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Martin Qaim, *Genetically Modified Crops and Agricultural Development*, Palgrave Macmillan, 2016, 206 pp. $102 Hardcover

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Abstract. Qaim is a leading academic researcher on the global impacts of genetically modified crops and his diligence and thoroughness abound in his newest book, *Genetically Modified Crops and Agricultural Development*. Qaim's objective is to inform the reader about the contribution that GM crops have, and can, make to improving economic circumstances and contribute to increased food security, particularly in developing countries. He accomplishes this objective through an artful blending of storytelling and scientific fact, allowing the reader to come away with a new appreciation for the technology and its impacts. The book provides an in depth review of the commercialization of GM cotton in India, informing readers about the extent and degree of benefits that have resulted over the past decade. This book should be required reading for those involved with organizations that actively campaign and protest against GM crops. Perhaps if those opposed gained the insights presented by Qaim, the European acceptance of a beneficial agricultural technology would begin to improve.
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1. Introduction

There are few academics, or otherwise informed individuals that have studied, researched and written about the impacts of genetically modified (GM) crops in developing countries more than has Matin Qaim. In *Genetically Modified Crops and Agricultural Development*, published by Palgrave, Qaim offers a fact rich, scientific assessment of the results of GM crop adoption, focusing specifically on those from GM cotton in India. Qaim's method of weaving together his science-based research and the larger social and economic impacts provides for an entertaining and informative read.

From the opening sentence, "What are the goals and priorities of agricultural development?", Qaim steps up and provides context for the next 180 pages that encourages readers to think seriously about the opening question he poses. To aid the reader in his challenge, he offers up three goals for agricultural development that he believes are fundamentally important for determining levels of success:

i) to produce sufficient levels of food to satisfy the requirements of growing populations;

ii) to improve the livelihoods of those directly involved in the agriculture sector; and

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iii) to ensure sustainable food production through efficient natural resource use and environmental preservation.

Qaim's opening question could be viewed as being framed, in part, from the establishment of the Millennium Development Goals (MDGs) and the Food and Agriculture Organization's report *How to feed the world in 2050* (FAO, 2009). Both the MDGs and FAO's report provided an alert to the world that concerted and serious efforts would be required to ensure that as the planet's population increases, fewer and fewer people would be living in situations of food insecurity. The importance of this was reinforced by the dramatic social protests and responses to the rapid rise in food prices in 2008, when some countries experiencing food shortages were faced with rioting and civil unrest. The essential message that Qaim offers in his opening paragraph is that food security is a vital issue to present day society and that concerted efforts will be required to ensure that the new inhabitants of our planet have sufficient food resources.

To begin his argument, Qaim draws on the most recent anthropological research to provide his readers with fascinating summary of how and why families developed and the role that plants played in this process. There is an excellent non-technical summary about the evolution of plant breeding that ranges from vigour and reduced shelling trait observations to early genetic knowledge and the contribution of Mendel. Complimenting this is the evidence of detailed research that explains the histories of the modern patent system (1623), the development of industrial fertilizers (1840s), the initial uses of chemicals (1850s) and the application of mutagenesis to plant breeding (1901). This is followed by a detailed explanation on the evolution of hybrid development and how this led to the establishment of incentives that facilitated the involvement of private firms in plant breeding.

One of the real benefits of this book is the effort that Qaim has taken to ensure that he presents as balanced approach as is possible. His discussion of how the world has reached this point in plant breeding is followed by an important cautionary note about the increasingly narrow number of plant varieties under cultivation. It is noted that 95% of human caloric intake is now provided from 15 plant species, with wheat, rice and corn providing 60% of calories. The potential for a decrease in biodiversity is noted, given that there are potentially 50,000 plant species that could contribute to feeding humans.

Investment in plant breeding is vital. Qaim provides an informative discussion of the Green Revolution and the benefits that resulted from this increased investment in plant breeding that began in the 1960s. An important observation made is that this period of rapid yield improvements was a combination of better seed traits and inputs. This increase in yields has begun to decline. Beginning in the mid-1990s, there was a global reduction in plant breeding investments, resulting in a decline in annual yield increases. The result of the reduced research and development investment is that annual yield increases in wheat, corn and rice have now fallen below the level required to support the existing global population. The FAO (2009) estimates that yield increases of 2% per year are required simply to feed the planets existing population. Non-seed production increases are reaching the upper boundary of their ability to contribute to improved yield increases and future yield increases are going to have to be seed-based.

