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GMOs and poverty: definitions, methods and the silver bullet paradox

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ABSTRACT

The question of whether genetically modified (GM) crops can help the poor is of urgent importance yet difficult to answer. This essay identifies two problem areas: methodology and implementation. Given the extraordinary diversity of both GM crops and poor populations, it is perhaps better to ask "Which poor could a specific GM crop benefit, and how?" Most GM crop analyses use narrow indicators over short time scales and neglect key variables such as institutions. Moreover, they suffer from a "silver bullet" paradox: both proponents and opponents of GM crops agree that they do not solve all the problems of smallholder farmers, yet they are continually adopted as though there were no alternative. The essay concludes with a call for cross-disciplinary approaches and a more differentiated definition of "poor".

RÉSUMÉ

Les cultures génétiquement modifiées (GM) peuvent-elles aider les pauvres? La recherche sur cette question soulève deux grandes problématiques. D'abord, elle pose des problèmes d'ordre méthodologique. En effet, vu l'extraordinaire diversité des cultures GM et des populations pauvres, il vaut mieux se demander : à quelle population pauvre une culture GM déterminée peut-elle profiter, et comment? La plupart des analyses de ces cultures utilisent un ensemble restreint d'indicateurs, sur une courte échelle temporelle, et elles négligent des variables clés telles que le cadre institutionnel qui régit leur introduction. De plus, la recherche souffre d'un problème d'implantation : le paradoxe de la "solution miracle". Bien qu'on reconnaisse que les cultures GM ne solutionnent pas tous les problèmes des petits agriculteurs, on continue néanmoins à les adopter comme si c'était là le seul choix possible, sans égard pour des stratégies d'ensemble impliquant des comparaisons et des complémentarités avec d'autres types d'interventions. En conclusion, cet essai met l'accent sur l'adoption d'approches empiriques plus différenciées, mieux contextualisées et à long terme, ainsi que sur le développement d'approches interdisciplinaires intégrées.

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How are we to think about the question "Can genetically modified (GM) crops help the poor?" This commentary unravels the terms of this debate and focuses on two key areas, one regarding methodology and one regarding implementation. The goal is to

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provide an analytical landscape in which to consider whether and how GM crops may help the poor.

Which GM crops?

The first term to analyse is "GM crops". Here we must begin with differences in terminology. The terms "genetically modified", "genetically engineered" and "transgenic" are often used interchangeably, but can refer to very different phenomena. "Genetically modified" is the broadest term, and can be used to refer to essentially any crop, since farmers have been genetically modifying seed via selection for centuries. The term genetically engineered is more precise, as it locates the altering of genes to a process of engineering, which generally connotes a specific set of actors, namely scientists in laboratories. This term, however, can also include those scientific processes which are otherwise known as "conventional" breeding techniques, including but not limited to the use of radiation to promote mutation. Transgenic is the most precise term, as it refers to taking a gene from one species and transferring it to a different species. This process is commonly what is referred to when considering all three terms, genetically modified, engineered or transgenic. Despite its faults, I will use the term genetic modification – or GM – in this essay, but use it in reference to transgenic processes.

Notwithstanding these differences in terminology, the expression GM crops refers to a wide diversity of traits, crops, proteins that confer a particular trait and germplasms, which makes it difficult to reach broad generalisations about their performance. One GM crop with a trait and one specific protein introgressed onto a particular germplasm and introduced into a particular socio-agro-ecological context could have vastly different outcomes and experiences than a different GM crop. It is important to narrow performance analysis to a particular crop, trait and socio-ecological context. The incredible diversity of GM crops makes any broad generalisations about their impacts on the poor tenuous.

One important distinction is between what can be called "first-generation" GM crops and "second-generation" GM crops (Schnurr 2015). First-generation GM crops refer to those commercialised GM crops that have been primarily developed for large-scale industrial agriculture. The two most common traits are insect resistance (Bt, or *Bacillus thurengiensis*) and herbicide tolerance (HT), with either trait, or a combination of those traits, conferred onto one of four crops: cotton, maize, canola or soy. First-generation GM crops constitute the vast majority of GM crops currently in the hands of farmers. One of these first-generation crops, insect-resistant cotton – Bt cotton – is by far the GM crop most widely grown by poor smallholder farmers in the Global South (James 2014).

