

Alexander J Stein, H P S Sachdev and Matin Qaim respond:

Michael Krawinkel raises three issues in his comment to our economic analysis of Golden Rice¹. First, he questions the scientific basis of the assumptions that we have used in our impact assessment. Second, he claims that the development of Golden Rice costs “a lot of money” and would mainly benefit “agrochemistry” companies. And third, he states that biofortification in general and Golden Rice in particular cannot replace any of the established micronutrient interventions for the foreseeable future.

Concerning his first point, Krawinkel stresses that assumptions on the nutritional potential of Golden Rice should be based on biomedical research instead of non-science-based speculations. In fact, our assumptions (which are described in the Supplementary Discussion online of the original article) are based on biomedical research. Small-scale feeding trials carried out at Tufts University (Medford, MA, USA) in the United States indicate that the β -carotene produced in Golden Rice is highly bioavailable to human subjects, with bioconversion factors exceeding those of most other plant-based provitamin A sources². Of course, these results need to be verified with larger samples, especially also with malnourished individuals from Golden Rice target populations. Yet, we feel there is sufficient scientific evidence to substantiate our argument that Golden Rice can contribute to improved vitamin A intakes. The remaining uncertainty with respect to bioconversion and other important parameters is the reason why we chose a scenario approach, using different sets of realistic assumptions. The scenario outcomes show that the assumptions influence the magnitude of the impacts, but not the overall finding that Golden Rice can be very cost-effective. This is also confirmed in a more comprehensive sensitivity analysis that we report in a forthcoming publication³. It lies in the nature of *ex ante* studies that results remain somewhat preliminary; we have stressed this in our correspondence. Nonetheless, we feel that sound *ex ante* research is a crucial prerequisite for efficient research policy.

Regarding Krawinkel's second point, in our original Supplementary Discussion online, we provided an overview of the R&D money invested into Golden Rice that is attributable to India. Including the projected outlay for 2007, the total worldwide cost so far amounts to \$9.3 million. Compared with the estimated annual cost of \$116–312 million for providing the 100 million Indian children with vitamin A

supplements who do not receive them so far (c.f. Supplementary Discussion, Box 1), this does not appear such a huge investment.

It is also a misconception that agrochemical companies would profit directly from bringing Golden Rice to market. Golden Rice varieties are being developed jointly by the private and public sector and, in the framework of a humanitarian mandate, they will be handed over to small-scale farmers who can reproduce the seeds themselves at no extra cost³. The companies involved agreed to waive royalties when Golden Rice is grown by farmers whose annual income is <\$10,000, which applies to over 99% of all rice farmers in India. Although institutional issues can be obstacles for a fair distribution of biotech benefits in general, intellectual property problems have been resolved in a pro-poor way in this particular example.

On the third point, we fully agree with Krawinkel. In the final paragraph of our original correspondence we clearly stress that, in spite of its potential, Golden Rice is no panacea and that a multiplicity of approaches is needed to address the problem of vitamin A deficiency. This backs the “portfolio approach,” that Krawinkel demands. Our research simply suggests that Golden Rice can be a promising and cost-effective additional tool, complementing existing micronutrient interventions.

In his final paragraph, Krawinkel also raises the issue of multiple micronutrient deficiencies and complains that Golden Rice reduces the problem to “single nutrients.” He himself, however, recommends “food fortification and

vitamin A supplementation” as strategies of “proven effectiveness,” ignoring that these interventions also focus only “on one nutrient” in most cases. Obviously, he uses double standards—and this seems to be systematic: he stresses the costs of Golden Rice, but fails to consider the costs of other interventions; he stresses what Golden Rice cannot achieve, but fails to mention that other interventions have their limitations, too. We consider our cost-effectiveness analysis, which uses a uniform standard to gauge costs and effects, as a more science-based approach.

Regarding multiple micronutrient deficiencies, our original Supplementary Discussion (p. 17) pointed out that “we did not look at the possibility of multiple biofortification of rice,” but that such an approach is possible and actually pursued in other research projects. Also, we stressed that “the promotion of dietary diversification [...] is the generally accepted long-term objective to fight any kind of micronutrient deficiency, not just vitamin A deficiency” (p. 18). Nonetheless, on the basis of various transparent assumptions in this *ex ante* analysis, we maintain that Golden Rice could play an important role if it receives the necessary policy support.

COMPETING INTERESTS STATEMENT

The authors declare no competing financial interests.

1. Stein, A.J. *et al. Nat. Biotechnol.* **24**, 1200–1201 (2006).
2. Tang, G., Qin, J., Grusak, M.A. & Russell, R.M., poster presented at the Micronutrient Forum, Istanbul, Turkey, April 16–18, 2007.
3. Stein, A.J. *et al. World Dev.*, in press (2007).

Trends in GM crop, food and feed safety literature

To the editor:

A letter by David Pelletier published last year (*Nat. Biotechnol.* **24**, 498, 2006) highlights the paucity of primary research articles focusing on genetically modified (GM) crop and food safety. This observation, also voiced by others¹, contrasts with trends that I have identified in the worldwide literature indicating a strong increase



in the publication of GM crop/feed studies in recent years². The high percentage (~50%) of opinion and commentary publications in the GM crop/feed literature³ can partly explain this discrepancy⁴. Even so, recent reviews have reported a large number of primary research studies focusing on the safety of GM crops^{5–7} or GM food^{8,9}.