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Growth, yield and Fusarium wilt resistance of six FHIA tetraploid bananas (*Musa* spp.) grown in the Australian subtropics

M.K. Smith[a,*], P.W. Langdon[a], K.G. Pegg[b], J.W. Daniells[c]

[a] Department of Agriculture, Fisheries & Forestry (DAFF), Maroochy Research Station, 47 Mayers Road, Nambour 4560, QLD, Australia
[b] DAFF, EcoSciences Precinct, 41 Boggo Road, Dutton Park, Brisbane 4102, QLD, Australia
[c] DAFF, South Johnstone Research Station, South Johnstone Road, South Johnstone 4859, QLD, Australia

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ABSTRACT

Six tetraploid hybrids from Fundación Hondureña de Investigación Agrícola (FHIA) were evaluated in Australia over a five year period. They included three AAAA hybrids (FHIA-02, FHIA-17 and FHIA-23) and three AAAB hybrids (FHIA-01, FHIA-18 and SH-3640.10) and they were compared with industry standards, 'Williams' (AAA, Cavendish subgroup) and 'Lady Finger' (AAB, Pome subgroup). They were screened for their resistance to Fusarium wilt race 1 and subtropical race 4 caused by the pathogen *Fusarium oxysporum* f.sp. *cubense* and they were also grown for several cycles on farms not infested with Fusarium wilt to record their agronomic characteristics. The AAAB hybrids, all derived from female parent 'Prata Anã' (AAB, Pome subgroup) were the most resistant to both races of Fusarium wilt and were very productive in the subtropics. They were significantly more productive than 'Lady Finger', which was susceptible to both races of Fusarium wilt. The AAAA hybrids, with the exception of FHIA-02 which was very susceptible to Fusarium wilt and displayed the poorest agronomic traits of the six hybrids, produced bunch weights as good as Cavendish but were significantly slower to cycle. FHIA-17 and FHIA-23, both derived from the female parent 'Highgate' (AAA, Gros Michel subgroup), were also significantly more resistant to Fusarium wilt than 'Gros Michel', while FHIA-17 demonstrated a level of resistance similar to 'Williams' and FHIA-23 was intermediate between 'Lady Finger' and 'Williams'.

1. Introduction

Rowe and Rosales (1994) stated that the objectives of the Fundación Hondureña de Investigación Agrícola (FHIA) breeding program were to develop productive dwarf dessert banana, plantain and cooking banana hybrids with resistance to black Sigatoka (*Mycosphaerella fijiensis*) and race 4 of Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*). Black Sigatoka is a very destructive leaf disease of banana (Jacome et al., 2003; Cook et al., 2013) and the fungus invades the leaf tissue causing necrosis leading to loss of functional leaf area and diminished yield. Many of the FHIA tetraploid hybrids have resistance to this pathogen due to the use of elite banana diploids with resistance to *Mycosphaerella* leaf spots in their breeding program (Ortiz, 2013). Fusarium wilt, on the other hand, is a lethal disease of banana which colonizes and occludes the xylem of susceptible cultivars to cause a terminal wilt (Stover, 1972; Ploetz, 1994; Ploetz and Churchill, 2011). Unlike black Sigatoka, no effective chemical control measures are possible against Fusarium wilt, hence the emphasis on genetic resistance.

'Goldfinger' (FHIA-01), a tetraploid banana produced by FHIA, was released to the Australian industry in 1995 (Whiley, 1996). It was promoted as an apple-flavoured dessert banana with resistance to Fusarium wilt race 1 and subtropical race 4, as well as resistance to black and yellow Sigatoka (*M. fijiensis* and *M. musicola*, respectively). The study reported here was initiated during this time to provide agronomic information and an assessment of resistance to Fusarium wilt to the banana industry on a range of FHIA hybrids which could provide economic alternatives for the Australian industry standards, 'Williams' (AAA, Cavendish subgroup) or 'Lady Finger' (AAB, Pome subgroup), in those areas affected by Fusarium wilt. This work also formed a small component of a much larger International *Musa* Testing Program (IMTP) coordinated by the International Network for the Improvement of Banana and Plantain, with Australia being one of 18 countries participating in the IMTP phase II program (Jones, 1994; Orjeda, 2000). However, the results from the Australian trial sites were never presented in their entirety.

