RICE

RICE AT RISK:
WILL THERE BE A CHOICE WITH GE RICE?

REPORT 2004

RICE AT RISK: WILL THERE BE A CHOICE WITH GE RICE?

GREENPEACE

report | worldwide | **issue** genetic engineering

RICE

RICE AT RISK:
WILL THERE BE A CHOICE WITH GE RICE?

PUBLISHED SEPTEMBER 2004


© GP/DANG NGO

introduction 3

i **GE RICE CAN'T BE CONTAINED** 3
ii **TRADITIONAL VARIETIES OF RICE THREATENED BY GE CONTAMINATION** 4
iii **OTHER ROUTES OF GE CONTAMINATION** 5
iv **PHARMACEUTICAL GE RICE – A SPECIAL THREAT** 5

conclusion 6
references 7

GREENPEACE

published by Greenpeace International
date September 2004
authors Dr Doreen Stabinsky and Dr Janet Cotter
editors Dr Doreen Stabinsky and Dr Janet Cotter
design & layout Tania Dunster, kÏ design, The Netherlands
printing Primaveraquint, The Netherlands
contact persons caroline.clinton@int.greenpeace.org, isabelle.meister@int.greenpeace.org

introduction

Proponents of genetic engineering argue that "co-existence" of genetically engineered (GE, sometimes called genetic modified, GM or transgenic) and non-GE rice is possible. They argue that countries, and even neighbouring farmers, will be able to produce and keep separate GE rice, non-GE (conventional), and organic rice for export and/or domestic consumption. However, there is strong evidence that co-existence for rice is not possible – GE contamination will occur.

i GE RICE CAN'T BE CONTAINED

Cultivated rice has many wild and weedy relatives with which GE rice can, and will, cross pollinate. The main cultivated rice species, *Oryza sativa*, cross pollinates (outcrosses) and produces viable offspring with close wild relatives, notably *O. rufipogon* (Lu *et al.* 2003). *O. rufipogon* is thought to be the ancestor of cultivated rice and is an endangered species in China (Gao 2004). However, it is also regarded as a weed in rice cultivation. In addition, weedy strains of O. sativa such as "red rice" occur where O. sativa is cultivated. This includes southern Europe and the USA where it is an important agricultural weed (NAPPO 2003; Messeguer *et al.* 2004). These wild and weedy relatives grow in close proximity to cultivated rice. Hence, there is a large overlap between the areas of cultivated rice and the wild and/or weedy relatives of rice in many parts of Asia and other rice growing areas (Lu *et al.* 2003).

Cultivation of GE rice will cause these wild and weedy relatives to become contaminated with the GE transgenes (the GE DNA insert). Numerous studies now provide a substantial amount of scientific evidence for cultivated rice outcrossing to non-GE rice (e.g., Langevin *et al.* 1990; Lu *et al.* 2003; Gealy *et al.* 2003; Chen *et al.* 2004; Messeguer *et al.* 2004; Song *et al.* 2002, 2003, 2004; and NAPPO 2003). Cultivated varieties of rice have been shown to outcross with both wild rice species (*O. rufipogon* and *O. nivara*) and weedy rice (mostly O. sativa, or red rice).

Cultivated rice pollen has been recorded at a distance of over 100 metres (Song *et al.* 2004) from the source plants and gene flow (outcrossing) has been observed at a distance of 43 metres (Song *et al.* 2003). However, a separation distance of only 10 meters is required between GE and non-GE rice fields in the USA, which is wholly inadequate to prevent GE contamination. Song *et al.* (2004) suggest an isolation distance of 100 m between GE and non-GE rice or close wild relatives and suggest that sugar cane may be planted as a buffer to reduce GE pollen dispersal. But, it is unclear how practical or effective these measures would be in areas where there are many small-scale producers, where neighbouring rice fields can be much closer than 100 m. In any case, isolation distances will not prevent GE contamination as there are many other routes for contamination to occur (see "Other routes of GE contamination" below).

RICE

RICE AT RISK: WILL THERE BE A CHOICE WITH GE RICE?

