‘PITA-9’: A Black-sigatoka-resistant Hybrid from the ‘False Horn’ Plantain Gene Pool

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Additional index words. banana, breeding, fruit quality, somaclonal variation, *Musa*, *Mycosphaerella fijiensis*

The Plantain and Banana Improvement Program (PBIP) and the East and Southern Africa Regional Center of the International Institute of Tropical Agriculture (IITA) are developing improved plantain (*Musa* spp., AAB group) and banana (*Musa* spp., AAA and ABB groups) germplasm with pest and disease resistance, high and stable yield, and good fruit quality (Vuylsteke et al., 1993a). The first crosses between triploid plantains and diploid bananas (*Musa acuminata* Colla.) were made in 1987, targeting the incorporation of host-plant resistance to the black sigatoka disease caused by *Mycosphaerella fijiensis* Morelet. Black sigatoka is an airborne fungal leaf spot that results in one-third loss of yield in plantain (Mobambo et al., 1993). Currently, all evaluated plantains are equally susceptible to black sigatoka leaf spot. Recently, IITA has registered 14 tetraploid tropical *Musa* plantain hybrids (TMPx) (Vuylsteke et al., 1993e) and 14 plantain-derived diploid hybrids (TMP2x) (Vuylsteke and Ortiz, 1995) to place these hybrids in the public domain and to announce their availability to interested researchers. Multilocal trials of TMPx

clones and local cultivars are being performed by national agricultural research programs (NARS) in 11 countries in sub-Saharan Africa and tropical America (Vuylsteke et al., 1993a), where black sigatoka is considered a major constraint to plantain production.

Currently, all TMPx have been derived from the ‘French’ plantain gene pool; hybrids from the more preferred ‘False Horn’ (or ‘Horton’) gene pool have not been recovered yet. ‘French’ plantains differ from ‘False Horn’ plantains in that the former produces a complete inflorescence with many relatively small fruit, many persistent intermediate flowers, and a male bud at maturity, whereas the latter has an incomplete inflorescence at maturity with few but large fruit and no male bud (Swennen, 1990; Swennen and Vuylsteke, 1987).

Sterility is the major limitation in ‘False Horn’ plantain hybrid production (Swennen and Vuylsteke, 1993; Vuylsteke et al., 1993d). However, a ‘French’ somaclonal variant of the ‘False Horn’ plantain cv. Agbagba showing increased female fertility (Vuylsteke et al., 1991, 1993d) made this gene pool accessible to conventional breeding schemes. Somaclonal variants, obtained through in vitro micropropa-

gation, are of limited use in plantain improvement because of their narrow spectrum of phenotypic variation and the generally poor agronomic performance of mutants (Vuylsteke et al., 1991). Nevertheless, Vuylsteke et al. (1991) suggested that the ‘French’-type somaclonal variant of a ‘False Horn’ plantain could be of value in the genetic improvement of this preferred, but highly sterile, plantain gene pool.

‘PITA-9’ is a black-sigatoka-resistant tetraploid hybrid derived from the female-fertile ‘French’ somaclonal variant of a ‘False Horn’ plantain. It produces high yields in the humid forest zone of Nigeria and Cameroon and has improved agronomic traits relative to the plantain landraces and good postharvest fruit qualities. As such, it provides NARS and farmers with an attractive alternative plantain for their production systems.

Origin

‘PITA-9’, tested as TMPx 1112-1, is a tetraploid ($2n = 4x = 44$) F₁ hybrid derived from interspecific interploidy crosses. It originated from a 1988 cross of the triploid ‘French Reversion’ somaclonal variant of the ‘False Horn’ plantain cv. Agbagba with the wild nonedible resistant diploid banana ‘Calcutta 4’ (Figs. 1 and 2). The cross was made at the IITA High Rainfall Station, Onne, Rivers State, Nigeria, where black sigatoka disease pressure is high. Between May 1988 and June 1992, 223 ‘French Reversion’ plantain bunches were pollinated, producing 538 seeds, of which only 273 had well-formed embryos. A total of 15 seedlings were germinated using in vitro embryo culture (Vuylsteke et al., 1990), of which nine were euploid. Only one seedling (1112-1) was tetraploid; the others were diploid.