One integral part of agriculture and crop production that is frequently overlooked by consumers and environmental organizations is that all forms of crop production have risks and environmental impacts. The important concept with this is that no one form of crop production is any riskier than any other. Regardless of whether the crop is produced via organic processes, conventional varieties or GM varieties, the risks are identical. The probability for herbicide resistance to develop

in weed populations is equal for conventional and GM crop production, while *e. coli* contamination is typically higher in organic production, revealing that risks are associated with all means of food production. Qaim provides a respectful discussion of risk, highlighting how additional regulatory oversight has been applied to GM crops for over 20 years now, without any incidence of a change in risk. An interesting contribution to this discussion is that the term genetic modification is a phrase that was first applied to genomic biology when the technology was in its infancy in the 1980s and present day plant breeding techniques have evolved so much that this term is no longer applicable. In fact, many organic crop varieties are developed via mutagenesis that triggers tens of thousands of gene changes, compared to some of the precision breeding techniques, such as gene silence that changes one or two genes to develop new varieties. While Qaim does not come right out and directly say it, it is scientifically accurate to say that biotechnology provides the lowest level of risk regarding the breeding of new plant varieties.

Qaim's lengthy program of research has contribute to his accumulation of knowledge and as part of this, it has allowed him to observe that there can be tendencies of both the pro-biotech and anti-biotech proponents to present data and results that favour their particular position. This is an important observation as there is ample results about the adoption of GM crops that have not undergone proper peer review and as such it is a challenge to accept the findings as there is the potential for observer bias. However, Qaim highlights that with GM crop adoption rates increasing year after year, farmers must be gaining substantial benefits, in spite of the higher seed prices, to continue with such a rapid increase in GM crop acreage. It is also identified that in some instances when farmers are not facing high pest pressures, they disadopt GM crop technologies and return to the use of conventional varieties, thus saving the cost of higher seed prices. Other research has indicated that non-adopters are gaining substantial benefits as their GM crop adopting neighbours have lowered weed and insect pest pressures to levels that provide benefits to them (Hutchinson, et al., 2010).

This rapid adoption rate has had some accompanying concerns, such as a tendency towards field monoculture and the potential for the development of herbicide resistant weeds. The ability of weeds to develop resistance to chemicals is a concern that existed long before the advent of GM crops, so attention needs to be made to ensure that the problem does not worsen through the use of GM crops.

Qaim provides an in depth discussion of the benefits of GM crops in developing countries, which is his field of expertise. He notes that in the early days of GM crops, critics claimed the technology would be short lived due to insects developing resistance to the plants that were insect resistant. Good farm management practices, such as the use of field refugia have helped to ensure that this problem has been prevented.

In examining Bt cotton adoption in India, Qaim identifies that critics of the technology said that Indian farmers would become dependent on large, multinational corporations which would lead to their ruin. Fortunately, nothing could be further from the truth. Qaim shows that there are over 1,000 Bt cotton varieties available in India, provided by over 40 companies, many of them Indian. Bt cotton adopters have increased household standard of living by 18% and food insecurity has been reduced by 15-20% following the adoption of Bt cotton. Qaim shows that even non-adopting farmers in India are benefitting from lower pest populations. The demand for labour has increased, generating increased economic activities in small, rural villages. Qaim documents that one hectare of Bt cotton results in an aggregate income that is 82% higher than with conventional non-GM cotton. Most importantly, 60% of the benefits of GM cotton in India go to those

that are either extremely poor or moderately poor, essentially those most in need. In households at these income levels, it is not uncommon for 70% of household income to be spent on food and GM crops have helped lower food prices and raise household incomes, a double benefit for the poorest in these societies.

As part of the global effort to respond to FAO's challenge of feeding the world in 2050, Qaim provides a detailed discussion on the vital role that investment plays in ensuring that this need is met. For the large part, the basic GM traits of insect resistance and herbicide tolerance have predominantly been breed into canola, corn, cotton and soybean varieties. Recently however, these traits have begun to be bred into other crop varieties that have more regional production regions. A detailed table is provided that highlights how 19 different traits are currently being bred into 19 additional crop types in 17 different countries. Many of the traits involved are designed to respond to climate change and to deal with drought tolerance. Over the past 30 years, drought has killed millions in developing countries, with the livelihoods of tens of millions being adversely affected. Developing new crop varieties that have improved drought tolerance, may be able to contribute to alleviating some pressures of food insecurity in cases of future drought.

An additional food concern is that an estimated two billion people globally are micronutrient deficient and breeding programs involving conventional and genomic breeding will be required to respond providing new varieties that are capable of addressing this situation. Genomic breeding is capable of raising micronutrient content by a higher amount than can conventional breeding, but it will be important to employ both techniques simultaneously. Substantial research efforts are being made to increase wheat yields. The International Wheat Yield Partnership has invested US$100 million with the goal of increasing wheat yields by 50% over the next 20 years.

