Bt Rice Is A Good Neighbor

– Jussi Tammisola, AgBioView, January 6, 2009 (Assoc. Prof. in Plant Breeding, Univ. of Helsinki, Finland)

Resistance breeding of crop plants was reacted against with biologically untenable claims by a few opponents of genetic modification in the news feature "Is China ready for GM rice?" published recently in Nature magazine [1]. In the news story Dr. Hans Herren, a godfather of the scientifically incompetent report of IAASTD, stated that "Genetic-modification technologies just treat the symptoms rather than dealing with the causes".

That is "political" nonsense. Genetic modification does not breed crops, as its opponents delude themselves, because it is not any doer but an array of new genetic tools. The technology can be utilized by plant scientists for the breeding of any conceivable trait considered useful for human purposes, all kinds of genetic "causes" included. Any geneticist could tell that the advantages of a new plant variety depend first and foremost on its traits and not on the methods used in its breeding [6,7].

Furthermore, fashionable emotional imagery and "Bambi" language was provided in the story by calling wild rice "the panda of the plant world". That was followed with a magic trick: rice cultivars resistant against stem borer were told to threaten wild rice with extinction due to natural gene flow and consequent trait introgression. However, according to the biological science just the opposite is true: the resistance trait could not harm but only help the wild plant species in holding its ground better in its struggle for survival.

In order to get such "panda news" rectified the following correspondence was submitted to the magazine, however without result.

To the Editor of Nature,

In the News Feature on the prospects of Bt rice in China [1], certain claims by proponents of other agendas (Herren, Heong, Andow, Baorong) violate the basics of ecological and population genetics. Contrary to their allegations, rice cultivars resistant against stem borer do not harm wild rice species but are good neighbors aiding them in survival.

When susceptible plant varieties are on a large scale replaced with resistant ones, the epidemic population densities of the pest are often reduced and stabilized to ecologically tolerable levels. Hence, common cultivation of Bt corn in USA has provided courtesy protection against European Corn Borer for organic and conventional farmers in the area as well [2]. Similarly, large-scale cultivation of Bt cotton has reduced the damages caused by bollworm on cotton, wheat, corn, soybean, peanut and vegetable fields in the neighborhood during the decade of Bt cotton cultivation in China [3].

Resistance against stem borer could help wild rice

The opponents warn that the minute natural gene flow from cultivated to wild rice would harm the latter. That is a common misconception, however.

If a gene for a trait beneficial for a plant species is being added into its gene pool, such an addition does not threaten the species but, quite the contrary, increases its genetic diversity and enhances its adaptation potential.*

Respectively, a gene harmful to the plant in its environmental conditions does not become common in its populations but its frequency remains low or negligible due to natural selection. Plant populations only adopt genes which provide them with advantages, not disadvantages.

Resistance against stem borer could only aid and not harm wild rice populations, just as it helps cultivated rice. Depending on a) how often and how bad damage stem borer may make to wild rice, and b) how great metabolic costs may be caused to the plant by the maintenance of the resistance trait, the resistance gene may become established in the plant's populations and its frequency be balanced to appropriate frequencies.**

Similarly, contrary to popular stories, protection against an alien pest (European Corn Borer) could only benefit teosinte, the wild progenitor of maize, in its struggle against extinction. However, resistance against corn borer has not become a realized option for teosinte populations in practice, even if somewhat higher gene flow is occurring in maize (due to cross-pollination) than in the self-pollinating rice. That being the case, should scientists assist the *in situ* conservation of the indispensable gene resources of certain endangered plants by providing their key populations with a few bottleneck traits necessary for their survival in the rapidly changing world?***

Resistances are indispensable in cultivars

Since the domestication of our crop species, these chosen plant species have been developed for much higher efficiency in the production of commodities for human use. Consequently, cultivated plants are now generally growing in much more dense and large populations and may now often provide us with up to 10-30 times higher yields per land area than in their native conditions.

That gradual adaptation of crop species for agriculture during the first 10,000 years of cultivation was the prerequisite for modern human civilizations. However, such vast biomasses also inherently offer much more promising resources for various plant pests to develop into devastating plagues. Therefore, the levels of resistance against various pests shall be enhanced in cultivated plants for ensuring efficient production and food security.