Second-generation GM crops include a broader suite of crops and traits, most of which have yet to be commercialised. These include the Artic Apple engineered not to brown, Omega-3-enhanced soy and the reduced-bruising potato, to name a few. Many second-generation GM crops are engineered to specifically address issues faced by poor smallholder farmers in the Global South. These include the disease-resistant Matooke (cooking banana) and disease-resistant cassava, among others. It must be noted that all the crops mentioned here have yet to be commercialised, so it is still unknown how they will perform in the hands of farmers. Moreover, the next generation of genetically modified organisms (GMOs) – or GM crops 3.0 – in the form of Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR) technologies may not be far from field trials

and commercialisation, which could set off another round of considering the appropriate role for genetic alteration techniques in agriculture (Caplan et al. 2015).

In short, our only knowledge of how GM crops perform in the hands of poor farmers is with first-generation GM crops, and Bt cotton in particular. We do not know how second- or third-generation GM crops will perform in the hands of poor Global South farmers. Notwithstanding issues with the diversity of crops, traits and contexts mentioned above, studying the performance of Bt cotton is our best empirical window into how other GM crops may perform in the hands of poor smallholders in the Global South.[1]

Which poor?

Before introducing the track record of Bt cotton, it is important to make two points about the term "poor". First, it is often assumed that the referenced poor are smallholder farmers in the Global South; however, this is not always necessarily the case. Notably, in Argentina, proponents herald the revenue generated from the export of GM soy as beneficial to both the rural *and* urban poor. Second, the rural farming poor encompasses an incredibly wide range of people, farming strategies, levels of capitalisation, labour patterns, land tenure regimes, ethnic groups, capabilities, educational levels and agro-ecological contexts. In this diverse matrix it is more fitting to ask *which* poor GM crops may help.

The diverse matrix of rural farming poor makes it essential to study how GM crops affect groups differently. One important variable to consider is class. As Bernstein (2010) notes, rural farmers can be roughly divided into three groups: (1) those who derive their livelihood primarily as paid agricultural labourers; (2) those who depend on family labour to grow their own food and trade or sell small surpluses; and (3) those who are engaged in more capitalist styles of farming. This last group tends to produce and trade cash crops, hire paid labour and make use of agricultural inputs including improved tilling techniques, pesticides and fertilisers. All three of these groups can fall under the same umbrella of "the poor", but each has different interests, capabilities and desires (see also Smale 2016). If, for example, GM crops principally help highly capitalised farmers, then one could answer that they help the poor, though perhaps not the poorest. Such a distinction opens up a debate on who should be the targeted beneficiaries of agricultural development interventions.

Another important distinction is gender. Some GM crop analyses treat the household as a single static unit, failing to take into account the different impacts for men, women, young and old. A GM crop is likely to benefit members of the household differently depending on the particular context. For example, if, as in Burkina Faso, the principal monetary beneficiaries of cotton are men, then the economic benefits of Bt cotton will primarily accrue to male household members. And since family female labour is essential to the successful production of cotton, any additional expansion of cotton growing will likely require additional unpaid female labour. Such gendered dynamics are important to investigate. A focus on gender is particularly needed as women comprise a large segment of the rural poor, and greater control over household resources by women leads to more spending on nutrition, education and child welfare (FAO 2015).

A number of other variables, including access to land, access to credit, educational levels, livelihood strategies and agro-ecological context, can also be responsible for driving GM crop adoption and performance requiring close analysis of local context

(Glover 2010). Many of these variables interact in important ways, blurring static and standard categories such as class and gender. For example, women who live in households that employ different agricultural livelihood strategies (for example, export cash crop production versus household food consumption) will experience the introduction of an improved technology such as Bt cotton in different ways.

In sum, GM crops enter complex socio-environments requiring careful analysis of the impacts on a diversified poor. I now turn to a discussion of the Bt cotton literature and how the recognition of the diversity of GM crops and the diverse types of poor may affect their analysis.

Bt cotton in the Global south

It is beyond the scope of this commentary to comprehensively review the literature on Bt cotton in the Global South. A number of authors have done extensive reviews, including Smale et al. (2006), Tripp (2009), Glover (2010) and more recently Fischer et al. (2015).

