Transgenic Rapeseed: Research and Management in China

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Rapeseed (*Brassica napus* L.) is the the most studied species in genetic engineering. In Canada and in America, at least 11 transgenic events of rapeseed have been approved for commercial production. Since 1995, Canada, Japan and America in succession have cleared environmental biosafety assessment and approved these varieties for food, feed and environmental release. More recently China and Australia also passed environmental biosafety assessment for some of the transgenic rapeseed events. In March 2004, China approved 7 transgenic rapeseed varieties, including GT73/RT73 from Monsanto and Ms8Rf3, Ms1Rf1, Ms1Rf2, OXY235, TOPAS19/2 and T45 from Bayer company for import as processing raw materials.

Genetic modified rapeseed has been commercially cultivated only in Canada and in America but exported to some other countries like China, Japan and Mexico. In Canada, GM rapeseed accounted for 75 per cent of the rapeseed acres in 2004, of which GT73/RT73 derived varieties accounted for about 42%, and the hybrid rapeseed varieties derived from Ms8 and Rf3 covered about 25%. GT73/RT73 and Ms8/ Rf3 have been the most utilized as parental materials in rapeseed breeding and more than 40 varieties derived from them have been registered and cultivated.

No GM rapeseed is cultivated commercially but research of genetic engineering of rapeseed is active. China has imported up to 3 MT and averagely 1 MT of rapeseed from Canada each year during the last five years. Over 60% of the imported rapeseed is transgenic. Imported rapeseed was approved only for processing materials and not allowed for planting in China.

1. Research of genetic modification of rapeseed in China

China adopted a promotional policy to embrace the benefits of biotechnology and is developing the largest plant biotechnology capacity outside of North America (Huang, Rozelle, Pray, & Wang, 2002).

The genetic transformation techniques have been well established. Transgenic plants have been achieved by *Agrobacterium*-mediated transformation, ballistic bombardment, pollen tube path technique and others. Several dozens of successful transgenic events have been reported; some of the events have been approved for environmental release and for field pilot trials (Table 2). The new traits include disease resistance, pest resistance, high oil content, seed oil profiles, biopharmaceutical traits, herbicide tolerance and hybrid production systems. The priority traits are *Sclerotinia* resistance and quality improvement (Table 2). In Zhejiang, Hubei, Hunan, Beijing, Shanghai, Yunnan and Shichuan provinces rapeseed genetic transformation studies have been reported. In Qinghai province where summer rapeseed is grown, breeding material gathered from various parts of China for multiplication and transgenic rapeseed is also included.

Table 2. Studies of genetic modification of rapeseed in China

Institutions	Target genes	New traits	Reference
Oilcrops Research Institute, CAAS	maize transposon Ac	*Slerotinia* tolerance	Guo *et al*., 2001
Oilcrops Research Institute, CAAS	glucanase and chitinase	*Slerotinia* tolerance	Wang *et al*., 2004
Oilcrops Research Institute, CAAS	Fae1-RNAi construct	Low erucic acid	Lu *et al*., 2004
Institute of Microbiology, CAS	*barnase*	Male sterility	Zhou et al., 1997
Institute of Microbiology, CAS	*oxy*	Herbicide resistance	Zhong *et al*., 1997
Institute of Microbiology, CAS	*bastar*	Male sterility restoration	Peng *et al*., 1998
Institute of Genetics and Developmental Biology, CAS	PAP	*Slerotinia* tolerance	Zhang *et al*., 1998
Institute of Genetics and Developmental Biology, CAS	chitinase	*Slerotinia* tolerance	Yang *et al*., 1999
Institute of Genetics and Developmental Biology, CAS	glucanase and chitinase	Disease tolerance	Lan *et al*., 2000
Institute of Genetics and Developmental Biology, CAS	*FAD2*	Fatty acids improved	Shi *et al*., 2001
Institute of Genetics and Developmental Biology, CAS	CaMV coat protein	Virus resistant	Lu *et al*., 1996
Institute of Botany, CAS	PHB	Biosynthesis of PHA decomposable plastics	Ye *et al*., 2000
Hunan Agricultural University	*Cry1*	Insect tolerance	Guan *et al*., 2000
Hunan Agricultural University	*barnase*	Male sterility	He *et al*., 2003
Xinan Agricultural University	Chitinase	*Slerotinia* tolerance	Lu *et al*., 2001
Xinan Agricultural University	*FPF1*	Flower date modified	Huang *et al*., 2002
Huazhong Agricultural University	Oxalate oxidase and chitinase	*Slerotinia* tolerance	Xu et al., 2003
Zhejiang Academy of Agricultural Sciences	Antisense PEP	High oil content	Lang *et al*., 1999
Shandong University	*cry1Aa10*	Insect tolerance	Hou *et al*., 2002
Tianjing Academy of Agricultual Sciences	*oxy* and *bar*	Herbicide tolerance	Jin *et al*., 1997
Peking University	Transcriptional factor CBFI	Low temperature tolerance	Zhen *et al*., 2000
Huazhong Normal University	cry1Aa10	Insect tolerance	Li et al., 1999