Consequently, resistance breeding has been an inextricable part of agricultural development all along the past century of scientific plant production. Rust-resistant wheat was one of the few core improvements that enabled the Green Revolution in the 1960s. A devastating new race (Ug99) of the very same stem rust fungus may now make world's wheat production collapse within a decade (or require heavy use of expensive fungicides), unless efficient resistance genes are searched for and introduced into thousands of bread wheat cultivars [4]. Maybe genes for complete (non-host) resistance against cereal rusts can be found from rice [5] or some wild grass species among the 10,000 known ones.

Resistance breeding shall not be belittled as a pottering around with symptoms, as Herren does. It has been, and will always be, an indispensable part of proper Integrated Pest Management systems in agricultural production. Now that we are finally finding genetic means for utilising the vast resources of resistance in the Nature, humankind has much better prospects of keeping its bio-economy in balance with the ever changing world ecosystems.

References

1. Qiu J (2008). Is China ready for GM rice? Nature 455: 850-852, doi:10.1038/455850a
2. Steffey K, Gray M (2007). Is the European Corn Borer an Endangered Species? Univ. of Illinois Extension, The Bulletin No. 24, Article 3, November 9, 2007, http://ipm.uiuc.edu/bulletin/article.php?id=865
3. Wu K-M, Lu Y-H, Feng H-Q, Jiang Y-Y, Zhao J-Z (2008). Suppression of Cotton Bollworm in Multiple Crops in China in Areas with Bt Toxin-Containing Cotton. Science 321: 1676-1678, www.sciencemag.org/cgi/content/abstract/321/5896/1676
4. Singh RP, Hodson DP, Jin Y, Huerta-Espino J, Kinyua MG, Wanyera R, Njau P, Ward RW (2006). Current status, likely migration and strategies to mitigate the threat to wheat production from race Ug99 (TTKS) of stem rust pathogen. In: CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 2006, 1, No.054, 13 p., http://dx.doi.org/10.1079/PAVSNNR20061054
5. Coffman R, Ward R (2008). Durable Rust Resistance in Wheat. Res. Project Cornell Univ. www.wheatrust.cornell.edu/about/objective09.cfm
6. NAS (2004). Composition of Altered Food Products, Not Method Used to Create Them, Should Be Basis for Federal Safety Assessment. National Academies of Sciences, USA, July 27, 2004, www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=10977
7. EUCARPIA (1989). Risk Assessment Regarding the Release of Transgenic Plants. Statement of Eucarpia (European Association for Plant Breeding Research), www.geenit.fi/Euc1989.pdf

* That is particularly clear regarding an added gene which is novel to the species and cannot supplant any pre-existing gene allele in the plant's genome. Though, in the beginning, selection favoring or disfavoring the novel gene may have similar effect also on the frequencies of the few gene alleles most strictly coupled with it in the chromosome. However, such a linkage drag effect is only temporary, and it is soon diminished due to genetic recombination in the population.

** If the overall population of stem borer will be stabilized at a sustainable level in China due to Bt-rice adoption, the fitness advantage of the resistance trait in the wild might prove substantially less in the future than it could be today. Consequently, the frequency of the resistance gene may remain low in natural populations in the long run (because just a low incoming gene flow cannot keep the frequency of the resistance gene at a high level in the receiving population).

*** Though, in fact, in situ conservation of the gene resources of an endangered plant species in its few populations remaining in nature is an inefficient or even hazardous exercise, because tiny populations inevitably lose gene alleles, particularly in changing environmental conditions as anticipated for the future. Fortunately, the core of the valuable genetic diversity of wild rice still exists in the thousands of accessions collected during decades for safekeeping in public gene banks. Nevertheless, these main lines were not even mentioned in the news story.

—International Assessment of Agricultural Knowledge, Science and Technology for Development virtually bankrupted scientifically and yielded a diseased report. The prospects of modern genetic science and technology – crucial for food security, energy and environmental protection in the future world – were rebutted and anti-science movement fed in the process. Consequently, prime life scientists left the exercise. By definition, aversion to science and technology cannot advance their transfer to developing countries.

Jussi Tammisola, Assoc. Prof. in Plant Breeding, University of Helsinki, Finland
(former Global Lead Author of IAASTD)