There are three general takeaway points from the literature. First, average yields and profits rose for smallholder farmers in the initial years after adopting Bt cotton. Second, benefits from Bt cotton varied considerably, and eroded or ended after a number of years. Third, the institutional context of adoption is an important, though underappreciated, factor when judging Bt cotton performance. I discuss these findings in relation to the method of evaluating Bt cotton below.

Narrow indicators

The two most common metrics to evaluate GM crops – average yield and profit – are needed but ultimately too narrow to fully assess whether and how they help the poor. First, let us consider averages. Averages are good at generalising across space and time to give an overall look at GM crop performance, but their power to generalise is also their greatest weakness. Averages obscure differences, and it is precisely the differential impacts of GM crops that are needed to assess their impact on the poor. Glover (2010) reports a high standard deviation of benefits in many GM crop analyses, which further underscores the need to unpack who benefits and who loses from these technologies. Unfortunately, analyses that report averages tend to dominate popular debates regarding GM crop performance for the poor.

Similarly, economic metrics are important but are also too narrow to definitively state whether GM crops help the poor. A majority of GM crop analyses use economic metrics such as profit to measure success. Profit is an important metric to evaluate and deserves to be a large part of any comprehensive evaluation of GM crop performance. However, poverty is a complex, multi-faceted social phenomenon, and economics is only part of the story. Other variables, including education, access to land, women's empowerment, food security and health, among many others, play a role in poverty and may be affected by GM crop introductions (see Schnurr 2016 and Smale 2016). To measure the linkages between GM crops and other variables influencing poverty is a daunting task. Even isolating the economic impacts of GM crops is an incredibly arduous process (Stone 2012); however, given the intense interest in GM crop performance and its relation to the poor, it is imperative to move the discussion beyond averages and profits.

A growing number of GM crop analyses do move beyond average yields and profits, but they are too few and fail to receive the importance they merit. Some examine differential impacts. For example, Subramanian and Qaim (2010) demonstrate benefits for women in central and southern India via increased labour returns. In the Philippines, Mutuc, Rejesus, and Yorobe (2013) show that farmers with larger irrigated farms are more likely to adopt Bt maize as opposed to their smaller, non-irrigated neighbours. Others link GM crops with broader metrics of wellbeing. For example, Qaim and Kouser (2013) link the cultivation of Bt cotton to higher household caloric intake. Overall these analyses should be applauded and built upon to complement our knowledge of GM crops in the Global South.

Short-term benefits

The benefits of Bt cotton for smallholder farmers decline with time, raising the question of whether short-term benefits are worth the intervention. Though Bt cotton in China, India and South Africa initially improved profits, these began to decline after several years of production.[2] The primary reason for a decline in profitability is the emergence of secondary pests, which require additional pesticide applications to control. Glover (2010) reviews the empirical record of GM crop introductions in China, South Africa and India and convincingly shows how pesticide use increases with time after the initial introduction of Bt cotton, eroding and eventually erasing any profit gains. The relatively short time-horizon of benefits for these farmers raises a number of important questions in relation to benefits to the poor: How long can GM crops help the poor? Is any short-term benefit worth it? How do smallholders who have experienced increases and then decreases in profits view their decision to adopt? The short-term nature of Bt cotton benefits has important implications when comparing GM crop introductions with other development interventions, a point I turn to below.

Institutions

A related variable affecting the length of Bt cotton benefits is institutional context. Analyses from South Africa and Burkina Faso demonstrate how institutional factors initially facilitated and later diminished GM crop benefits for the poor. Access to reliable credit is essential for poor smallholder farmers to purchase high cost Bt cottonseed. In South Africa, credit for smallholder farmers to purchase Bt cottonseed was initially available, leading to enthusiastic and swift adoption. However, after the secure credit mechanism dissolved, most poor smallholder farmers gave up the production of Bt cotton altogether (Schnurr 2012). Bt cotton in South Africa is now almost exclusively grown by commercial farmers and the relatively well-off.

