'Arkin' has a number of positive attributes including high production, moderate fruit size with good color and broad ribs. Although classified as a sweet type, the 'Arkin' has a relatively low sugar content coupled with low acidity and only good flavor (Campbell and Koch, 1989). The tree has an upright growth habit, is prone to wind stress (Marler et al.,