Summary: Despite the FSEs pioneering efforts in ecological research, their framework for evaluating the biodiversity and environmental consequences of using GMHT, rather than conventional, crops is too narrowly conceived to fully or fairly evaluate the risk-risk trade-offs that underpin the environmental rationale for adopting GMHT crops. In particular, the FSEs give short shrift to several potential environmental benefits of GMHT crops.

Submitted by Indur M. Goklany, Ph.D., 8726 Old Courthouse Rd., Vienna, VA, USA 22182; ph: 202-208-4951; e-mail: igoklany@cox.net

Qualifications: Specialist on the application of the precautionary principle, and GM crops. Author: (1) *The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment* (Cato Institute, Washington, DC, 2001); (2) "From precautionary principle to risk-risk analysis," *Nature Biotechnology* 20, 1075 (2002); (3) "Precaution without perversity: A comprehensive application of the precautionary principle to genetically modified crops," *Biotechnology Law Report* 21, 377-396 (June 2001).

Although the results of the farm scale evaluations (FSEs) provided a bumper crop of information on the biological effects of different herbicide management regimes associated with genetically modified herbicide tolerant (GMHT) and conventional crops, they do not provide a comprehensive assessment of the biodiversity and environmental consequences of cultivating GMHT rather than conventional varieties because they did not evaluate key arguments that underpin the environmental rationale for GMHT crops[1].

In this submission, for the sake of brevity I will not address the issue of gene flow beyond drawing attention to the remarks in the Scientific Commentary at page 18[2].

The environmental rationale for HT crops, whether genetically modified (GM) or conventionally bred, is based on the notion of trading off one set of environmental risks for another, i.e., their environmental justification, if any, would hinge on risk-risk analysis[1,3]. On one side of the risk equation is the possibility that HT crops would enable more efficient weed control resulting in negative effects on species dependent on those weeds, at least in the short run and in the immediate vicinity of farm plots. This aspect has indeed been a major focus of the FSEs. In fact, the FSEs show that in cases where herbicides are already heavily used on conventional crops, employing GMHT crops may not be equally effective in ridding fields of weeds, which is why GMHT maize fares better than conventional maize under the FSEs' biodiversity criteria.

On the other side of the risk equation is the hope that careful use and management of HT crops could have positive impacts on biodiversity which, in the aggregate, could overwhelm the negative impacts of more effective weed control[1]. But the FSEs do not give this potentially positive side of the equation its due.

There are at least three arguments for the positive side of the equation.

Firstly, since a major reason for tilling the soil is to reduce pressure from weeds on crops, HT crops facilitate minimum tillage cultivation. By stemming soil erosion, such cultivation practices protect future agricultural productivity, reduce the transport of particles containing fertilizers and pesticides into aquatic systems and the atmosphere, reduce the turbidity of water entering streams and estuaries, and control the loss of carbon stored in the soil into the atmosphere[1]. In addition, minimum tillage cultivation allows the farmer to leave crop residue on the soil surface, which helps conserve soil moisture and reincorporate organic matter in the soil[4], which further helps the soil sequester carbon. Minimum tillage also reduces fuel consumption on the farm.

Secondly, to the extent that management of a conventional non-HT crop does not sufficiently reduce weeds, more efficient weed control means that the crop has less competition for space, sunlight, water and other nutrients which could enhance yields[1]. If so, less land would need to be cultivated for a given

level of production, thereby helping reduce the single largest threat to biodiversity, namely, the conversion of habitat to agricultural use[5]. That, in turn, would allow more land to be set aside for conservation[5]. Moreover the reduction in the area under cultivation would itself reduce the area subject to greater erosion, and all the other previously-listed erosion-induced negative consequences[1]. It would also reduce any inputs that are applied based on the area under cultivation.

Thirdly, to the extent herbicides are already employed to control weeds, if the herbicides to which HT crops are designed to be tolerant are selected and used prudently, then it might be possible to reduce the overall amount, toxicity and/or persistence of herbicides that would otherwise be used to control weeds[1]. In turn, the pesticide load in water and other environmental media should also be reduced.