* Corresponding author. Tel.: +61 7 5453 5800; fax: +61 7 5453 5901.
E-mail address: mike.smith@daff.qld.gov.au (M.K. Smith).

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Table 1
Description and disease resistance/susceptibility of FHIA hybrids to Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense* race 1 and subtropical race 4) and black Sigatoka, *M. fijiensis*).

Hybrid	Description and synonym	R1	STR4	BS
FHIA-01	AAAB, Pome hybrid dessert type 'Goldfinger'	R	R	HR
FHIA-02	AAAA, Williams hybrid? dessert type 'Mona Lisa'	S	S	HR
FHIA-17	AAAA, Highgate hybrid dessert type	R	S	R
FHIA-18	AAAB, Pome hybrid dessert type 'Bananza'	R	R	HR
FHIA-23	AAAA, Highgate hybrid dessert type	R	S	R
SH-3640.10	AAAB, Pome hybrid dessert type 'High Noon'	R?	R	S

From Daniells and Bryde (2001). S—susceptible, R—resistant, HR—highly resistant.

Varietal observation trials were conducted in tropical north Queensland (17°38′S) at the same time on 4–10 plants for each hybrid and published in departmental reports (Daniells and Bryde, 2001; details provided in Tables 1 and 5). However this study, for the first time, gives a comprehensive account of the agronomic characteristics and Fusarium wilt resistance/susceptibility of six FHIA hybrids grown in a subtropical region of Australia.

2. Materials and methods

2.1. Plant materials

Tissue cultured material of the hybrids was kindly supplied by Fundación Hondureña de Investigación Agrícola and used to establish a field block at South Johnstone Research Station (SJRS; 17°S, 147°E). Suckers collected at SJRS from the FHIA hybrids, as well as standard reference lines, were subsequently used to re-establish tissue cultured plants. These plants were micropropagated and established in the field for experimental work when they reached a height of 20 cm in 2.5 L planter bags (Smith and Hamill, 1993).

2.2. Establishment and maintenance of field trials

The Wamuran, Queensland site (27°S, 153°E and an altitude of 380 masl) previously formed part of a commercial Cavendish plantation and was characteristic of many of the steep-land farms in subtropical areas of the eastern coast of Australia. The soil is classified as a yellow dermosol (McKenzie et al., 2004) and is a heavy clay–clay loam. The slope varied from 10° to 40° and had a north-east aspect. Two sites were free of Fusarium wilt disease (*F. oxysporum* f.sp. *cubense* or *Foc*), while another site used for disease screening was infested with a subtropical race 4 vegetative compatibility group (VCG 0120) (Moore et al., 2001).

The Cudgen, New South Wales site (28°S, 154°E and an altitude of 32 masl) was part of a commercial Lady Finger plantation before replanting with Cavendish. The soil on the near-level site was classified as a red ferrosol (McKenzie et al., 2004) and was infested with race 1 *Foc* (VCG 0124/5) (Moore et al., 2001).

A series of field trials were carried out over an extended period, commencing in November 1996 and concluding in November 1999 (Table 2). Plants were established at a density of 1680 plants/ha with a spacing of 2.5 m × 2.5 m and grown using standard commercial practices (Broadley et al., 2004). Fertilizer as N, P, K plus trace elements (Nitrophoska®) was broadcast by hand at the rate of 150–200 g per plant every 3 months and water was supplied through overhead sprinklers. Weeds were controlled by hand hoeing and detrashing to remove old necrotic leaves was performed by hand at each site every 4–6 weeks to keep stools clean. Lorsban® (chlorpyrifos 500 g/L ai.) was the only pesticide applied to the plants and was used mainly for the control of banana weevil borer (*Cosmopolites sordidus*) and was applied at the recommended rate twice yearly at the sites used to collect agronomic data.

2.3. Agronomic measurements

Blocks were visited weekly and when banana plants started bunching, pseudostem height (from the soil surface to the point of intersection of the 2 upper-most leaves) and pseudostem circumference (at 30 cm above ground) were measured. The number of green leaves was also recorded at bunching and then again at harvest. Other parameters recorded at harvest included: date, bunch weight, bunch stalk weight, number of hands, number of fingers in bunch, number of fingers in third proximal hand, and length of middle finger of the outer whorl of the third proximal hand. Productivity (t/ha/yr) was calculated as tonnes of fruit (bunch weight minus stalk weight) produced per hectare (planting density of 1680 plants) over a year. In the case of the ratoon crop data both the plant crop and the first ratoon fruit weights were combined.

