Studies on sugarcane mosaic in Cuba

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Abstract This paper summarises results obtained in Cuba related to studies on Sugarcane mosaic virus. The phytopathological basis of SCMV evaluation, control measures and designing a control strategy, sources of resistance, resistance of commercial sugarcane cultivars, prevailing races, antibodies for diagnosis and SCMV capsid protein properties are discussed. The importance of improving the methods for resistance evaluation is highlighted and the results obtained in biological modelling of SCMV-sugarcane interactions are examined. Recently, differences observed in resistance response at three testing sites for SCMV evaluation have indicated the need to update the evaluation procedure for a more reliable method.

Key words Sugarcane mosaic virus, resistance evaluation, breeding program

INTRODUCTION

Sugarcane mosaic is widely distributed in the world and its economic significance varies among regions. In the mid-1920s, a disease epidemic threatened the sugar industry in Cuba. Thus, in the breeding program sugarcane mosaic virus (SCMV) resistance is considered as a key selection criterion when releasing new cultivars. Results obtained in the breeding program have allowed the eradication of mosaic from commercial fields.

This paper reports on results obtained in Cuba related to SCMV, including the determination of the phytopathological basis for mosaic control, the establishment of an evaluation system for mosaic resistance in the breeding program, the development of diagnostic techniques and the modeling of host-pathogen interaction based on morpho-physiological indicators. Additionally, results of molecular characterization of Cuban isolates are reviewed; as well as the determination of the effect of SCMV on cane yield.

RESULTS AND DISCUSSION

Results from a national survey (1967-1970) showed that SCMV infections were absent in commercial fields of resistant sugarcane cultivars, and that susceptible cultivars were not infected when they were surrounded by resistant cultivars (Rodríguez 1979).

The climatic conditions in Cuba are favorable for SCMV spread. It was shown that all noble sugarcane varieties (Saccharum officinarum) and wild cane such as S. barberi in the Cuban germplasm are susceptible to SCMV. There are also susceptible cultivars in the other wild species S. robustum, S. sinense and S. spontaneum. Sweet corn and sorghum cultivars are highly susceptible.

In our studies sweet corn juice showed higher virus concentration than sorghum and most of sugarcane cultivars. The highest viral concentration was detected in sugarcane cultivar B34104; thus, infected juice from this cultivar was used as the inoculum source in the screening procedures developed for the breeding program.

Maximum viral concentration was recorded 20 days after inoculation in the first fully expanded leaf (+1). Higher infection rates were obtained when the viral inoculum was diluted in phosphate buffer (22 mM, pH 7.45) and inoculated plants were kept in diffuse light.

SCMV inoculum can be preserved at 4°C for 1 day, but freezing and thawing decreases virus viability. SCMV was inactivated by heating at 55°C for 10 min. Inoculation of sugarcane cultivars Co281, CP29-291, CP31-294 and CP31-588 and differential symptoms showed the presence of SCMV strain B.
The analysis of the main factors related to viral infection in natural conditions showed that the virus was transmitted by *Aphis maidis* (Fitch), but not by *Sipha flava* (Forbes). Under field conditions, viral infection is related to planting season, how close it is to the inoculum source, heavy weed infestation, nitrogen fertilization, age of ratoon and cultivar susceptibility. Sugarcane planted in the summer is infected more than crops planted in the autumn. In addition, higher nitrogen fertilization rates resulted in higher levels of viral infection.

For evaluation under artificial conditions several factors were considered. Three artificial inoculations methods were compared: virus inoculum deposited on the spindle leaf; rubbing virus inoculum onto young leaves; and foliar spraying of viral inoculum using a high-pressure air-blast spray. This last method gave the best results for seedlings inoculation. The use of infusoriun powder as an abrasive and keeping inoculated plants under diffuse light increased the infection rates.

The evaluative system for SCMV susceptibility in the breeding program is presented in Figure 1 (INICA). This scheme has been modified with the artificial inoculation in the final stages instead of the clonal stages.

