The response reproduced below was submitted further to an invitation to comment on the draft Discussion Paper by the Nuffield Council on Bioethics: *The use of genetically modified crops in developing countries,* during June to August 2003. The views expressed are solely those of the respondent(s) and not those of the Council.

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This Discussion Paper on the use of GM crops in developing countries is most welcome. We agree with the analysis that more food will have to be produced for an increasing population, and for a rising standard of living as economic development occurs, from the same area of land (at best) and using less water. Consequently it is yields per hectare and per tonne of water that must increase. The yield potential of crops must be raised by breeding better cultivars, using transgenic techniques when appropriate. (This is in addition to the GM crops for better performance in adverse environments, or with improved nutrional value, or resistant to pests and dieases, that rightly receive much attention in the Discussion paper.) Crops with higher yield potential raise the ceiling yields that farmers can strive for, and may reduce the selection pressure on pests and diseases to acquire resistance, if there is a bigger pot for all to share, as it were.

In rice, plant breeders have combined all the genes for high yield using conventional breeding technologies, and a barrier to raising yield potential has been reached (Cassman 1994). One possibility for greatly increasing yield potential and breaking the yield barrier is the introduction of the C4 pathway of photosynthesis. This would also improve water productivity and the efficiency of fertilizer use. Crops with C4 photosynthesis such as maize and sugar cane, in warm and sunny environments, have high rates of photosynthesis, produce high yields, are comparatively thrifty in their use of water, and are more productive per unit of nitrogen. Evolution has not produced a C4 rice (although there are C4 grasses that grow in similar habitats, some of them weeds of rice crops) but a genetically engineered C4 rice might raise the yield potential by 50% and make a substantial saving in water use. It is worth mentioning that in such a rice the rice grain would be essentially unchanged but more grain would be produced per unit of land area, water and fertilizer used to grow it.

We could not find in the draft Discussion Paper any mention of this idea, which continues to attract attention and research effort (Mann 1999, Ku et al. 1999, Surridge 2002). The topic was thoroughly discussed at a workshop held at the International Rice Research Institute (IRRI) in 1999; the proceedings have been published (Sheehy et al. 2000) and have been well received (e.g. Lawlor 2002). Some feasibility studies are in progress at IRRI. These include

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introducing maize genes for some enzymes of the C4 pathway into elite indica rice cultivars, and screening the germplasm collection for any trace of naturally-occurring C4 activity in rice and related species.

Clearly, a C4 rice is an ambitious and long-term project: it will require introduction of about a dozen genes to provide an additional metabolic pathway along with the anatomical modification (Kranz anatomy) associated with productive C4 plants. This is all the more reason for co-ordinated, multi-disciplinary research to be started now. Widespread acceptance of the potential benefits of GM crops in developed countries, and confidence that risks can be identified and managed, will be essential for investors in such research. We hope that the final version of the Discussion Paper will achieve that aim, and that space will be found to mention C4 rice.

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