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Commentary

Is There a Need for 'Overkill' in Required Studies for Risk Assessment of Genetically Modified Organisms?

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INTRODUCTION

Public awareness and understanding of the technology behind the creation of Genetically Modified Organisms (GMOs) varies greatly from country to country, and indeed within the different sectors of any one country. Perhaps, it is "the fear of the unknown" at work, or it is just a pure rejection of the idea that "Man is playing God". For whatever reason, and for whatever vested interest, there is often widespread clamor for stringent studies to be carried out when conducting a risk assessment of GMOs.

For example, in Indonesia, regulation on the release of GMOs requires studies on any impact on non-target organisms (NTOs) as well as on soil microorganisms (Machmud Thohari 2014). Similarly, in Vietnam, it is mandatory to determine if there is any impact to the soil environment or ecosystem (Truong 2014), while in Cambodia, there is worry over high levels of damage to NTOs and the environment from GMOs, because of the lack of capacity to cope with such damage if it occurs (Pisey 2014).

All too often, opponents of modern biotechnology (a term used to define technologies resulting in GMOs), and, indeed, the regulators themselves forget that there is already a procedure in place to provide a check and balance; the risk assessment (RA) protocol. Most times, RA is far more stringent when conducted on GMOs compared with when exotic species which are non-GMOs are involved (Tan 2013). It is also overlooked that modern biotechnology can after all be considered a sophisticated new tool in plant breeding, an activity which has been practiced both by farmers and scientists for millennia, and a technology accepted by all and sundry.

While GMOs are currently used in biological and medical research, for the production of pharmaceutical drugs, in experimental medicine (e.g. gene therapy) and in agriculture, this paper is confined to discussions on GMOs in agriculture.

Impact of GMOs

Putting aside threats – real or imagined – for a minute, let us impassively review the impacts of GMOs thus far. Starting in the early 1990s, the commercial planting of GM crops has been growing steadily and by 2012 has covered 170 million hectares (Figure 1) in 28 countries (James 2012). The main commercial GM crops, namely, soybean, corn, canola and cotton, carry herbicide tolerance and insect resistance.

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The rapid uptake of GM crops at a rate of 6% per annum augers well for their reputation, reflecting confidence in their benefits. It has been claimed that the adoption of GM crops has increased crop productivity by a value of US$98.2 billion. It has guarded the environment, by cutting down on 473 million kg of active ingredient (a.i.) of pesticides, and conserved biodiversity by saving 108.7 million hectares of land from being developed. It is also estimated that planting GM crops has helped alleviate poverty among some 15.0 million small farmers and their families, totalling more than 50 million people (James 2012).