Fudan University	*GNA*	Insect tolerance	Tang *et al.*, 2001
Yunnan Academy of Agricultural Sciences	*TuMV-cp*	Virus resistance	Wan *et al.*, 1995
Henan Normal University	*cry1*	Insect tolerance	Zhou *et al.*, 1993

The Zhejiang Academy of Agricultural Sciences has successfully developed transgenic varieties called Gaoyou No.1 and Gaoyou No.2 through antisense PEP strategy, which contain over 50% of oil content in seed, the highest oil content in the world and show good potential of industrialization. They also obtained transgenic lines with very high erucic acid content. The Hunan Agricultural University is known to develop Bt rapeseed for insect resistance. The Oil Crops Research Institute of CAAS developed transgenic lines with increased resistance to *Sclerotinia* and with high efficiency of phosphorous utilization. They are currently involved in research to elucidate and utilize plant metabolic pathways operating in oilseeds. Low erucic acid and high vitamin E are targeted.

2. Potential environmental risks and transgenic rapeseed

As shown in table 2, there are a couple of foreign genes involved in the experiments; some of the genes are controversial in their biosafety characteristics. In the stage of initial generations, introduced traits of the transformants are genetically unstable and not all the effect of genetic modification could be expected. Food safety and environmental safety concerns may be aroused due to the uncertainty of the impact if they are not properly regulated.

The typical concerns about potential adverse impact of transgenic rapeseed on natural ecosystems raise three questions :

1) Will transgenic rapeseed become hazardous plants, toxic, allergic or invasive to the nature?
2) Will transgenic rapeseed transfer its gene to other species, causing gene dispersal and resulting in hidden risks of food safety and environmental safety?
3) Will transgenic rapeseed cause extinction of other species and impact on biodiversity?

China is a biological diversity centre of *B.rapa* and *B.juncea* (Liu, 1985). Rapeseed is a *Brassica* species, readily crossed with *B.rapa* and *B.juncea*. There are a wide range of important vegetables which are *B.rapa*, such as, Chinese cabbage (*B.campestris* ssp, *Pekinensis*), Hong Caitai (*B.campestris* var.*purpuraria*), Youcai (*B.campestris* ssp.*chinensis*), Wutacai (*B.chinensis* var.*rosularis*), Jingshuicai (*B. japonica*), Caixin (*B.parachinensis*), Genwuqing (*B.campestris* ssp.*rapifera*), and there are also a wide range of important vegetables which are *B.juncea*, such as Genjie, Zhacai (*B.juncea* var.*tumida*), Baoxinjie (*B.juncea* var.*capitata*), Dayejie (*B.juncea* var.*foliosa*), Yajie (*B.juncea* var.*germmifera*), Genjie (*B.juncea* var.*megarrhiza*), Fenniejie, Xuelihong(*B.juncea* var. *multiceps*), Huayejie(*B.juncea* var.*multisecta*), Zhijie(*B.juncea* var.*scelerata*). These plants are an important source of vegetables, edible oils, condiments or animal feed. They are extensively distributed and cultivated all year round. China is also the largest rapeseed producer with an annual production of 12 MT and the planting area of 7.8 M H. Rapeseed is cultivated almost all over the country from East to West and from North to South (Liu 1985). In particular, wild *B.rapa* and *B. juncea* are common weeds found in agricultural fields (Li,1998).

