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Comparison of Host Reaction to *Fusarium oxysporum* f. sp. *cubense* Tropical Race 4 and Agronomic Performance of somaclonal variant 'GCTCV-119' (AAA, Cavendish) and 'Grand Naine' (AAA, Cavendish) in Commercial Farms in the Philippines

A.B. Molina[1], E.G. Fabregar[2], R.O. Soquita[2] and V.G.O. Sinohin[1]
[1] Bioversity International CfL Asia Pacific, Los Baños, Philippines
[2] Lapanday Fruits and Development Corporation, Davao City, Philippines

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Abstract

Recent reports of the occurrence of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (Foc TR4), causal agent of Fusarium wilt, in some commercial Cavendish banana plantations in the Philippines is of great concern to the Philippine banana industry. In an effort to mitigate the disease, 'GCTCV-119', a Foc TR4-resistant somaclonal variant of 'Giant Cavendish' selected by the Taiwan Banana Research Institute, was evaluated and compared with the commercial cultivar 'Grand Naine' in Foc-infested farms in Davao, Philippines. Isolates obtained from infected samples from these farms were previously typed as VCG1213/16, the vegetative compatibility group associated with TR4. Tissue culture-derived planting materials of 'GCTCV-119' and 'Grand Naine' were planted in randomised blocks in two farms where severe Fusarium wilt incidence was previously observed. After 12 months of disease incidence monitoring, 'GCTCV-119' showed no Fusarium infection, while 36 and 51% incidence was recorded for 'Grand Naine' in Calinan and Quibilan farms, respectively. Two years after establishment, 'GCTCV-119' plots in the Quibilan farm are still free from infection of Fusarium wilt while the 'Grand Naine' plots have been totally eradicated because of severe disease incidence. Agronomic and fruit quality traits were also recorded. Although 'GCTCV-119' proved to be highly resistant to TR4, it matured later and had a lower bunch weight and greater hand curvature resulting in more rejects when packed. 'GCTCV-119' is however sweeter as it has more total sugars and total soluble solids than 'Grand Naine'.

INTRODUCTION

The banana industry is of great importance to the Philippines. In 2007, banana was grown on 438,700 hectares with a total production of 7.8 million metric tonnes. It is the fifth most important crop in the country, after rice, corn, coconut and sugarcane; and the second agricultural export commodity, after coconut (BAS, 2009; Eusebio and Anit, 2009). It is crucial to the livelihood of millions of small-holder growers and provides an affordable year-round food for rural and urban poor. Equally important, commercial plantations in the Southern Philippines that grow bananas for the export market bring in much needed foreign exchange. The industry has enjoyed an average annual growth of 9% in export volume. In 2008, an industry total of over 150 million 13-kg-boxes were exported, generating total revenues of over US$ 400 million (BAS, 2009; PBGEA, pers. commun., 2008). This made the Philippines the second largest banana exporter in the world after Ecuador.

Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *cubense* (Foc), is a real concern of the banana industry. While Cavendish cultivars (AAA), that form the mainstay of banana production for export, are highly resistant to Foc race 1 that destroyed 'Gros Michel' (AAA)-based production in the 1950s, they are susceptible to another virulent strain that recently emerged in Asia (Molina et al., 2009; Ploetz, 2005; Ploetz, 2000). Known as tropical race 4 (TR4), this strain has caused severe epidemics in Cavendish in tropical zones, different from less severe infections previously reported on Cavendish in the subtropics. TR4 also affects other cultivars, including important cultivars grown by small-holder farmers for the local market. The recent confirmation of Foc TR4 in some Cavendish farms in the Philippines (Molina et al., 2008) is of great concern to the industry, as this pathogen poses a potential threat to the long-term sustainability of Cavendish-based exports.

The use of resistant cultivars as a long-term strategy to manage Foc has been hampered by the failure of breeding programmes to produce cultivars with similar productivity and fruit quality as the Cavendish types, to satisfy the inflexible demand of the global banana trade. Some cultivars released from the breeding programme of the Fundación Hondurena de Investigación Agrícola (FHIA) are high yielding and resistant to major banana diseases, including against TR4 (Huang et al., 2005) but are not accepted by the export market. There has been some success in selecting and using some somaclonal variants of Cavendish by the Taiwan Banana Research Institute (TBRI), as part of an integrated approach to sustain banana export (Hwang and Ko, 2004). Some of these were shared with the International *Musa* Transit Centre (ITC) for inclusion in the International *Musa* Testing Programme (IMTP). These were subsequently distributed by ITC through the INIBAP/BAPNET National Repository, Multiplication and Dissemination Centre (NRMDC) programme in Asia for more extensive evaluation and promotion (Molina, 2004). Giant Cavendish Tissue-Culture Variant 'GCTCV-119' (AAA), one of the TBRI somaclones, showed good resistance to TR4 in earlier evaluations in China (Huang et al., 2005). This study is the first field trial to evaluate a Cavendish cultivar against Foc TR4 under field conditions in the Philippines.

