
**A REVIEW OF EXISTING REGULATIONS FOR GM CROPS
AND PROGRESS MADE ON GM SUGARCANE
RESEARCH IN CHINA**

By

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KEYWORDS: Regulations, GM Crops, GM Sugarcane, China.

Abstract

In China, legislation is in place and a system has been established for the safety assessment of genetically modified organisms (GMOs). The Ministry of Agriculture is responsible for the regulation of genetically modified (GM) crops and a Biosafety Committee has been authorised to handle the safety evaluation for such crops. A set of regulations for GM crops has also been promulgated. Good progress has been made in GMO development in the laboratories, but so far no GM sugarcane has reached commercial testing. A number of standard protocols for the detection of GM crops and their derived products have been developed and one for detecting GM sugarcane is currently being formulated.

Introduction

China is one of the countries that grows genetically modified (GM) crops in the world. There are five GM crops presently cultivated in China namely tomato, pepper, poplar, papaya and cotton (Wang *et al.*, 2007). In 2006, GM cotton was the leading crop being grown over 3.5 million hectares and covering up two thirds of the total cotton planting area. With the fast adoption of GM crops, China is also developing biosafety measures to ensure their safe use. A system has been established for the assessment of GM crops and legislation is also in place for their control. The Ministry of Agriculture is responsible for the regulation of GM crops and for agricultural products derived from them. A Biosafety Committee, to oversee agricultural GMOs, is authorised to handle the safety evaluation for all greenhouse experiments, environmental impacts, release, and commercial production. A set of regulations for GM crops, animals and microbes has also been promulgated. In this paper, a review of the various biosafety measures in place in China as well as progress achieved in the development of GM sugarcane is reported.

Regulations for GM crops in China

China has issued a set of regulations for GM crops, animals and microbes. In 1993, the first regulation for the administration of genetic engineering was promulgated by the State Scientific and Technological Commission. Thereafter, more regulations were formulated and five major ones for agriculture were further promulgated by the Chinese State Council (Anon., 2001) and Ministry of Agriculture (Anon., 2002).

The State Council, well ahead of the entry into force of the Cartagena Protocol on Biosafety in 2003, promulgated a primary regulation entitled 'Regulations on Administration of Agricultural Genetically Modified Organisms Safety' in May 2001 (Anon., 2001). This regulation caters for the control of GM plants, animals and microbes with the objectives to protect human health and the

environment. The regulation which contains 56 articles also aims to strengthen control on genetic engineering research and development (R&D), as well as production, processing and trading of GM agricultural products, including plants, animals and microbes. It calls for mandatory assessment of the safety of all GM products being developed as well as for labelling of such products. Research institutions are required to have facilities and techniques to ensure the safety of their research on GMOs. Research institutions developing GMOs, upon completion of experiments, need to apply for a Safety Certificate from the State Agriculture Administration Department (SAAD) for their final product. An individual engaged in the production and processing of GM products must also have the approval from the SAAD or from the provincial level. Products listed and authorised in the GM Product Catalog in China must be properly labelled before they are marketed. The SAAD is also responsible for approving the import of GMOs and GM products while the Entry-Exit Inspection and Quarantine Bureaus are responsible for their export. The SAAD also has the power to ban any production, processing or trading of GM product that is found to be a hazard to human health, and the environment.

Procedures in safety assessment of GM sugarcane

Article 2 of the 'Regulations on Administration of Agricultural Genetically Modified Organisms Safety' developed by the State Council describes the procedures for the assessment of GM crops related to research, restricted field-testing, medium-scale field-testing and productive testing. Restricted field-testing concerns small-scale tests conducted within a controlled system or under controlled conditions. For GM sugarcane, such experiments can be conducted in a contained greenhouse. Medium-scale field-testing can be carried out under natural environmental conditions with appropriate safety measures. The field should be fenced and, in the case of GM sugarcane being tested, no other sugarcane plantations should be present within a distance of 300 metres for non-flowering varieties and 500 metres for flowering varieties, the isolation distance being based on other crop species (Anon., 2002). Productive testing consists of large-scale tests prior to commercial production and application. When an experiment has passed one testing stage and requires testing in the next stage, a new application must be made to the SAAD. If the tests pass the safety evaluations conducted by the Biosafety Committee and a Safety Certificate is obtained, the SAAD may give its approval. Research on GMOs in China conducted by Chinese-foreign contractual cooperation or joint capital or sole foreign capital must have the approval from the competent Agricultural Administrative Department of the State Council.