In Burkina Faso, Bt cotton investors were attracted to the country given its vertically integrated cotton sector. Only one entity – the cotton company – controlled all seed distribution and cotton lint collection, making Bt cottonseed distribution easy and the credit mechanism very secure (Dowd-Uribe 2014a).[3] Burkinabè smallholders quickly adopted Bt cotton after commercialisation in 2008, reaching 70 per cent of all smallholders by 2013 (ISAAA 2015). However, in 2014, Burkina Faso began to phase out Bt cotton entirely due to issues with the poor lint quality of Bt cotton cultivars. Burkinabè cotton companies,

not farmers, made the decision to begin phasing out Bt cotton, citing heavy losses in reduced demand for their cotton on global markets (Dowd-Uribe and Schnurr 2016). Ultimately the hasty introduction and concentration of power within the cotton companies led to a rejection of the technology. Moving forward, such institutional dynamics merit greater attention for those interested in whether and how GM crops can help the poor.

Double counterfactual

The question "Can GM crops help the poor?" orients our attention to GM crops rather than a broader set of strategies that also may benefit poor farmers. In truth, the lead question is rhetorical. Of course GM crops can help the poor. After considering the wide variety of GM crops and the diverse matrix of the poor, it is relatively easy to find many examples of particular crops helping a particular poor. The same conclusion can be drawn with other development interventions such as integrated pest management (IPM) programmes. They too help the poor. As noted above, the question is best oriented to *which* poor the GM crops may benefit, for how long, and at what cost?

Some draw attention to the methodological difficulty in isolating the effect of the GM crop, something researchers call the counterfactual problem (Stone 2012). Isolating the effect of the GM crop is important in order to know whether and how that crop benefits the poor. The difficulty arises from two problems: selection bias and cultivation bias. Selection bias is the tendency for early GM crop adopters to be more productive farmers. Thus, GM crop analyses are predisposed to measure an increase in yields and profits as the farmers who planted them were likely to be more productive with or without the technology. The cultivation bias refers to the extra care farmers may give their GM crop fields due to the high seed cost. In other words, the extra care that farmers give their GM crops may be the reason for higher yields, rather than higher yields resulting from the GM crop itself.

An additional counterfactual challenge for GM crops is the lack of comparison with other agricultural development interventions. GM crops are seldom if ever compared to other strategies to benefit poor smallholder farmers. This results in what can be called a double counterfactual problem: GM crop analyses are often predisposed to measure a positive outcome for the poor due to selection and cultivation bias, and the lack of a comparison with other development intervention limits thinking to GM crops alone. In other words, the double counterfactual problem leads one to think that if GM crops help the broadly defined poor, then they should necessarily be pursued as a development intervention.

Empirically comparing GM crops to other agricultural development interventions would be a complex methodological challenge. Nonetheless, simply considering the criteria upon which interventions could be compared helps to re-centre GM crops as one of many interventions that could address poor smallholder farmers. What could the metrics of such an evaluation be? The equitability of outcomes? Average profits? Food security indicators? Cost-effectiveness? The greatest potential for long-term impacts on poverty? A consideration of these criteria orients the discussion from whether GM crops help the poor to whether GM crops are the best or most appropriate strategy to help the poor.

Silver bullet paradox

In the polarised debate of whether GM crops can help the poor, it is difficult to find common ground. On one account, however, there is broad agreement. Both proponents

and opponents agree that GM crops are not a silver bullet strategy for the myriad challenges facing poor smallholder farmers. GM crop advocates such as Calestous Juma state that "biotechnology alone cannot solve the world's agricultural challenges. But even though it is not a silver bullet, it should still be included in the package of technological options available to farmers" (Juma and Gordon, 2015, 1). Matin Qaim (2014, 136), referenced above, states clearly that "Bt technology is not a silver bullet". Vandava Shiva, an ardent opponent of GM crops, agrees, with a twist: "Monsanto gets the silver, Farmers get the bullet".[4]

The paradox lies in the fact that, despite this agreement in principle, in practice GM crops are developed and implemented as though they were silver bullet solutions.[5] In other words, GM crops are developed and introduced without linkages to other complementary interventions. What accounts for this apparent paradox? The private financing behind the development and deployment of most GM crops is a good place to start. GM crops are primarily developed by private capital often in conjunction with other private and/or public enterprises. Private development of a technology puts a premium on a relatively quick return for investors. This speed of return on investment has been implicated in the lint quality issues in Burkina Faso, reported above. But this speed can also be related to the lack of connection made with other interventions.