Of course, each of these three pro-HT crop arguments, no less than the anti-GMHT crop argument, needs to be verified. It is critical to evaluate all aspects of the risk-risk tradeoff lest the precautionary approach, which the Environment Secretary has indicated the government is taking[6], miscarries and we end up with an outcome which increases, rather than reduces, overall risks[1,3]. But the FSEs fail to do this because their treatment of some of the pro-GMHT arguments is cursory, at best.

The first pro-GMHT crop argument — that it would increase the area under minimum tillage and its associated consequences — is addressed relatively perfunctorily, as is evident from the Scientific Commentary (SC). The SC does so in the context of the potential effects on the abundance of different weeds, while noting that: "In practice, many British soil types are not appropriate for minimum tillage"[7]. However, there is some potential for increased minimum tillage[8]. That ought to be factored into any evaluation, as should the consequences of erosion on water quality, loss of soil carbon, and their impacts[9,10].

Regarding the second argument — that higher yields could free up more land for the rest of nature — the SC notes that because FSEs "were not intended to compare the performance of the crops but rather the effects on biodiversity of management of the crops, data on yields were not necessary and were not collected routinely"[11]. So much for that argument in support of GMHT crops! There are, nevertheless, reasons to believe that yields might be higher for GMHT beet[8,12,13] and oilseed rape[14,15], although not necessarily for GMHT corn[16]. Such yield results would, in fact, seem consistent with the FSEs' results on weed biomass.

With respect to the third argument — that the quantities, persistence and/or toxicity of herbicides employed might be reduced — Champion et al.'s paper notes that pesticide use dropped for two of the three GMHT crops (compared to conventional varieties) — 43% for GMHT beet, 36% for GMHT maize (measured as active ingredient) — but was not significantly changed for the third (GMHT spring oilseed rape)[17]. However, the SC's treatment of this issue is also thin. Notably, U.S.[18] and Canadian[15] experience suggests that herbicide usage might indeed drop if GMHT canola were to be substituted for conventional varieties.

For its part, the Royal Society's press release accompanying the publication of the FSE papers in the *Philosophical Transactions (B)* also notes that herbicide usage generally dropped with HT crops but it, too, is silent on the other environmental arguments in favor of HT crops. Similarly the non-technical summary posted on the DEFRA website notes that GMHT maize would allow farmers to replace more intensive and persistent herbicides, such as atrazine (which, it notes, would be good news for wildlife)[19]. However, it also is silent on the other environmental arguments for supporting HT crops. To make matters worse, neither the Scientific Steering Committee (SSC) information bulletin (on the DEFRA web site[20]) nor the brief summary of results included at the very start of the non-technical summary, which is likely to be read more widely than either the Scientific Commentary or, for that matter, the rest of the non-technical summary, mention the differences in herbicide usage between GMHT and conventional crops. But perhaps worst of all, the SSC's *Final advice to Ministers*, does not acknowledge any of the three elements of the broader environmental rationale for cultivating GMHT crops. No doubt advice to Ministers must be brief and to the point. But brevity cannot excuse lack of balance.

Because neither the FSE papers nor, perhaps more importantly, the brief pieces most likely to be read by the general public do justice to the pro-GMHT side of the risk-risk equation, the debate regarding the environmental merits (or lack thereof) of GMHT crops has been inherently (but, I believe, inadvertently) skewed. Given this less-than-comprehensive evaluation in the FSEs, it is mildly surprising that not all GMHT crops fared worse than their conventional counterparts, as opposed to two out of three.