2.4. Assessment of Fusarium wilt infection

Plants were judged to have external symptoms of disease if they displayed any sign of wilting, yellowing of foliage, petiole buckling or splitting of the pseudostem base. However the most definitive test was to rate plants on internal symptoms of Fusarium wilt which were recorded at or near harvest of the plant crop. Plants were removed from the soil and cut transversely through the rhizome about one-quarter of the way above the rhizome's base. The cut surface of the rhizome was rated for discolouration on a scale of 1–6 (Jones, 1994; Orjeda, 1998): (1) no vascular discolouration; (2) isolated points of vascular discolouration; (3) less than one-third of the vascular tissue discoloured; (4) one- to two-thirds of the vascular tissue discoloured; (5) greater than two-thirds of the vascular tissue discoloured; and (6) total vascular discolouration or discolouration of leaf bases or both. Samples of infected pseudostem or rhizome tissue from diseased plants were collected for analysis of vegetative compatibility group.

2.5. Experimental design and statistical analyses

A completely randomised design was used with between 6 and 9 treatments, depending on site, consisting of varieties where each variety was replicated between 13 and 29 times (one replicate was a single plant). Unequal replication for each banana hybrid and cultivar was due to differences in availability of planting material. This design was selected as recommended for banana field experiments by Orjeda (1998). For the agronomic characteristics, data was analyzed by ANOVA and tested using the significance level of $P = 0.05$. Severity of *Foc* infection was analyzed using the Kruskal–Wallis test. Incidence of Fusarium wilt was compared using generalized linear models for a binomial distribution with logit link followed, where significant, by pair-wise *t*-tests. Again testing was at $P = 0.05$.

3. Results

Four tetraploid FHIA hybrids have shown good levels of resistance to Fusarium wilt at both the race 1 and subtropical race 4 field

Table 2
Outline of experiments conducted to assess performance of FHIA hybrids with standard cultivars.

Location	Planting date	Completion date	Assessment
Wamuran, QLD	Nov. 1996	April 1999	Agronomic; plant and ratoon crop
Wamuran, QLD	Jan. 1998	Nov. 1999	Agronomic; plant crop
Wamuran, QLD	Dec. 1997	Nov. 1999	Fusarium wilt STR4[a]
Cudgen, NSW	Oct. 1997	March 1999	Fusarium wilt R1[b]

[a] Assessment for resistance to *Fusarium oxysporum* f.sp. *cubense* subtropical race 4.
[b] Assessment for resistance to *Fusarium oxysporum* f.sp. *cubense* race 1.

evaluation sites in Australia. These are FHIA-01 (commercially marketed as 'Goldfinger' in Australia), FHIA-17 and FHIA-18 ('Bananza'). Interestingly while SH-3640.10 ('High Noon') showed few external symptoms consistent with *Foc* infection at the race 1 site and produced good bunches, when the plants were internally examined many were found to be infected with *Foc* with discoloured vascular tissues apparent in the rhizomes and pseudostems. In contrast very few of the 'High Noon' plants at the subtropical race 4 site showed internal symptoms after destructive sampling (Table 3).

FHIA-02 and FHIA-23, on the other hand, were susceptible to both races of *Foc*. The controls performed as expected with 'Williams' showing resistance to Fusarium wilt race 1 but was susceptible to subtropical race 4, 'Lady Finger' was susceptible to both races of Fusarium wilt and 'Gros Michel' was likewise highly susceptible to both races (Table 3).

With regard to the agronomic performance of the FHIA hybrids in the Australian subtropics, all outperformed 'Lady Finger' in terms of bunch weight, number of hands, number of fingers and finger length and weight (Table 4). Many also compared very favourably with 'Williams' which is the standard Cavendish variety grown in Australia. For instance, 'Goldfinger', 'High Noon' and FHIA-17 consistently produced big, heavy bunches on a plant of equal or taller stature. Whereas FHIA-17 and 'Goldfinger' were the most productive hybrids in the subtropics, 'High Noon' and FHIA-23 had longer cycling times that tended to lower its productivity. FHIA-02 was the only hybrid that consistently underperformed compared to 'Williams' and the other FHIA hybrids.