The limited uptake of GM crops in the European Union has long been problematic for global agriculture production and trade. While not an easy or simple subject matter, Qaim does an admirable job of simplifying the subject matter such that it is comprehendible for readers. He discusses how the original GM traits of herbicide tolerance and insect resistance did not have great appeal to EU farmers and hence these very farmers had a minor social voice when the European based non-governmental organizations (NGOs) began to actively campaign against GM crops. In spite of EU evidence that GM crops are as safe as existing crop varieties, the EU regulatory system has become politicized and is now in gridlock, unable to approve any GM crop for production. Varieties submitted for EU regulatory approval as far back as 2005, still languish at the committee level due to the political interference of NGOs.

One of the troubling aspects of the EU regulatory system is that the European Commission is ignoring its own regulatory requirements, rejecting the advice of the science experts within the European Food Safety Authority (EFSA). The EU does allow some imports of GM crops, but only when economic circumstances dictate that this be allowed. For instance, for several years, the EU tried to source non-GM animal feed and when it became apparent that virtually all of their feed suppliers had gone to virtual full adoption of GM varieties, the EU relented and now allows GM varieties to be imported without restriction as long as they are used as animal feed. Interestingly, none of the resulting meat, dairy or eggs are required to be labelled as resulting from animals fed GM feed. What is revealed by this labelling discrepancy is that the EU legislation requiring products containing greater than 0.9% GM ingredients as having to be labelled has no grounding in science or improved food safety, but is a politically motivated results of NGO lobbying to try to scare EU consumers into avoiding GM based food products.

One of the highlights of the book is Qaim's targeted criticism of the NGO movement and their unwillingness to acknowledge the multitude of quantified benefits from GM crops, particularly in developing countries. He concedes that the concerns that were first raised by these groups in the early days of GM crops, 20-25 years ago were valid. Issues such as farmer exploitation by multinational corporations, control of intellectual property would harm crop agriculture research and development and a host of science related concerns. Evidence to date, complied over 20 years and a good portion of it by Qaim himself, shows no indication of farmer exploitation. The multinational biotechnology firms that the NGOs so quickly accused of being nothing more than rapacious capitalists have donated intellectual property to numerous crop development projects in developing countries. An excellent example of this is the discussion on the Bill and Melinda Gates Foundation's project on Water Efficient Maize for Africa (WEMA). Philanthropic donations of this nature demonstrate just how off base NGO criticisms have been, of not only biotech products but also biotech companies.

European society in general holds the belief that GM crops created a host of social problems. This perspective is due to the transition of the environmental movement into a 'protest industry', one that is no longer concerned about scientifically informing individuals about ways to protect and improve the environment. Many of these so called 'environmental groups' now invent risks and deliberately misinterpret science to serve their own means. Being the lead protestors against GM crops is good business as it raises hundreds of millions in donations, proving what a successful business model this is for the environmental movement. So lucrative is this business model that environmental groups have now adopted a business strategy from the tobacco industry and have recently resorted to attacking academics and experts that have published research about the benefits of GM crops and biotechnology, trying to discredit these experts. Indeed, Qaim even discusses attacks on his credibility that have personally occurred. This tactic is identical to that perpetuated by the tobacco industry from the 1960s through to the 1990s. It shows just how terrified the environmental movement is about how the widespread knowledge of the benefits of GM crops as they know that their ability to scare the public and raise funds will rapidly come to an end as will their ability to influence European politicians and policy.

European environmental organization opposition to GM crops is a battle for the future of their very existence. These organization know they have deceived the European public by promoting junk science, ignoring peer reviewed evidence and even going as far as to capture the International Agency for Research on Cancer (IARC) for their own nefarious means. The constant manipulation of mainstream media about worries over glyphosate and other chemical use keep society constantly on edge and worried about the safety of their food. When the European public soon realizes that they have been lied to by these organizations, their wrath may indeed be furious, resulting in the virtual demise of these fearmongering organizations.

The economic reality is that every single day, approximately 800 million individuals on this planet do not have access to sufficient calories and as a result of this are perpetually malnourished. In large part, European based environmental groups need to be held directly accountable for the continuation of this deplorable situation. Clearly, environmental advocates of today are far more concerned in power and profit and readily dismiss the problem of how to provide nourishing food for an increasing global population.

What will be required to feed the world by 2050? In one word, investment. Investments in the development of new plant varieties will be the essential tool to ensure that as a planet, we are able to produce adequate amounts of food required

to feed 9 billion or more. Investment is required in all forms of plant breeding and genomic research has to be part of the solution. Without investments in new technologies and innovative crops and food, hundreds of millions will continue to be food insecure, resulting in a compounding of the migration and terrorism problems that Europe has recently faced.

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