Outcrossing rates of rice are lower than those of maize or canola (oilseed rape), but they are still significant. Measured outcrossing rates vary from 0.04 % (Messeguer *et al.* 2004) between cultivated rice and 0.005-0.01 % for cultivated rice to weedy rice and 1.2-2.2 % to wild rice (Chen *et al.* 2004). However, the persistence of weedy rice varieties means that these unwanted populations will become reservoirs for the escaped genes from GE rice. Rice seed has varied dormancy, but weedy rice has a stronger seed dormancy than cultivated rice (Gu *et al.* 2003), increasing the potential for weedy rice populations to persist as reservoirs of GE transgenes that could contaminate future non-GE rice crops. As Messeguer *et al.* (2004) state: ***"Although the gene flow values are relatively low, the shattering and dormancy of the red rice seeds, which ensure their persistence in the field, lead into an undesirable effect of durability of the transferred genes."***

Rice outcrossing already causes problems in rice cultivation. Red rice is a problem weed in many rice-growing regions of the world, contributing to extensive yield losses in some areas. Because of the problems that already exist with red rice, the prospect of herbicide-tolerant red rice is a stated fear for the rice-growing agricultural community (Danley-Greiner 2001). There are concerns that if red rice becomes tolerant to the herbicide used in conjunction with a GE herbicide-tolerant rice, it will become more difficult to control, and of course, will make the herbicide-tolerant variety useless for farmers (Gealy *et al.* 2003; Chen *et al.* 2004).

We can conclude with certainty that gene flow from GE rice to non-GE rice, wild and weedy relatives will occur. The GE contaminated populations of wild and weedy species of rice are likely to be persistent, becoming reservoirs of GE transgenes for further contamination.

ii TRADITIONAL VARIETIES OF RICE THREATENED BY GE CONTAMINATION

Traditional varieties of rice in Asia could become contaminated with GE transgenes if GE rice is grown. Transgene contamination has already been found in local traditional varieties of maize in Mexico (Quist and Chapela 2001; CEC 2004).

GE maize imported into Mexico from the USA for food is now inadvertently being grown in Mexico and has resulted in contamination of local traditional varieties through outcrossing. Farmers in Mexico traditionally save seed from one harvest to the next; sowing and seed exchange between farmers is common. This is in contrast to the hybrid system where seed is bought each year from a seed merchant. The GE contamination in the traditional maize varieties will be highly difficult, if not impossible, to eliminate. It will persist in these local traditional varieties and can spread by seed exchange or cross-pollination. The tradition of locally bred varieties and seed exchange is very similar for rice in parts of Asia. Therefore, just as traditional varieties of maize have been contaminated in Mexico, traditional varieties of rice could become contaminated with GE in Asia.

GE contamination of locally bred traditional varieties is a cultural violation. GE contamination could have adverse effects on biodiversity (for example, if the GE contamination is from an insecticidal GE rice, such as *Bt* rice). Importantly, it will remove farmers' choice to grow non-GE rice by producing widespread GE contamination.


© GP/DANG NGO


© GP/NOVIS

iii OTHER ROUTES OF GE CONTAMINATION

Cross-pollination (outcrossing) of rice in the field is an important route of contamination but it is not the only way that non-GE varieties of rice could become contaminated. The potential for contamination unfortunately exists at many points along both the production and distribution chains.

For example:

* Human error. GE and non-GE rice may become mixed when seed and plants are transferred, for example during sowing; transplanting; harvesting; moving seed or labelling or storing seed and grain. In seed plots there can be planting errors.
* Ineffective segregation. The infrastructure requirements for segregation of GE and non-GE rice are very high, much greater than the infrastructure currently available in many parts of the world. This lack of segregation capacity can lead to contamination of food supplies and seed stocks.
* Trucks transporting GE rice can be the source of GE grains that fall on fields or roadsides during transport and loading. This means that even if GE rice is not cultivated but only imported, contamination of non-GE rice and its wild and weedy relatives could still occur.
* Many small farmers do not own farm machinery and hire someone with a machine to do seeding or harvesting for them. The machinery may operate on several farms during a day or week. GE seed or a GE rice crop could contaminate a non-GE rice farm if the machinery is not specially cleaned in between farms.
* Farmers often sell their rice through middlemen who gather rice from several farms together in one truck for transportation to processing plants (mills). If the truck mixes a single crop of GE rice into a non-GE consignment, it will become contaminated. Similarly, a non-GE rice consignment may be contaminated if the truck was previously used for a GE consignment and not carefully cleaned.
* In many parts of Asia, farmers will grow multiple crops of rice, sometimes as many as three and a half crops in a year. It means they continue to grow rice without a break. Rice seeds that fall in the field during harvesting can germinate during the next cropping cycle. If the first crop is GE, but not the next, there is potential for contamination in the second crop.