When yield and cycling times of the FHIA hybrids from these subtropical trials were compared to their growth and performance in the tropics (Daniells and Bryde, 2001), it was obvious that the hybrids were more productive in a warmer environment, while the performance of each hybrid relative to one another remained more or less the same. For instance FHIA-02 had the fastest crop cycle in both the subtropics and tropics, FHIA-17 had the heaviest plant crop bunches and SH-3640.10 had the longest fingers overall (Table 5).

Table 3
Results of field evaluation of banana varieties for resistance to Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense* race 1 and subtropical race 4)[a].

Hybrid	Internal symptoms R1 (Rating 1–6)[b]	Internal symptoms STR4 (Rating 1–6)[b]
Williams	1.00a	2.45b
Lady Finger	3.83d	5.45d
Gros Michel	5.83e	5.63d
FHIA-01	1.00a	1.00a
FHIA-02	3.35cd	5.20d
FHIA-17	1.00a	1.83ab
FHIA-18	1.00a	1.20a
FHIA-23	1.74b	4.20c
SH-3640.10	3.90*d	1.45a

[a] Planted IMTP trials at Cudgen 7 October 1997 for testing against *Foc*R1 and at Wamuran 4 December 1997 for testing against *Foc*STR4.
[b] Scale: 1 = Rhizome completely clean, no vascular discolouration, 2 = Isolated points of discolouration in vascular tissue, 3 = Discolouration of up to one-third of vascular tissue, 4 = Discolouration of between on-third and two-third of vascular tissue, 5 = Discolouration greater than two-thirds of vascular tissue, and 6 = Total discolouration of vascular tissue and/or discolouration of leaf bases.
* Plants were severely infected internally and yet still had few external symptoms and produced harvestable bunches. Values in a column followed by the same letter are not significantly different ($P < 0.05$).

4. Discussion

This study has demonstrated that many of the hybrids developed by Fundación Hondureña de Investigación Agrícola have resistance to Fusarium wilt race 1 and subtropical race 4 while producing good sized bunches in both the tropical and subtropical banana growing regions of Australia. Only a few of the hybrids imported into Australia were susceptible to major diseases or were not as productive as hoped. It is interesting that although the hybrids were bred and selected in the tropics they, for the most part, show excellent productivity in the subtropics. In fact the FHIA hybrids have performed well in a variety of situations around the world whether it be the lowland tropics of Rwanda (Gaidashova et al., 2008), the wet subtropics of São Paulo, Brazil (Nomura et al., 2013) or the dry subtropics of Mozambique (Uazire et al., 2008). In Cuba disease resistant FHIA hybrids are increasingly replacing susceptible banana and plantain cultivars on the island and, as early as 2000, accounted for over 12% of total banana production (Frison and Sharrock, 2000).

However, it is in the area of postharvest performance and consumer acceptance that more work is required. FHIA-01, or 'Goldfinger', which was released in 1995, briefly had a small niche in the Australian supermarkets. Inadequate supplies of fruit and perceived problems with ripening and eating quality have contributed to its demise. Others such as SH-3640.10, or 'High Noon', have recently been shown to have excellent eating qualities and research has shown that a significant population of Australian consumers prefer it over Cavendish and Lady Finger in blind taste tests (Daniells et al., 2013). Similarly SH-3640 was found to have good post-harvest quality and acceptability in terms of aroma and palatability with consumers in southern Mozambique, whereas less than 50% indicated a preference for FHIA-17, FHIA-21 and FHIA-23 (Uazire et al., 2008). However in Cameroon FHIA-21 and FHIA-17 are preferred (Tenkouano et al., 2011). Obviously consumer preference will vary and depend on whether fruit is eaten fresh or cooked and how willing the consumers are to switch to new varieties over local varieties that have been eaten for generations.