In rapeseed production area, double or triple cropping systems are commonly in practice. It is the most common that rapeseed is grown after a crop of rice or cotton and no crop rotation is done. Volunteer plants are very heavy in these places.

Therefore, gene dispersal with hazardous effect, if any, may pose an extensive impact.

3 Current status of biosafety capacity building in China

Chinese Government has paid much attention to trade and its safety issues. National governments have been struggling to keep up with the new developments in order to ensure that while their citizens are able to enjoy the benefits of this new technology, those benefits do not come at the expense of health, safety or the environment.

In November 1993, the State Science and Technology Commission of China issued the Safety Administration Regulation on Genetic Engineering, which was the first law on biosafety in China. According to this Regulation, three years later, the Safety Administration Implementation Regulation on Agricultural Biological Genetic Engineering was issued in July and entered into effect in December 1996 by the Ministry of Agriculture (MOA), China. In the same year (1996), MOA established the Office of Genetic Engineering Safety Administration (OGESA) to regulate field tests, environment releases and commercialization of transgenic organisms in China. The Guideline for Biosafety Management of Agricultural GMO was issued on May 23, 2001, by Chinese Government. On January 5, 2002, MOA issued three managing documents according to the Guideline, which are as follows : Biosafety Evaluation Regulation for Agricultural GMOs, Import Regulation for Agricultural GMOs and Labelling Regulation for Agricultural GMOs. These three Regulations, implemented on March 20, 2002, fully described the procedures and methods of the RARM of agricultural GMOs, the test of imported GM products, and the label method of Agricultural GMOs. Transgenic rapeseed and its products are listed in the catalogues appended in the labeling regulation.

In order to implement the regulations, technical supporting institutions have been established. Center of MOA for environmental risk assessment of transgenic rapeseed was established and attached to Oilcrops research institute, CAAS. This center is furnished with a well-equiped GMO detection laboratory and with an isolated experimental farm specifically for transgenic rapeseed trials. In April, 2004, the center finished the risk assessment of seven transgenic varieties of canola developed by Bayer (Ms1Rf1, Ms1Rf2, Ms8Rf3, T45, Topas19/2, Oxy235) and Monsanto (GT73) companies. Based on the results and the management regulations of Chinese government on agricultural GMOs, all the 7 transgenic varieties were issued with the safety certificate for import in China as processing raw materials.

Standards for environmental and food risk assessment and for qualitative gene specific detection have been stipulated and issued. Event-specific detection methods have been established and put into identification trials in several laboratories.

4. Conclusion

B.napus is a major source of edible oil and forage protein, while *B.rapa* and *B.juncea* are vital vegetables. All these species are very important in agricultural production and national economy in China. Due to the large reproduction quotient, numerous crossable plants and the persistence of soil seed bank, *B.napus* can transfer transgenes to *B.napus*, *B.rapa* and *B.juncea* etc. Rapeseed has higher probability in gene dispersal than other major crops in China. With more and more transgenic varieties releasing, the problems of gene dispersal and gene stacking must be emphasized. Risk assessment of transgenic crops should be made on a case-by-case basis. Indeed, no crucial biosafety problem has been found and all the transgenic rapeseed events in commercialization are relatively safe, but it does not mean transgenic crops are all safe and no need to regulate. It is also wrong if we deny transgenic techniques and stop the progress in commercialization for the potential risks. It is dangerous to handle the transgenic biosafety issues in an incomprehensive way. In order to push the commercialization of transgenic rape into reality, we need to study how to prevent the transgene escape and how to keep the risks within an acceptable limit.