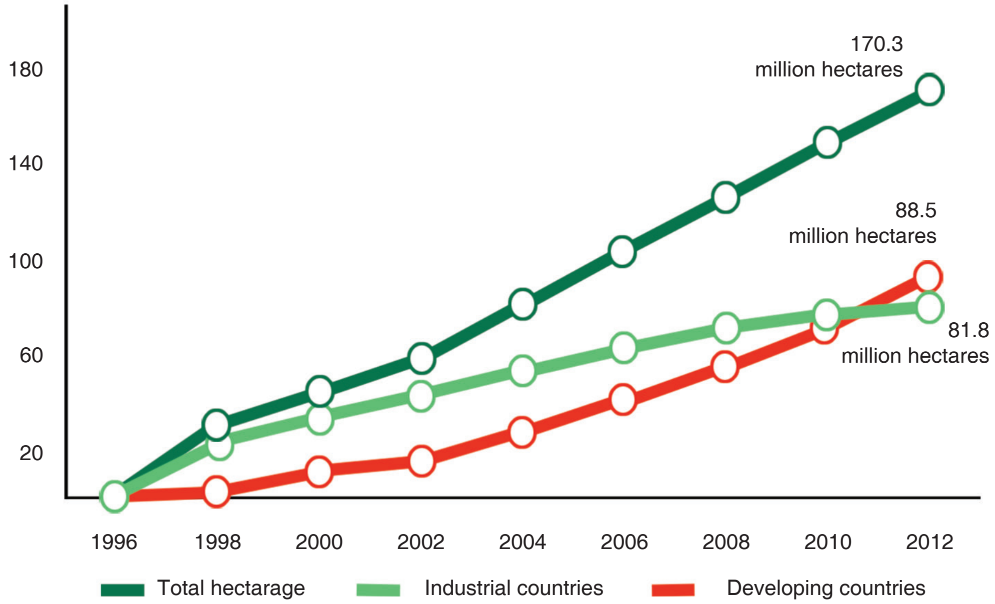

Figure 1. Area under GM crops (1996-2012)

Source: (James 2012)

For example, currently, close to 800,000 ha out of the total corn area of 3 million ha in the Philippines are planted with GM corn. As a result of the move towards growing GM corn, Philippines, which was previously a corn-importing country, has become self-sufficient in the crop, and in 2013 started exporting corn to Korea (Manalo 2014b). Most of the cotton crop (98%) in Australia comprises GM varieties with insect and herbicide tolerance genes. Furthermore, the switch to GM cotton has resulted in more than 80% reduction in chemical pesticide use; this translates into savings amounting to AUD400-700/ha in pesticide cost as well as significantly reducing the drastic harm caused by the previous practice of spraying pesticide as much as 8-10 times per cotton crop (Tate & Richardson 2014).

KEY QUESTIONS RAISED BY THE CONCERNED PUBLIC

1. **Should the Precautionary Principle[2] not be adopted whenever there is doubt or lack of data on the cause and effect of GMOs impacting negatively on human and animal health, or the environment?**

   This is often the clarion call of anti-GMO activists instigating the banning of GMOs, until there is scientific evidence to prove otherwise. However, what is often forgotten is that the Precautionary Principle in its original form reads:

   > "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public,

[2]The Precautionary Principle is commonly used as a basis for environmental and public health policy.

should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action." – *Wingspread Statement* on the Precautionary Principle, Jan. 1998

The operative words are "when an activity raises threats of harm", or in other words, under rather dire circumstances. Oftentimes, the principles of risk assessment reveal that no such threats can reasonably be identified even if no data from in-depth studies are available. In short, the Precautionary Principle should only be invoked when a real need warrants it.

2. Are not studies on the impact of GMOs on non-target organisms (NTOs) always necessary?

First, it should be understood that NTOs can cover a very wide range of living organisms. Even if the question is amended to cover only beneficial NTOs, these can range from soil microorganisms (e.g. N-fixing bacteria, those involved in the breakdown of organic matter and recycling), earthworms and insects (e.g. pollinators, predators, parasitoids) to higher life forms such as fishes, birds, reptiles, amphibians and mammals (including Man). Indeed, non-GMO activists would have us cover the whole gamut of life on earth, regardless of whether some of these life forms are in themselves a danger to human or animal health.

As it is impossible to do impact studies on all organisms, it will be necessary to choose representative species. Selection of focus species is another bone of contention. It is necessary to consider impassively whether there is the possibility of harm in the first place. Several examples follow:

Example 1: Insect-resistant GM cotton, specifically bearing the *bt* gene

- **Risk from the *bt* gene**

  First of all, the gene originates from *Bacillus thuringiensis*, a commonly occurring soil bacteria. Secondly, *B. thuringiensis* has previously been accepted and used as a safe biological pesticide to control lepidopteran pests. Why then is there the distinction and bias against GMO cotton in which the *bt* toxin is now produced by the crop itself to ward of the same pests instead of having the bacteria sprayed on the crop? It would make better sense to use the knowledge and experience gained from testing the safety aspects of chemical pesticides and to apply these to insect-resistant GM crops. Similary, pesticide management practices can be used when growing these GM crops.