Four additional regulations, based on the primary regulation by the State Council, concerning safety assessment (Anon., 2002), labelling, processing, and import and export of agricultural products have also been promulgated by the Ministry of Agriculture.

Gene cloning for genetic modification of sugarcane

Apart from the genes obtained from abroad for sugarcane transformation including the *galanthus nivalis* agglutinin (*GNA*) gene from the snowdrop lily (Chen *et al.*, 2004a) and *Hs1 pro-1* gene (Chen *et al.*, 2004b) for pest resistance, as well as the *leafy* (Li *et al.*, 2003) gene for plant flowering, Chinese scientists have cloned a few genes. In 2000, a trehalose synthase gene (*Tsase*) was cloned using RT-PCR based on the sequence of a trehalose synthase gene from the Basidiomycete, *Grifola frondosa*, and the sequence of 2199 bp containing a start codon and a stop codon was transformed into sugarcane (Zhang *et al.*, 2000). A few genes were cloned from the coat protein gene and the NIB coding region of *Sugarcane mosaic virus* (ScMV), namely ScMV-CP-E (Jiang *et al.*, 2006), ScMV-HC-Pro (Liu, 2008), SrMVP1 and *Nib* (Yao *et al.*, 2006a). ScMV-CP-E

is a gene from ScMV-CP and a specific inhibitor to strain E of ScMV. The ScMV-HC-Pro and SrMVP1 genes are factors in RNA-mediated silencing in viruses. The *Nib* gene contains the consensus motif GDD box to resist the virus. The templates to clone the above genes and their pathways are different but they all aim at inhibiting expression of ScMV. In addition, a gene from *Sugarcane yellow leaf virus* coat-protein (ScYLV-CP) was cloned and a ScYLV-CP prokaryotic expression vector was constructed to evaluate the gene's function (Huang *et al.*, 2007). Furthermore, a full-length cDNA library was constructed from a water-stressed plant of *Erianthus arundinaceus* in order to isolate genes for drought tolerance (Liu and Zhang 2008; Cai *et al.*, 2009). For the improvement of sugarcane, the gene BADH (encoding betaine aldehyde dehydrogenase) for drought tolerance (Yu, 2004), and a new promoter Prd29A (Wu *et al.*, 2008) were cloned from *Arabidopsis thaliana*. A gene coding for sucrose phosphate synthase (He *et al.*, 2007) was also cloned from sugarcane and the sequence was analysed. Another gene, resveratrol synthase (RS) from grape was transferred into sugarcane for value-added products (Xu *et al.*, 2008b). RS is one of the key enzymes in resveratrol biosynthesis, which catalyses one molecule of coumaroyl CoA and three molecules of malonyl CoA to form one molecule of resveratrol.

Leading method in sugarcane gene transformation

At the start, sugarcane transformation was mediated by *Agrobacterium tumefaciens* strain LBA4404 (Chen *et al.*, 1996). Another strain EHA105 was found suitable for gene transfer into sugarcane (Zhang *et al.*, 2006). Thereafter, particle bombardment, a direct DNA transforming system suitable for the transformation of monocots, has been used for transformation of sugarcane. This system can transfer minimal gene expression cassettes (promoter, open reading frame, terminator) into plant genomes and also generates safer transformants, in addition to multiple genes delivery. Direct gene transfer now prevails over *Agrobacterium tumefaciens* and is a major approach for gene transfer into sugarcane calli (Chen and Chen, 2004). Almost all existing GM sugarcane lines so far developed in China are as a result of particle bombardment except for one event (Zhang *et al.*, 2000). However, some disadvantages of using the particle bombardment system have been observed. A large population of GM sugarcane plants needs to be screened in order to identify a desirable line, resulting in huge screening costs. Hence, the use of *Agrobacterium tumefaciens* for gene transfer into sugarcane is being reevaluated.

Progress on GM sugarcane research

China has made good progress at the laboratory level on the development of GM sugarcane. The gene *Tsase* was transformed into sugarcane by *Agrobacterium tumefaciens* strain EHA105 in 2000 (Zhang *et al.*, 2000). This gene produces trehalose, a healthy sugar that could be a substitute for sucrose. Three transgenic plants were confirmed by PCR and Dot-Southern blot analysis and are in the stage of restricted field-testing. The transgenic plants are also promising drought-tolerant clones.