Taking the characteristics of each hybrid into consideration, it can be said that 'Goldfinger' is a very productive variety with growth, yield and bunch characteristics as good or better than the standard Cavendish variety, 'Williams', and in a range of environments (Tables 4 and 5). Langdon et al. (2008) conducted planting density trials in the subtropics with 'Goldfinger' at a steep-land site and a more level site that suited greater mechanisation, and again 'Goldfinger' demonstrated good productivity compared to 'Williams', particularly on more marginal sites. Its resistance to Fusarium wilt is exceptional and it is one of the few varieties that can be grown in areas where Fusarium wilt race 4 has caused the collapse of traditional Cavendish varieties. Moore et al. (2001) also noted both 'Goldfinger' and FHIA-18 developed very little yellow Sigatoka leaf spot (*M. musicola*) in the *Foc* evaluation trials which were not sprayed for leaf diseases. However, significantly more leaf

Table 4
Agronomic characteristics of nine FHIA hybrids and two industry standards grown in a subtropical region of southeast Queensland.

Plant crop[a]

Cultivar; hybrid	No days to harvest	Plant height (m)	No leaves at harvest	Bunch wt (kg)	No hands	No fingers	Finger wt (g)	Finger lgth[b] (cm)	Productivity[c] (t/ha/yr)
Williams	539.0c	2.53b	7.58a	27.95a	11.25c	180.2b	139.9cd	20.79a	29.2a
Lady Finger	541.2c	2.90d	5.41d	9.17e	6.89h	75.2f	112.1f	14.99e	9.8e
FHIA-01	526.0bc	2.58b	6.75abc	22.11b	9.46de	122.0d	166.8ab	20.49a	23.4b
FHIA-02	459.7a	2.29a	6.42bc	12.52d	7.58g	99.4e	113.1f	14.94e	15.4d
FHIA-17	601.8d	3.05e	4.38e	28.07a	12.66b	201.8a	126.8de	19.72b	27.4ab
FHIA-18	574.4cd	2.82cd	4.80de	19.92bc	10.00de	147.6c	124.4cdef	16.85d	14.7d
FHIA-23	617.7d	3.26f	3.75e	26.67a	13.44a	209.8a	115.8ef	19.17b	22.4bc
SH-3640.10	612.0d	2.81d	6.86ab	20.95b	9.04ef	121.1d	160.6b	20.29a	20.2c

First ratoon[d]

Cultivar; hybrid	No days to harvest	Plant height (m)	No leaves at harvest	Bunch wt (kg)	No hands	No fingers	Finger wt (g)	Finger lgth[e] (cm)	Productivity[f] (t/ha/yr)
Williams	896.9b	2.88a	8.13a	24.43df	10.60bc	157.2ab	145.9b	21.20a	32.8a
Lady Finger	878.4b	4.03g	6.05b	12.37h	7.19d	90.2c	125.8cd	15.66f	13.8d
FHIA-01	895.9b	3.41cd	7.06ab	30.26ab	11.38ab	156.8ab	180.7a	21.21a	33.6a
FHIA-02	771.4a	3.15b	6.91ab	21.09eg	9.91c	146.5b	133.0bc	17.14e	24.5c
FHIA-17	934.8bc	3.33bcd	3.60cd	24.52cdef	12.20a	178.6a	126.3bcd	18.74cd	31.4ab
FHIA-23	907.8bc	3.16abc	1.25d	19.95fg	11.50ab	179.5a	99.6d	17.04def	28.6b
SH-3640.10	999.0c	3.65def	6.25abc	30.47abc	10.50bc	155.5ab	182.3a	21.36ab	29.2b

Plant crop[g]

Hybrid	No days to harvest	Plant height (m)	No leaves at harvest	Bunch wt (kg)	No hands	No fingers	Finger wt (g)	Finger lgth[h] (cm)	Productivity[i] (t/ha/yr)
FHIA-01	477.3ab	2.63cd	8.67ab	26.50bc	9.33e	134.3c	174.9ab	21.44a	30.6a
FHIA-02	500.2b	2.49d	9.00ab	18.86d	9.62de	145.0c	115.0d	15.89d	20.8b
FHIA-17	563.4c	3.13a	6.86c	33.67a	12.00b	197.9a	149.3bc	20.22ab	32.8a
FHIA-18	578.9c	2.90b	7.26c	24.04c	10.65c	167.7b	137.2cd	18.91c	22.8b
FHIA-23	605.9c	3.31a	6.70c	33.05a	13.20a	215.6a	137.3cd	19.66bc	29.7a
SH-3640.10	500.7b	2.71c	8.46b	26.61bc	9.38e	132.8c	179.9a	21.17a	29.6a