In summary, despite the FSEs pioneering effort in ecological research, their evaluation framework was too narrowly conceived to fully or fairly evaluate the risk-risk trade-offs that underlie the environmental rationale for adopting GMHT crops. The FSEs confirm what we already knew or suspected — that weed-killers kill weeds, that delaying their use allows weeds to grow larger, and that killing weeds disadvantages weed-feeding invertebrates but favors detritivores. But they shed little light on whether any negative impacts on biodiversity of more effective weed control might be overcome by the positive impacts resulting from higher yields (which would help reduce the amount of land diverted to agriculture), increases in conservation tillage, and net reductions in the amount, toxicity, or persistence of herbicides employed. Unless the evaluation framework used by ACRE (and the precautionary approach) is expanded to incorporate these considerations, there is a danger that the resulting recommendations might, perversely, increase, rather than reduce, environmental risks associated with canola, beet and maize farming. Moreover, for both fairness and transparency, these considerations should be conveyed to the public in the brief summaries of results (which the general public is most likely to read), as well as in any advice proffered to ministers.

I suspect that a proper evaluation of the countervailing risks of using GMHT rather than conventional crops along the lines proposed above would show that GMHT crops, while imperfect, nevertheless could, with appropriate management, provide net gains to the U.K. environment (compared to conventional crops)[1,3]. This would be consistent with the U.S.[18] and Canadian[15] experience which suggests that if GMHT crops are designed and managed judiciously, the net result could be a reduction in pressures on biodiversity, accompanied by improvements in farm income, water quality, conservation of carbon in the soil, and preservation of farm productivity.

References

[1] Goklany, I.M. 2001. *The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment* (Cato Institute, Washington, DC).
[2] Firbank, R.G. et al. 2003. *The implications of spring-sown genetically modified herbicide-tolerant crops for farmland biodiversity: A commentary on the Farm Scale Evaluations of Spring Sown Crops*, online at http://www.defra.gov.uk/environment/gm/fse/results/fse-commentary.pdf, visited on November 12, 2003.
[3] Goklany, I.M. 2002. From precautionary principle to risk-risk analysis. *Nature Biotechnology* 20, 1075.
[4] Fawcett, R. & Towery, D. 2002. *Conservation Tillage and Plant Biotechnology* (West Lafayette, Indiana, USA: Conservation Technology Information Center).
[5] Goklany, I.M. 1998. Saving habitat and conserving biodiversity on a crowded planet. *BioScience* 48, 941-953.
[6] DEFRA news release at http://www.defra.gov.uk/news/2003/031016a.htm.
[7] Firbank, R.G. et al. 2003, p. 14.
[8] May, M.J. 2003. Economic consequences for UK farmers of growing GM herbicide tolerant sugar beet. *Journal of Applied Biology* 142, 41-48.
[9] Firbank, R.G. et al. 2003.
[10] Robinson, R.A., and Sutherland, W.J. 2002. Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology* 39, 157-176.
[11] Firbank, R.G. et al., p. 6.
[12] Dewar, A. M., et al. 2003. A novel approach to the use of genetically modified herbicide tolerant crops for environmental benefit. *Proceedings of the Royal Society (London) B* 270, 335-340.
[13] Strategy Unit. 2003. *Field Work: weighing up the costs and benefits of GM crops: Analysis papers*. Online at http://www.pm.gov.uk/files/pdf/GManalysis1234.pdf, visited on November 12, 2003, p. 47.
[14] Strategy Unit, p. 45.
[15] Serecon Management Consulting Inc. & Koch Paul Associates. 2001. *An Agronomic and Economic Assessment of Transgenic Canola.* Prepared for the Canola Council of Canada. Online at http://www.canola-council.org/, visited on November 12, 2003.

[16] Strategy Unit, p. 48.
[17] Champion, G.T. et al. 2003. *Philosophical Transactions of the Royal Society (London) B* 358, 1801–1818.
[18] Gianessi, L.P., Silvers, C.S., Sankula, S. & Carpenter, J.E. *Plant Biotechnology: Current and Potential Impact For Improving Pest Management In U.S. Agriculture: An Analysis of 40 Case Studies* (Washington, DC: National Center for Food and Agricultural Policy 2002), online at <http://www.ncfap.org/40CaseStudies.htm>, visited November 21, 2002.
[19] Burke, M. 2003. *GM crops: Effects on farmland wildlife* (Farmscale Evaluations Research Team and Scientific Steering Committee, DEFRA).
[20] http://www.defra.gov.uk/environment/gm/fse/index.htm.