Insect pests can cause significant yield losses in sugarcane. In 2004, genes of *GNA* for aphid-resistance and *Hs1 pro-1* for nematode-resistance were introduced into sugarcane calli via particle bombardment and transgenic plants were obtained and tested in the greenhouse. Sugarcane transgenic lines with *cryIA(c)* gene were obtained in 2008 following particle bombardment and an application has been made for restricted field testing (Xu *et al.*, 2008a). The cloning of the coat protein genes of *Sugarcane mosaic virus* (ScMV) was initiated in 2004 and several groups were involved (Yao *et al.*, 2004, 2006; Guo *et al.*, 2008). More than four genes including ScMV-CP-E, ScMV-HC-Pro, SrMVP1, and *Nib* have been cloned and transformed in variety Badila and hybrid

clones. A few GM plants with SCMV-CP-E are now ready for productive testing. A cloned BADH gene for drought tolerance and a new promoter Prd29A from *Arabidopsis thaliana* were transferred into sugarcane callus tissue by particle bombardment. A number of experiments are currently being performed at laboratory and field level for the development of GM sugarcane.

Standards for detection of GM sugarcane

A number of standards have been promulgated in China for the detection of GM crops including maize, rapeseed, soybean, potato, cotton, tobacco, tomato and rice and their derived products. These standards provide guidelines for detecting the GM component and for the biosafety assessment of the GM crops and their derivatives. However, no standard for detection of GM sugarcane has been developed so far. The Ministry of Agriculture is presently working on a Standard for the detection of GM sugarcane and its derived products.

Conclusion

The development of GMOs has progressed extensively in the laboratory in China. Emphasis is also on biosafety measures to ensure the safe use of the GMOs due to the increasing demand from farmers to exploit such crops. It is expected that GM sugarcane will be one of the leading GM crops in the future in view of its specific characteristics for adaptation to less productive lands and due to its non flowering nature in mainland China, thus representing low biosafety issues.

Acknowledgement

This review was financially supported by the China Projects 2007I0036, 20083500039, and 2006-G37.

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**UNE REVUE DES LÉGISLATIONS EXISTANTES POUR LA BIOSÉCURITÉ DES
PLANTES GÉNÉTIQUEMENT TRANSFORMÉES ET LE PROGRÈS DE LA
RECHERCHE EN CANNE À SUCRE GÉNÉTIQUEMENT MODIFIÉE EN CHINE**

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**MOTS-CLÉS: Règlements, Plantes Génétiquement Modifiées,
Canne à Sucre Transgénique, Chine.**

Résumé

LA LÉGISLATION étant en place, un système a été établi en Chine pour évaluer les risques associés avec les organismes génétiquement modifiés (OGMs). Il incombe au Ministère de l'Agriculture de réglementer les plantes génétiquement modifiées (GM) et un Comité pour la biosécurité est autorisé à évaluer les risques associés avec les plantes GM. Un nombre de règlements pour les plantes GM a été promulgué. Ainsi, des progrès conséquents ont été accomplis dans la production des OGMs au laboratoire, mais jusqu'ici aucune canne transgénique n'a atteint l'étape d'évaluation commerciale. Un certain nombre de protocoles standard pour la détection des OGMs et leurs produits dérivés ont été développés. En sus, un protocole est actuellement en préparation pour la canne transgénique.

**UNA REVISIÓN DE REGULACIONES ACTUALES PARA LOS CULTIVOS GM Y
AVANCES EN LA INVESTIGACIÓN DE CAÑA DE AZÚCAR EN CHINA**

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**PALABRAS CLAVE: Regulaciones, Cultivos GM,
Caña de Azúcar GM, China**

Resumen

EN CHINA, existen un marco legal y un sistema establecido para la evaluación de seguridad de organismos genéticamente modificados (OGMs). El Ministerio de Agricultura es responsable de la regulación de cultivos genéticamente modificados (GM) y un Comité de Bioseguridad ha sido autorizado para conducir la evaluación de seguridad para tales cultivos. Asimismo, un conjunto de regulaciones para los cultivos GM ha sido promulgado. Un buen avance ha sido conseguido en el desarrollo de GMO en los laboratorios, pero al momento ninguna caña de azúcar GM ha alcanzado una evaluación comercial. Se ha desarrollado un número de protocolos estándar para la detección de cultivos GM y de sus productos derivados, y actualmente existe uno definiéndose para la detección de caña de azúcar GM.