[a] Planted at Wamuran on 22 November 1996.
[b] Finger length was measured from the middle finger of the outer whorl of the third hand from the proximal end.
[c] Calculated at a planting density of 1680 plants/ha. Values in a column followed by the same letter are not significantly different ($P < 0.05$).
[d] Planted at Wamuran on 22 November 1996.
[e] Finger length was measured from the middle finger of the outer whorl of the third hand from the proximal end.
[f] Calculated at a planting density of 1680 plants/ha and combined fruit weight of both plant and ratoon crops. Values in a column followed by the same letter are not significantly different ($P < 0.05$).
[g] Planted at Wamuran on 22 January 1998.
[h] Finger length was measured from the middle finger of the outer whorl of the third hand from the proximal end.
[i] Calculated at a planting density of 1680 plants/ha. Values in a column followed by the same letter are not significantly different ($P < 0.05$).

spot was apparent on 'High Noon' at all of the subtropical field sites. Also as Smith et al. (1998) concluded, 'Goldfinger's tolerance to burrowing nematode and resistance to leaf spot pathogens enhances its "clean and green" credentials, as chemical control for these pests are not required. The potential for use of disease-resistant FHIA hybrids as organically grown bananas has been well documented (Frison and Sharrock, 2000). Other characteristics that are attractive are Goldfinger's resistance to underpeel discolouration during winter production, the ripe fruit does not discolour/oxidise when sliced and its longer shelf life than 'Williams' (Seberry and Harris, 1998).

Table 5
Comparison of the agronomic characteristics of FHIA hybrids grown in the Queensland subtropics[a] (27°S) and tropics (17°S)[b].

Hybrid	Crop cycle (mth)		Plant height (m)		Bunch weight (kg)		Fruit length (cm)	
	PC	Ratoon	PC	Ratoon	PC	Ratoon	PC	Ratoon
Williams: ST	18.0	29.9	2.53	2.88	28.0	24.4	20.8	21.2
T	10.5	16.7	2.21	2.97	29.3	41.4	25.0	27.6
FHIA-01: ST	17.5	29.9	2.58	3.41	22.1	30.3	20.5	21.2
T	13.6	25.9	2.87	3.62	31.8	40.4	24.2	25.0
FHIA-02: ST	15.3	25.7	2.29	3.15	12.5	21.1	14.9	17.1
T	10.9	19.8	2.82	3.44	24.6	33.1	23.5	22.9
FHIA-17: ST	20.1	31.2	3.05	3.33	28.1	24.5	19.7	18.7
T	14.8	27.5	3.20	3.69	41.3	45.9	26.8	26.9
FHIA-18: ST	19.1	–	2.82	–	19.9	–	16.9	–
T	13.0	21.6	3.59	4.04	37.6	37.0	23.9	23.7
FHIA-23: ST	20.6	30.3	3.26	3.16	26.7	20.0	19.2	17.0
T	15.7	28.6	3.47	3.57	35.1	47.8	25.2	25.4
SH-3640.10: ST	20.4	33.3	2.81	3.65	21.0	30.5	20.3	21.4
T	11.8	20.0	3.25	3.61	34.2	48.2	26.5	26.7

[a] Values from subtropical site (ST) was plant (PC) and ratoon crop from Wamuran planted on 22 November 1996.
[b] Values from tropical (T) site come from Daniells and Bryde (2001) and were planted 31 October 1991.

It would be interesting to optimise fruit quality and test market 'Goldfinger' and the other FHIA hybrids, particularly those showing potential for the Australian market.

FHIA-02, on the other hand, was not only susceptible to both races of Fusarium wilt it also produced the smallest bunches, even though cycling time was generally faster than the other FHIA hybrids (Table 4). Likewise FHIA-23 was also susceptible to both races of Fusarium wilt, although it was not as badly infected with R1 as it was STR4. FHIA-23 was also one of the slowest to produce bunches and by the time a bunch was produced it had the least number of leaves to take the bunch through to harvest. Despite this bunch weights were on average 26.5 kg. The other 'Highgate' derived tetraploid, FHIA-17, demonstrated better resistance to both races of Fusarium wilt and its agronomic characteristics were as good or better than FHIA-23.