- **Risk to beneficial insects**

  The *bt* toxin has a narrow toxicity range, targeting mainly lepidopteran pests. Beneficial insects, such as bees providing pollination services, are unlikely to be affected. Indeed, if there is a harmful effect, they are unlikely to "hang around" the "hostile" GM crop and be killed, when they can fly away to other plants for their nectar. By the same token, would it not mean that planting rice (which is not attractive to bees) is more "harmful" to bees because this agricultural practice has eliminated the native plants frequented by bees?

  Furthermore, consider this fact: The normal agronomic practice for managing the cotton bollworm is to spray chemical pesticides from 8-10 times for one crop cycle. Chemical pesticides kill a wide range of insects, regardless of whether they are pests or beneficials. Would not such a practice invoke greater harm to NTOs than *bt* cotton which only targets lepidopteran pests. Will the management practices for GM cotton in fact increase risks to NTOs?

- **Risk to beneficial soil microorganisms**

  The issue here is soil health. Would planting GM cotton adversely affect soil microorganisms resulting in a poor soil ecosystem? Again, the rationale would be to compare the cultivation of a GM crop with an accepted practice like crop rotation. Switching from soybean (a leguminous crop) to corn (a non-legume) is a widely adopted cropping system in the USA. The growing corn will naturally suppress N-fixing bacteria in the soil. This is not considered bad as it is the result of normal agricultural practice. In other words, traditional crop rotation affects the relative populations of microorganisms (NBSI 2013), probably much more so than a GM crop will. It should be remembered that the microorganisms in a soil ecosystem are always in a state of flux; with constant changes of certain species dominating others depending on prevailing environmental conditions (Turner *et al*. 2013). It is more important to determine whether such changes will affect soil health; thus, instead of doing difficult studies on the effect on soil microfauna and microflora, it may be easier to do crop performance tests after growing a GM crop, and to look for any differences in terms of negative effects.

- **Risk of gene flow to NTOs**

  This is unlikely because other than a very low level of outcrossing with *Gossypium barbadense*, cultivated cotton (*G. hirsutum*) is not cross-compatible with other *Gossypium* species (OGTR 2002). Gene transfer to unrelated plant species is even more highly improbable because of genetic incompatibility barriers that are well documented for distantly related plant groups. There is also no evidence of horizontal gene transfer from cotton to other plant taxa (OGTR 2002).

- **Risk of resistance build-up in GM crop**

  The building up of insect resistance usually occurs when chemical pesticides are used in conventional agriculture. This should be used as the starting point in the risk assessment of insect-resistant GM crops. Thus, if the pest develops resistance to the GM crop, there is actually no greater harm than if insecticides had been used. The efficacy of the GM product is more of an issue than a problem of a greater risk to the environment. Hence, it is a stewardship issue which involves appropriate management strategies.

  A few strategies can be adopted to ensure that there is lower likelihood of a build-up in resistance. One of them is employing the refuge policy. A ‘refuge’ refers to a crop of the same or a related species that is planted nearby to enable growth and reproduction of the target pest without the selection pressure imposed by the *bt* toxin (Qiao *et al*. 2010). For instance, in the Philippines, conventional (non-GM) varieties are used: first, as border rows (and as pollen trap plants), and later, as mixed seed (“bag in a bag”), when selling GM seed to farmers. The ratio of GM: non-GM seed can range from 80:20 to 95:5; depending on the perceived likelihood of risk (Manolo 2014a). Refuges are used to dilute the effect of any resistant insects. Resistance will probably still develop, but this strategy slows it down; furthermore, continuous monitoring for resistance build-up is carried out.

Example 2: Herbicide-resistant GM corn, specifically bearing the glyphosate-resistant gene

- **Risk of weediness**

  The principles of post-border weed risk assessment can be adopted, giving due attention to the following in the GM crop:

  (i) Is there a significant change in the morphology?

  Changes associated with weediness are quite readily recognised, e.g. if the GM corn produces thorns, has rambling growth, aggressive roots and/or toxins, then there is reason for concern because these are the traits of weeds.

(ii) Is there an increased capacity to spread or persist?