The tetraploid seedling was established in an early evaluation trial at Onne in 1989 and selected due to its black sigatoka resistance,

Received for publication 6 Sept. 1994. Accepted for publication 29 Oct. 1994. We thank Leo Oragwa, Julian Osuji, and Josephine Okoro for assistance in embryo culture, chromosome counting, and data processing, respectively. We acknowledge the International Network for the Improvement of Banana and Plantain for making the diploid male parent available. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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‘Agbagba’ (BSS 3x ‘False Horn’ plantain, almost complete sterility)

↓ somaclonal variation through micropropagation

‘French Reversion variant’ x ‘Calcutta 4’
 (BSS 3x plantain with increased fertility) (BSR wild 2x banana)

↓ selection in early evaluation trial

‘TMPx 1112-1’
 (BSR 4x plantain hybrid)

↓ multilocal trials over

↓ 3 locations & 3 years (2 cycles)

‘PITA-9’

(BSR, high yields in humid forest zone, and good fruit quality)

Fig. 1. Origin of the black-sigatoka-resistant (BSR; black-sigatoka-susceptible = BSS) 4x plantain hybrid ‘PITA-9’.

average bunch weight (≈ 10 kg), improved ratooning, and acceptable fruit size (Vuylsteke et al., 1993c). TMPx 1112-1 was advanced to multiplication plots in 1990 where it regularly produced bunches of >20 kg (Fig. 2). In 1991, TMPx 1112-1 was included in multilocal trials at IITA stations in Nigeria (Ibadan and Onne) and Cameroon (M'Balmayo). The encouraging results that were obtained in the humid forest stations at Onne and M'Balmayo (Table 1) provided convincing evidence that TMPx 1112-1 should be registered as 'PITA-9' for distribution to NARS in the humid tropics of Africa and elsewhere.

Description and performance

'PITA-9' exhibits high levels of partial resistance to the black sigatoka leaf-spot disease (Vuylsteke et al., 1993b). It produces high yields in representative areas of the humid forest zone of western and central Africa (Ortiz et al., 1994; Ortiz and Vuylsteke, 1993) and has fruit quality and shelf life characteristics similar to those of the 'False Horn' and 'French' plantains.

Host response to black sigatoka resistance was measured using the Vakili (1968) method, which consists of recording the youngest leaf

spotted (YLS). A high-YLS value indicates more functional leaves on the plant and hence a greater resistance to the fungus. In multilocal trials, 'PITA-9' showed a relative gain of $\approx 100\%$ in functional leaves without black sigatoka spotting compared to the susceptible plantains (Table 1). Host response in the partially resistant 'PITA-9' is based on slower or delayed disease development, probably due to the action of recessive and additive alleles (Ortiz and Vuylsteke, 1994a). This may provide a durable resistance to *M. fijiensis*.

'PITA-9' has a dense pendulous bunch consisting of 6 to 7 hands and 80 to 100 medium-sized (145 g) curved fruit with long pedicels (Fig. 2). It has deciduous neutral flowers and a convolute male bud with deciduous bracts. The peel of its immature fruit is green and turns yellow when ripening. Unripe fruit have an angular cross section with bottlenecked apices and a dark-yellow pulp. Phenotypically, the bunch of 'PITA-9' resembles that of the 'French' plantains because of the similar number of hands and fingers (i.e., fruit). However, the large fruit size of the hybrid, an important quality trait, makes 'PITA-9' a more attractive clone than the average 'French' plantain.