GM crop interventions are rarely combined with other development interventions and rarely include poor farmers in choices of which GM crop technologies to pursue. Pairing GM crops with other interventions, such as IPM techniques, or including poor farmers in GM crop production trajectories makes good sense, but is not intentionally pursued. Pursuing such pairings would require GM crop developers to coordinate with or fund complementary interventions, or take several more years in the development of appropriate technologies. In both cases, this would delay a return on investment. A lack of connection to IPM interventions is particularly unfortunate, as IPM techniques would likely increase both the equitability and duration of GM crop benefits, two of the greatest challenges they currently face.

GM crop interventions may also take resources away from complementary interventions. As a researcher in Burkina Faso, I witnessed how a GM crop introduction can capture the employee time and institutional resources of public entities (Dowd-Uribe 2011). In this case, Burkina Faso's cotton research institute has been underfunded for years, a casualty of structural adjustment programmes and the liberalisation of the cotton sector. The introduction of Bt cotton, and the funding it brought, turned the attention of public servants in the cotton research institute towards measuring Bt cotton impacts and planning for its eventual implementation. But such public resources could have been put to other uses, many of which may have been complementary to the task of addressing the needs of smallholder farmers.

In short, the very nature of GM crop interventions may occlude other development interventions that could be complementary or achieve similar goals.

Conclusion

The terms of this debate require greater precision. The term "GM" comprises an array of crops adopted into an incredible diversity of agro-ecological contexts. Disaggregating these crops and places is an important first step. A second step is to disaggregate the poor.

The poor are a diverse matrix of people and farming practices. Each group comprised under the umbrella term "poor" experience the introduction of a GM crop differently. Unfortunately, little is known still about such differential impacts. Almost 20 years since their introduction, empirically analysing the specific and localised impacts of GM crops in their entirety is still urgently needed to understand how they impact the poor.

A disaggregated and contextualised empirical landscape may begin to reorient a discussion of whether GM crops can help the poor. The creation of such a landscape requires a more pluralistic and comprehensive approach to the study of GM crop introductions. It must include contributions from a variety of academic disciplines, and the study of disaggregated impacts across a number of different criteria. It must also look at GM crop introductions over larger time scales and include institutional features as key variables for analysis. The accumulation of such empirical research is our best strategy to answer whether GM crops have the possibility of being "pro-poor".

However, the question of whether GM crops can help the poor should not preclude the larger, more important discussion of what development strategies best address the needs of poor smallholder farmers. The question of whether GM crops can help the poor is too narrow and closes off a broader conversation about the types of interventions to address poor smallholder farmers and strategies to democratise development interventions; it precludes a comparison with other, potentially better or complimentary interventions, while muting a discussion of what criteria should be used to judge success. Positioning GM crops as simply one of many imperfect interventions to address the needs of poor smallholder farmers opens up a broader space for debate and raises the question of the appropriate role of GM crops in agricultural development. Almost 20 years since the introduction of GM crops, this is an important question that has yet to be sufficiently addressed.

Notes

1. An additional avenue to understand GM crop performance among the poor is to prospectively study what the introduction of second-generation GM crops may do once commercialised (see, for example, Addison and Schnurr 2015). Both prospective studies of second-generation GMOs and retrospective studies of first generation GMOs are needed for a comprehensive view of GM crop performance.
2. Peschard (2012) makes this point in reference to Brazil.
3. The liberalisation of Burkina Faso's cotton commodity chain resulted in three cotton companies with exclusive geographic areas of operation. Though independent, these companies must have the same pricing for inputs and seeds. I refer here to the dominant company, the government-controlled Société Burkinabé de Fibres et Textiles (SOFITEX), which controls over 80 per cent of the total cotton market, and dominates national cotton policy. See Dowd-Uribe (2014b) for more details regarding Burkina Faso's liberalisation process.
4. "Pests, Pesticides and Propaganda: The Story of Bt Cotton." [blog] Accessed 10 December 2015. http://vandanashiva.com/?p=317
5. Otero (2012, 286–290) calls this focus on technical solutions the modern agricultural paradigm.

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