![Evaluation system for SCMV in the Cuban breeding program (INICA 2011).](image)

SCMV was purified with the aim of producing polyclonal antibodies for the later development of diagnostic techniques. A DAS-ELISA protocol was developed for virus detection. The implementation of this technique also allowed detection and reporting in Cuba of sugarcane bacilliform virus (Rodriguez *et al.* 1986). In addition, immune-microscopy techniques for cell studies in susceptible plants inoculated with the virus was developed. Other analysis based on the amino acidic profile of the capsid viral protein (through HPLC) confirmed SCMV as the causal agent of mosaic in Cuba.

Studies of modelling the host-pathogen interaction showed an increase in nitrate reductase and ribonuclease enzymes in susceptible cultivars from 7 to 14 days after virus inoculation, and later at 35 days, a decrease. In the case of the enzymes phenyl-alanine amioulinase, peroxidase and polyphenol-oxidase, their levels were elevated 28 days after viral inoculation. Thus, plant height, rate of infection, viral concentration and nitrate reductase activity were the variables used as markers of cultivar susceptibility (Piñón 1993).

Despite SCMV eradication from commercial field in Cuba, some symptomatic variations of susceptibility reactions for standard genotypes (controls) have been confirmed at the SCMV testing sites. The inoculum source of each site was characterized by comparing their nucleotide sequences and grouping into SCMV subgroups. They showed a great similarity among them (Puchades *et al.* 2015). This study validated that mosaic of sugarcane in Cuba is caused only by SCMV.
The standard cultivars used in SCMV inoculated trials were assessed. Cane yield, pol% and tonnes pol/ha were recorded and analysed by means of variance analysis. The susceptible genotype C236-51 showed losses of 27% in cane yield and 11% of pol% cane. These results offered a clear relationship between yield and the level of infection with SCMV, and emphasized the importance of improving the procedures to assign resistance ratings to new clones.

These studies have contributed in maintaining commercial fields free from SCMV and to improving the efficiency of the breeding program to obtain new sugarcane cultivars resistant to mosaic.

REFERENCES


Etudes de la mosaïque de la canne à sucre à Cuba

Résumé. Cet article récapitule les résultats obtenus à Cuba sur le Sugarcane mosaic virus. Les bases phytopathologiques de l'évaluation du SCMV, les mesures de lutte et la conception d'une stratégie de lutte, les sources de résistance, la résistance des cultivars commerciaux de canne à sucre, les races dominantes, les anticorps pour le diagnostic et les propriétés de la protéine de capsid de SCMV sont discutés. L'importance d'améliorer les méthodes d'évaluation de la résistance est soulignée et les résultats obtenus dans la modélisation biologique des interactions SCMV-canne à sucre sont examinés. Récemment, des différences observées dans la réponse de résistance sur trois sites d’essais pour l'évaluation de SCMV ont montré le besoin de mettre à jour la procédure d'évaluation pour disposer d'une méthode plus fiable.

Mots-clés: Sugarcane mosaic virus, évaluation de la résistance, programme de création variétale

Estudios sobre mosaico de la caña de azúcar en Cuba

Resumen. Este artículo resume los resultados obtenidos de estudios del virus del mosaico de la caña de azúcar, Sugarcane mosaic virus, en Cuba. Se discute la base fitopatológica de la evaluación del SCMV, las medidas y el diseño de una estrategia de control, fuentes de resistencia, la resistencia de las variedades comerciales, razas prevalentes, los anticuerpos para el diagnóstico y las propiedades de la proteína de la cápside del SCMV. Se resalta la importancia de mejorar los métodos para la evaluación de la resistencia y se examinan los resultados obtenidos en el modelo biológico de la interacciones SCMV-caña de azúcar. Recientemente, las diferencias observadas en la reacción de resistencia al SCMV en tres localidades han indicado la necesidad de actualizar el procedimiento de evaluación por un método más confiable.

Palabras clave: Sugarcane mosaic virus, evaluación de resistencia, programa de mejoramiento