'PITA-9' has improved agronomic traits. Its plant stature is shorter than that of widely cultivated medium-sized plantains (Table 1), which confers reduced susceptibility to plant loss by wind damage. This trait is important in areas where strong winds occur periodically. 'PITA-9' has a longer fruit filling time than the plantains. Nevertheless, the hybrid has a shorter production cycle than the plantains due to its

Fig. 2. Black-sigatoka-resistant (center) 4x plantain hybrid 'PITA-9', obtained from crossing the 3x susceptible 'French Reversion' somaclonal variant of the 'False Horn' plantain cv. Agbagba with the highly resistant (right) wild 2x 'Calcutta 4' banana. The bunch of 'TMPx1112-1' weighed 23 kg, which is almost double the weight of the most productive (left) 'French' plantain cv. Obino l'Ewai, which phenotypically resembles 'French Reversion'.

Table 1. Multilocal agronomic evaluation of the black-sigatoka-resistant tetraploid plantain hybrid 'PITA-9' compared to reference plantain cultivars in IITA stations at Onne (O), Nigeria; M'Balmayo (M), Cameroon; and Ibadan (I), Nigeria, from 1991 to 1994 (plant and first ratoon crops).

Clone	Youngest leaf spotted ^x			Plant ht (cm)		Days to flowering		Fruit filling time (days)		Ht of tallest sucker ^z (cm)		Bunch wt (kg)		Yield potential ^y (t·ha ⁻¹ ·year ⁻¹)		
	O	M	I	O ^w	M	O	M	O	M	O	M ^w	O	M	O	M	I
PITA-9	8 a ^v	10 a	9 a	330	280 c	290 b	281 c	103 a	111 a	238 a	213	14.8 a	11.0 a	22.9	17.1	12.1
Obino l'Ewai ^u	5 b	5 b	6 b	387	361 a	371 a	360 b	101 a	90 c	202 ab	191	11.3 b	11.2 a	14.6	15.1	11.6
B. Tannap ^v	5 b	5 b	5 b	326	304 b	321 ab	368 b	95 ab	95 bc	175 b	168	9.1 b	10.2 a	13.3	13.4	12.9
Agbagba ^t	4 b	4 b	5 b	340	370 a	370 a	437 a	90 b	102 ab	200 ab	235	4.3 c	4.9 b	5.7	5.5	7.8

^zAt harvest.

^yYield potential = [bunch weight $\times$ 365 $\times$ plant density] / [1000 $\times$ production cycle]. Statistical tests were not performed because of estimated values. Plant density is 1667 plants/ha. Production cycle = days to flowering + fruit filling time.

^xGenotype response to black sigatoka according to Vakili (1968).

^wMeans not statistically different.

^vMean separation within columns by Duncan's multiple range test at $P \leq 0.05$.

^u'French' plantains from Nigeria and Cameroon, respectively.

^t'False Horn' plantain, most common and preferred clone in Nigeria.

Table 2. Fruit quality evaluation of the black-sigatoka-resistant tetraploid plantain hybrid 'PITA-9' compared to reference plantain cultivars at Onne, Nigeria (1992 to 1994).

Clone	Fruit wt (g)	Fruit pulp (%)	Pulp yield ^z (t·ha ⁻¹ ·year ⁻¹)	Dry matter content ^y (%)	Dry matter yield ^x (t·ha ⁻¹ ·year ⁻¹)	Shelf life (days)	Consumer acceptability in taste panels	
							Green boiled fruit	Ripe fried fruit
PITA-9	145 b ^w	57.5 b	13.2	35.1	4.6	11.5 a	Good	Good
Obino l'Ewai	140 b	62.7 a	9.2	37.3	3.4	7.3 b	Very good	Very good
B. Tannap	97 c	61.6 a	8.2	35.3	2.9	6.5 c	---	Good
Agbagba	252 a	61.7 a	3.5	37.1	1.3	11.6 a	Very good	Very good

^zPulp yield = yield potential (see Table 1) $\times$ fruit pulp. Statistical tests were not performed because of estimated values.