GE rice cannot be contained – there are so many routes that can cause GE contamination of non-GE rice. These routes can spread GE rice contamination over long distances and will affect all types of non-GE rice, including hybrid rice. Even if there were rigorous controls placed on the distribution, planting and transport of GE rice, GE contamination would still occur because of human error. GE rice contamination would be highly difficult to eradicate and would probably increase because of the persistence of populations of wild and weedy relatives, which would also become GE contaminated.

iv PHARMACEUTICAL GE RICE – A SPECIAL THREAT

Some crop plants, including rice, have been genetically engineered to produce pharmaceuticals and industrial chemicals (GE "pharm" crops). Box 1 shows some of the wide variety of compounds that are currently being engineered into rice plants. These pharm crops are not intended to be eaten by humans and animals, but to be used by drug companies or in industrial processes. The compounds produced by these plants are often biologically active chemicals and all are potentially toxic to animals and humans. The genetic engineering industry insists that they can produce these compounds by genetically engineering crops such as maize and rice and keep them out of the human and animal food supply. However, many people, including scientists, doubt that these pharm crops can be kept out of animal and human food supplies and are concerned about the possible consequences (see, for example Anon 2004).

RICE

RICE AT RISK:
WILL THERE BE A CHOICE WITH GE RICE?

"Contamination of human foods with plant-made pharmaceuticals can occur through dispersal of seed or pollen. Wildlife, especially waterfowl, can transport seed for long distances, as can extreme weather events such as floods or tornadoes. Harvesting equipment can carry seed residues to conventional fields, seeds can be spilled from trucks, or unharvested seeds can sprout as volunteers amid the following year's crop. Cross-pollination occurs at considerable distances in high winds or by insect, even with self-pollinating crops such as rice." **(Freese *et al.* 2004).**

Moreover, widespread contamination of the non-GE (conventional) crop seed supply in the US increases doubts that GE pharm crops can be contained. As Freese *et al.* (2004) conclude:

"When certified and even breeder seeds, whose cultivation is subject to extraordinary gene confinement measures, become contaminated, it becomes impossible to believe in 100% containment of pharm genes, no matter how stringent the gene confinement measures that are applied (including geographic isolation)."

BOX 1: PHARMACEUTICAL AND INDUSTRIAL COMPOUNDS THAT HAVE BEEN GENETICALLY ENGINEERED INTO RICE PLANTS

Lactoferrin
Lysozyme
Alpha-1-antitrypsin
Dirigent protein
Laccase
Pinoresinol reductase
Pinoresinol-lariciresinol reductase
Secoisolariciresinol reductase
Antithrombin
Serum albumin
Aminoglycoside 3′-adenylyltransferase
CBI (the identity of many compounds are not divulged in applications, claiming this information as "confidential business information")

source: Freese 2002.

Pharm rice could pose a special threat to farmers saving their seed. Ellstrand (2003) considers a hypothetical example of a pharm crop genetically engineered to produce a non-edible, commercial, biochemical compound. The GE transgene producing the chemical is passed to wild or weedy relatives of the crop, which then act as a reservoir for the escaped transgene. This "reservoir" can then return the GE transgene back to the crop at a different place and time, resulting in GE pharm contamination. This becomes especially problematic if farmers follow the tradition of saving seed from one harvest for planting for the next. The frequency of the GE transgene could increase year-to-year as the seed is saved. Eventually, the concentration of the commercial biochemical compound could reach toxic levels in the harvested seed and have an impact on human health. As Ellstrand (2003) states, the scenario is very unlikely, but none of the steps are unrealistic. Therefore, if GE pharm rice ever became mixed with, or contaminated, local varieties of rice where seed is saved, it has the potential to have serious impacts on human health.

conclusion - co-existence is not possible

Proponents of GE argue that "co-existence" of GE and non-GE rice is possible. Lessons from Mexico show that GE contamination cannot be prevented. There are several routes that can lead to the contamination of non-GE rice, and preventing contamination all along the production and distribution chain is impractical and impossible. This contamination will threaten traditional varieties and remove farmers' choice. **Rice must be protected and kept GE-free.**

RICE

RICE AT RISK: WILL THERE BE A CHOICE WITH GE RICE?