METHODOLOGY

Evaluation of Resistance to *Fusarium oxysporum* f. sp. *cubense* tropical race 4

A field trial was carried out to evaluate the resistance of 'GCTCV-119' to Foc TR4 in a commercial field known to be infested with Foc TR4. The popular commercial cultivar 'Grand Naine' (AAA) was also included in the trial as susceptible reference. The field trials were done in small blocks in two farms (Quibilan and Calinan) of the Lapanday Agricultural and Development Corporation, Davao Del Norte, Philippines. These two farms have sections with recent history of serious epidemics of Fusarium wilt. Foc isolates obtained from infected samples of these farms were previously typed as VCG1213/16, the vegetative compatibility group associated with TR4 (Molina et al., 2008).

'GCTCV-119' was obtained from the Bureau of Plant Industries - Davao Research Station, one of the designated NRMDCs in the Philippines, while 'Grand Naine' was sourced from the existing commercial materials used by the company. Planting materials of 'GCTCV-119' and 'Grand Naine' were produced through in-vitro cultures at the tissue-culture laboratory of the Lapanday Agricultural and Development Corporation. The

in-vitro propagated plantlets were hardened in the screenhouse for 8 weeks before being transferred to the field.

The trials were established in the field in May 2007. A total of 250 plants were planted in two replicate blocks for each cultivar. Cultural practices, such as fertilisation, pruning and sanitation, irrigation and drainage, were implemented as recommended for commercial production. Disease incidence was determined by assessing and recording the accumulated number of plants showing typical Fusarium wilt symptoms. Such symptoms include yellowing of older leaves and – in advanced infections – pseudostem splitting. Plants with symptoms were cut down and destroyed by burning with rice hulls. Disease scouting was done on a weekly basis as a part of the normal disease management survey of the plantation. Disease incidence was calculated by taking the ratio of plants with symptoms to the total number of plants assessed in each experimental block.

Evaluation of Agronomic Performance, Yield and Fruit Quality

A separate field trial was carried out to evaluate the agronomic and yield characteristics of 'GCTCV-119' and 'Grand Naine' in a farm with no known incidence of Foc infection. Plant height, days from planting to shooting and days from shooting to harvest were assessed. Yield components were determined by weighing the bunch at harvest, counting the number of hands per bunch andthe number of fingers per hand, and measuring finger length and finger caliper-grade.

Fruit quality of each cultivar, in terms of starch, sugar content and total soluble solids, were analysed in the laboratory of the Lapanday Fruits Company. Analyses were done on fruits immediately after harvest (green), on fruits subjected to ripening immediately after harvest, and on fruits that were ripened after a simulated 15-day transport by storing experimental fruits in boxes kept in refrigerated containers at 14-15°C.

RESULTS AND DISCUSSION

After 12 months of field disease incidence evaluation, no 'GCTCV-119' plants showed Fusarium wilt symptoms, while 36 and 51% incidence was recorded for 'Grand Naine' in Calinan and Quibilan farms, respectively. The high incidence of TR4 on 'Grand Naine' confirms the high inoculum pressure in these farms where Foc epidemics have been observed in the last 4 years. Symptoms were observed in some plants as early as 4 months after planting. The results also confirm that 'GCTCV-119' has field resistance to Foc TR4, as demonstrated earlier in field trials (Huang et al., 2005; Hwang and Ko, 2004).

While 'GCTCV-119' proved to be highly resistant to Foc TR4, its agronomic traits and yield were inferior to 'Grand Naine'. 'GCTCV-119' took longer to mature, with an average of 233 days to shooting compared with 162 days for 'Grand Naine', and had a smaller bunch, and lower bunch weight and hand weight (Table 1). This resulted in a lower yield per crop cycle and per year. Although 'GCTCV-119' had more fingers per hand, these were shorter and thinner (lower finger calibration). As a result, fewer fruits of 'GCTCV-119' met current market standards, giving a lower box/stem ratio of marketable fruits. It was also observed that 'GCTCV-119' had a greater hands curvature resulting in more rejects when packed.

'GCTCV-119', however, had better fruit chemical characteristics. It had significantly higher starch levels (which eventually converted into sugar when ripened), more titratable solids (TTS) and fewer acids (TTS). All these characteristics make

'GCTCV-119' sweeter than 'Grand Naine'. This confirms the results of fruit quality studies conducted by Hwang and Ko (2004).

CONCLUSIONS

Results of the preliminary field trial in the Philippines showed that 'GCTCV-119' is resistant to Foc TR4 under field conditions, in contrast to the commonly grown Cavendish variety for the export market 'Grand Naine'. Yield components were inferior relative to 'Grand Naine' under current market standards. Nevertheless, 'GCTCV-119' has potential as part of an integrated approach to managing Foc TR4 should the market choose to accept smaller fingers, or in a situation where Cavendish could no longer be grown due to severe Foc epidemics. There is also an opportunity to further improve the cultivar through recurrent selections of improved somaclones in plantations of 'GCTCV-119' where tissue culture is used. Although not publicly documented, it is known that some Indonesian commercial Cavendish plantations have already selected and are now using an improved 'GCTCV-119' with better plant height, better bunch size and earlier maturity. This opportunity could be exploited in the Philippines, where tissue culture is extensively used in establishing new plantations and in rehabilitating old ones.

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Tables

Table 1. Bunch and fruit characteristics of GCTCV 119 and Grand Naine.

Cultivar	Bunch weight (kg)	No. of fingers/hand	Hand weight (kg)	Finger calibration (mm)	Finger length (cm)
GCTCV 119	20.5	21	2.4	38.7	19.3
Grand Naine	31.9	18	3.4	45.7	22.6