A higher risk of invasiveness can be gauged from:

- Ease or speed of establishment
- Greater tolerance to weed management practices
- Increased reproductive ability
- Higher dispersal ability (including by deliberate human spread)

3. Will GM crops threaten the environment and biodiversity?

We should be reminded that the practice of agriculture in itself is already a threat to the environment and biodiversity. To farm, forests have to be cleared, which means significant losses in flora and fauna in that area, not to mention major changes in the diverse microbial populations in the soil (including soil losses through erosion where the land gradient so predisposes the area) right after land-clearing. Subsequent activities associated with agriculture, such as fertiliser applications and pest (including weeds) control measures, further threatens the environment and biodiversity – the former by its direct effects on soil microorganisms, and the latter through absolute and indiscriminate kill.

Thus, given this scenario, will GM crops be any worse, or could they, for a fact, curb some of the harm resulting from normal farming practices? Consider this: In the Philippines, a cocktail of pesticides is usually used to grow eggplants, with spraying up to 80 times in a crop cycle. Added to that, after harvest, the fruits are dipped in an insecticide solution (Manalo 2014a). The question then arises: Would not the planting of *bt* eggplant be less harmful to the environment and biodiversity? Why then should different values be imposed on GMOs when carrying out a risk assessment?

4. Will GM crops pose a risk to human and animal health?

In a nutshell, GM crops are developed for very specific targets, e.g. *bt* crops produce a toxin which protects them from lepidopteran pests. Yet, there is always the worry that the transgene will interact in an unpredicted manner with other genes in the recipient organism and give rise to new novel and toxic proteins. The history of safe use of GM crops as food, food ingredient or feed for more than 20 years should be dispel such a doubt … nevertheless, it persists. This concern should and can be allayed by using the established food safety protocols, e.g. like those in Codex Alimentarius (2014), for testing food products.

Further, the perceived harm from GM crops should be taken in context. Using the previous example of *bt* eggplant in the Philippines, compared with conventional non-GM eggplant, which is sprayed up to 80 times with pesticides, followed by postharvest dipping in insecticide, would not the GM eggplant be safer to eat than the ‘normal’ eggplant?

Some Concluding Remarks

Sometimes, regulators of modern biotechnology may be their own worst enemies. Rightly or wrongly, they are invariably ‘influenced’ by the nay-sayers; bending over backwards to accommodate to their every whim, which may occasionally not work in their favour.

For example, in most countries when conducting field trials on GM crops, it is necessary to choose an isolated area (far from production areas of the non-GM crop equivalent). The field trial has many border rows, including a physical barrier (such as a fence) and bears a warning sign board that a GM crop is under evaluation and to keep out. Finally, at harvest there are stringent measures to destroy the crop and to prevent seed and fruit from being taken out for general propagation and consumption. Such a protocol is adopted to ensure proper and safe handling of GMOs, as well as to put the public’s mind at rest that the regulators and the technology developers are carrying out their duties responsibly with regard to protecting the environment. However, it can raise unexpected and heightened anxieties on the part of the public! From the layman’s point of view, the protective measures taken and the isolation of field trials on GM crops may arouse more suspicions over their safety. The subsequent destruction of the harvested crop and prohibition of its consumption, either as food or feed, may also give rise to more anxieties.

The overlying guiding principle in risk assessment of GMOs should be examining the safety of the GMOs in the proper context. The identified hazard should be weighed against the harm caused by conventional practice in the absence of the GMO. Furthermore, each GM crop can be tested for its efficacy and any perceived risk assessed for its safety using established guidelines and protocols already adopted:

- For testing of pesticides (Martínez Vidal & Garrido Frenich, 2006)
- For weediness (e.g. post border weed risk assessment)
- For food or feed (e.g. Codex Alimentarius)

All said and done, more effort has to be directed towards developing greater public awareness to acquaint the man in the street with what are GMOs and why are they developed as well as the checks and balances being practiced throughout the process of creating and testing a new GM crop variety, right up to its release for public use and consumption.

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