In contrast Nomura et al. (2013) found FHIA-02 to be as productive as FHIA-17 by the first ratoon harvest (31.5 t/ha/yr and 30.7 t/ha/yr, respectively), although bunch size was smaller than FHIA-17 (22.3 kg and 26.3 kg, respectively). When their standard Cavendish cultivar, 'Grande Naine' was compared to these two hybrids, and unlike our results where 'Williams' performed well in relation to the hybrids, it produced small bunches (12.6 kg) and had lower productivity (16.4 t/ha/yr). On the other hand, Uazire et al. (2008) found their standard, 'Grand Naine', produced large bunches (34.1 kg) and cycled well (63.4 weeks), and was significantly better than FHIA-17 (21.5 kg bunches and 66.3 weeks to bunch emergence).

Of the Pome derived tetraploids 'Goldfinger' has already been discussed, however FHIA-18, also known as 'Bananza', showed considerable promise from a disease resistance and agronomic perspective. It was as resistant to both races of Fusarium wilt as 'Goldfinger', however it had a significantly longer cycle time and carried fewer leaves at harvest. But having said that, FHIA-18 significantly outperformed 'Lady Finger' in most agronomic performance measures. In fact FHIA-18 also outperformed local cultivars in the Brazilian subtropics ('Prata Anã and Grande Naine; Nomura et al., 2013) and in the Rwandan lowland tropics ('Barabeshya' and 'Poyo'; Gaidashova et al., 2008). 'High Noon' was another interesting hybrid. As mentioned in the previous section and also noted by Moore et al. (2001), 'High Noon' showed few external symptoms at the R1 site, however internal discoloration was prominent, and yet at the STR4 site it had few internal symptoms (Table 3). While the agronomic performance of 'High Noon' was similar to FHIA-18 in many respects, it did produce significantly larger fingers (Table 4). In the dry subtropics of Mozambique, Uazire et al. (2008) regarded SH3640 as the best performing of the FHIA hybrids evaluated (others included FHIA-17, FHIA-21 and FHIA-23), and comparable to 'Grand Naine'.

In conclusion, the banana breeding program at Fundación Hondureña de Investigación Agrícola has produced several tetraploid hybrids that are productive in a range of environments, including the Australian subtropics, and which demonstrate significant levels of resistance to pests and diseases that currently threaten the production of Cavendish and Pome cultivars. In fact, Orjeda et al. (2000) concluded from the global IMTP Phase II trials that of the four FHIA hybrids evaluated (FHIA-01, FHIA-03, FHIA-17 and FHIA-23) all four were consistently the best-yield genotypes in comparison to the other 11 hybrids and local cultivars under evaluation. With few exceptions their bunches outweighed bunches produced by all the other improved and local cultivars and, furthermore they responded well to careful management and fertilizer application. Orjeda et al. (2000) concluded from data collected from 18 countries that FHIA-17 and FHIA-23 were the most stable and best-yielding cultivars across sites followed by FHIA-03. Although FHIA-01 had good yields there was also much variability from site to site.

In Australia, particular interest is being shown in 'High Noon', FHIA-18 and variants of 'Goldfinger' which require further optimisation of postharvest management and consumer evaluation to determine how well they will perform in the Australian market. Also while they demonstrate resistance to R1 and STR4 Fusarium wilt, it will be very interesting to re-examine their resistance to tropical race 4 (TR4), as earlier studies by Walduck (2005) indicated that 'Goldfinger' and FHIA-18 were less susceptible to TR4 Fusarium wilt than Cavendish, however the trials were terminated due to funding constraints. It must be noted that while STR4 is widespread in banana growing districts in southeast Queensland and northern New South Wales, TR4 is recognized as a more serious threat to the Australian banana industry since it has established itself in the Northern Territory around Darwin from 1997, but fortunately it is still isolated from the main production areas along Australia's tropical and subtropical east coast. Future varietal selection and evaluation should include screening for resistance to TR4.

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