^yMeans not statistically different.

^xDry matter yield = pulp yield $\times$ dry matter content. Statistical tests were not performed because of estimated values.

^wMean separation within columns by Duncan's multiple range test at $P \leq 0.05$.

earlier flowering (Table 1). 'PITA-9' develops one or two suckers freely, but further suckering is partially inhibited due to the action of the nonapical dominance (*Ad*) gene (Ortiz and Vuylsteke, 1994b). This habit results in rapid growth of the ratoon crop [i.e., the follower has reached $\approx 75\%$ of total growth at the time the mother plant is harvested (Table 1)] and shortens the successive production cycles. Short stature, early maturity, and regulated suckering are important components of perennial productivity of this vegetatively propagated crop.

In addition to these desirable traits, 'PITA-9' also produces good bunches with equal or higher weights than those of the plantains (Table 1). Because of its shorter production cycle, 'PITA-9' has great yield potential (in tons per hectare per year), which is higher in the humid forest zone (Onne and M'Balmayo) than in the forest-savanna transition zone (Ibadan) (Table 1). This difference was expected because the hybrid was selected in the High Rainfall Station in Onne and may not be well adapted to the longer dry season of the transition zone. This variation emphasizes the need for multilocal testing in *Musa* before cultivar release in a targeted agroecological zone.

'PITA-9' has sweet-aromatic yellow fruit pulp when ripe, with a similar dry-matter content but a lower percentage of fruit pulp than plantains (Table 2). The hybrid yields more dry matter per unit production area and time than plantains. 'Agbagba' and 'PITA-9' bunches have the same long shelf life (full ripening period), which is significantly longer than that of the 'French' plantains (Table 2). Shelf life at $25 \pm 3^\circ\text{C}$ was measured in terms of changes in peel color from harvest until the fruit peel reached a fully yellow color with black spots. This postharvest trait is of considerable commercial importance to farmers, retailers, and consumers because fruit with a short shelf life will result in greater postharvest losses.

The intermediate phenotypic expression between 'False Horn' and 'French' plantains of 'PITA-9' suggests that the somaclonal variation event, which resulted in the 'French Reversion' mutant, only partially affected the original 'False Horn' genotype of 'Agbagba'. Thus, some traits of 'Agbagba' were maintained in the 'French Reversion' variant and transmitted to its offspring (e.g., shelf life). This was not surprising because ripening period seems to be under the control of partially dominant genes (PBIP, 1993).

Results of sensory evaluation by taste panels, consisting of trained Nigerian assessors (Table 2), reveal that 'PITA-9' was ranked consistently as the best of all black-sigatoka-resistant tetraploid hybrids (PBIP, 1993) that were registered recently (Vuylsteke et al., 1993e). Hence, 'PITA-9' could be adopted more readily by local consumers because its fruit quality traits are close to those of the traditional plantains.

Increased fertility levels allow using 'PITA-9' as a parent for further ploidy manipulations via $4x \times 2x$ crosses and for population improvement within the 'False Horn' gene pool. For example, 'PITA-9' has been crossed with its diploid full-sib 'TMP2x 1297-3' (Vuylsteke and Ortiz, 1995) with the objective of applying directional selection for increased fruit size in the segregating population to obtain progenies with large fruit of acceptable quality. This approach seems to be feasible in plantain hybrid populations based on variance component estimates (PBIP, 1993).

Availability

Limited numbers of virus-tested, in vitro plantlets are available on request to the Leader, Plantain and Banana Improvement Program, IITA, Oyo Rd., PMB 5320, Ibadan, Nigeria or IITA, c/o L.W. Lambourn & Co., Carolyn House, 26 Dingwall Rd., Croydon CR9 3EE, England. Recipients are asked to give appropriate recognition of the germplasm source if it is used in developing a new germplasm, parental line, or cultivar.

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