REFERENCES

Anon. 2004. Drugs in crops – the unpalatable truth. (Editorial) Nature Biotechnology 22: 133.

CEC (Commission for Environmental Cooperation of the North American Free Trade Agreement) 2004. Maize and biodiversity: the effects of transgenic maize in Mexico. http://www.cec.org/maize/index.cfm?varlan=english. <Accessed 28th August 2004>

Chen, L.J., Lee, D.S., Song, Z.P., Suh, H.S. and Lu, B-R. 2004. Gene flow from cultivated rice (Oryza sativa) to its weedy and wild relatives. Annals of Botany 93: 67-73.

Danley-Greiner, K. 2001. Researchers study potential risk of herbicide-tolerant red rice. 6 April. www.agweb.com. <Accessed 5 August, 2004>

Ellstrand, N.C. 2003. Dangerous liaisons? When cultivated plants mate with their wild relatives. Baltimore, MD: John Hopkins University Press.

Freese, B. 2002. Manufacturing drugs and chemicals in crops. Washington, D.C.: Friends of the Earth. http://www.foe.org/ <Accessed 28th August 2004>

Freese, B., Hansen, M. and Gurian-Sherman, D. 2004. Pharmaceutical rice in California. Comments submitted to California Department of Health Services, California Environmental Protection Agency, and California Department of Food and Agriculture. Washington, D.C.: Friends of the Earth. http://www.foe.org/ <Accessed 28th August 2004>

Gao, L. 2004. Population structure and conservation genetics of wild rice Oryza rufipogon (Poaceae): a region-wide perspective from microsatellite variation. Molecular Ecology 13:1009-1024.

Gealy, D.R., Mitten, D.H. and Rutger, J.N. 2003. Gene flow between red rice (Oryza sativa) and herbicide-resistant rice (O. sativa): implications for weed management. Weed Technology 17: 627-645.

Gu, X.Y., Chen, Z.X. and Foley, M.E. 2003. Inheritance of seed dormancy in weedy rice. Crop Science 43: 835-843.

Langevin, S.A., Clay K. and Grace, J.B. 1990. The incidence and effects of hybridization between cultivated rice and its related weed red rice (Oryza sativa L.). Evolution 44(4): 1000-1008.

Lu, B-R., Song, Z. and Chen, J. 2003. Can transgenic rice cause ecological risks through transgene escape? Progress in Natural Science 13: 17-24.

Messeguer, J., Marfa, V., Catala, M.M., Guiderdoni, E. and Mele, E. 2004. A field study of pollen-mediated gene flow from Mediterranean GM rice to conventional rice and the red rice weed. Molecular Breeding 13: 103-112.

NAPPO (North American Plant Protection Organization). 2003. Pest fact sheet – Oryza rufipogon Griff. Washington, D.C.: NAPPO. http://www.nappo.org/PRA-sheets/Oryzarufipogon.pdf <Accessed 28th August 2004>

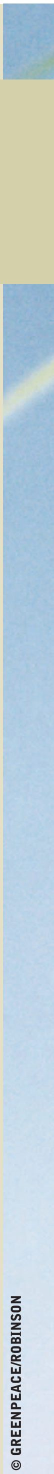
Quist, D. and Chapela, I.H. 2001. Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico. Nature 414: 541-543.

Song, Z.P., Lu, B-R., Zhu, Y.G. and Chen, J.K. 2003. Gene flow from cultivated rice to the wild species Oryza rufipogon under experimental field conditions. New Phytologist 157: 657-665.

Song, Z.P., Lu, B-R., Zhu, Y.G. and Chen, J.K. 2004. Pollen flow of cultivated rice measured under experimental conditions. Biodiversity and Conservation 13(3): 579-90.

RICE

RICE AT RISK:
WILL THERE BE A CHOICE WITH GE RICE?



GREENPEACE

greenpeace international
Ottho Heldringstraat 5, 1066 AZ Amsterdam, Netherlands
t +31 20 514 8150 f +31 20 514 8151
www.greenpeace.org