GM crops in Ethiopia: a realistic way to increase agricultural performance?

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Much has been published on the application of genetically modified (GM) crops in Africa, but agricultural performance has hardly been addressed. This paper discusses the main consequences of GM crops on agricultural performance in Ethiopia. Three main criteria of performance – productivity, equitability and sustainability – are evaluated in the context of the Ethiopian agricultural sector. We conclude that the application of GM crops can improve the agricultural productivity and sustainability, whereas equitability cannot be stimulated and might even exacerbate the gap between socioeconomic classes. Before introducing GM crops to Ethiopian agriculture, regulatory issues should be addressed, public research should be fostered, and more *ex ante* values and socioeconomic studies should be included.

Influence of biotechnology on Ethiopian agricultural performance

The main promise of supporters of biotechnology – specifically, genetically modified (GM) crops – is higher agricultural yield; but, is this really the case in developing countries like Ethiopia? Does biotechnology really have a positive effect on agricultural performance in this country? These questions might be answered in the context of Ethiopian agriculture, to which GM crops have been introduced as a solution; yet, Ethiopian politicians have expressed their concerns about the adoption of these crops. Although scientists are optimistic about the possible application of GM crops in Africa, the politicians stress the historical picture of the political changes in the Ethiopian agricultural system (Box 1), and conclude that this technology should be developed at home and empirically tested by African countries to avoid potentially harmful impacts that could result from the new environment [1]. In response, the African Agriculture Technology Foundation has provided an extended discussion on the application of GM crops in Africa (http://ofabafrica.net/aatf-new/strategic_initiatives/regulatory_matters/en/). We illustrate herein the main prospects and consequences of applying biotechnology to the Ethiopian agricultural sector, using three main indicators of agricultural performance as our guide: productivity, equitability and sustainability.

Productivity

Productivity measures agricultural output. In Ethiopia, most farmers are subsistent and classified as peasants (Box 1). There are around 12 million peasant farmers, more than half of which have <1 ha and mostly cultivate for their own consumption (www.ruralpovertyportal.org). The productivity of peasants' farms is not high; cereal yield, for example, has been reported by the United Nations Food and Agriculture Organization as only 1.1 t/ha in 2008 (http://faostat.fao.org/). The peasants therefore try to find ways to enhance their agricultural productivity [2]. Yet, in the Ethiopian situation, there is a big gap between the present state (i.e. low productivity) and the future, higher productivity, which could perhaps be narrowed by using improved biotechnological methods such as GM crops. With GM crops, yields can be higher while holding the same land coverage [3]. Furthermore, GM crops are usually more resistant to pests and fewer crops will consequently be lost in harvest. As farmers spend less money on pesticides, they will be able to invest more in new seeds or other agricultural inputs. Therefore, application of GM crops can increase productivity, as compared with their current conventional crops.

Equitability

Although the land reforms in 1975 and 1991 (Box 1) have improved the distribution of land, the equitability in the agricultural sector of the country remains very low [4]. Most of the benefits go to the large state farms [5,6]. These farmers can earn more products, and in turn, income, and consequently use more modern technology. The farmers own more land of higher quality, which usually leads to higher productivity. This makes it possible for farmers to sell a great part of the harvest at the market, which brings in more profit. Such factors thus enforce and reinforce each other in a cycle of benefits for the large state farms.

Conversely, the peasants are often subsistent and cannot bring their harvest to the market. There are several reasons for this problem, including undeveloped infrastructure and markets in rural areas. On average, a peasant farmer has to walk for half a day to reach local markets where the prices are up to 70% lower than in urban markets [7]. As a result, the peasants do not have the capital for investment in improved seeds, more land, irrigation systems or other agricultural tools.

Would biotechnology be able to narrow the gap between the wealthier and poorer farmers in Ethiopia?

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Box 1. A political history of the Ethiopian agricultural system

Pre-1975

Before 1975, the Ethiopian agricultural policy was focused mainly on the interests of landowners. A feudal agrarian system was present in Ethiopia. On the one side, there was a group of big landowners with possibilities to invest in their farm and therefore able to buy improved seeds and fertilizers; on the other side, there was a very large group of peasants who had no access to such inputs. The agricultural sector was rather primitive, without the possibility to be modernized [19].

1975–1991

In this period, the Dergue ruled the country and initiated land reform. Peasants associations (PAs) were set up for small farmers. The agricultural sector was divided into three farming systems: individual, state and producers' cooperatives. Individual farms were mostly peasantry, subsistent, and belonged to the PAs. State farms were owned by the state, and mainly included former estates, plantations and large commercial farms. Although the situation in the agricultural policy had changed and the Dergue initiated the PAs, the state farms were still receiving the most attention [20,21].

1991-present

In 1991, the Ethiopian People's Democratic Revolutionary Front occupied Addis Ababa. Consequently, a new constitution was adopted, which stated that all the lands belong to the state. However, peasants were allowed to use the land based upon the rules that had to be defined at lower levels; that is, federal and regional. In most cases, this meant that small-scale farmers could lease the land from the local government. As a result, more people were able to obtain access to inputs and markets. Nevertheless, the state farms still have the most access to modern technologies. Many small-scale farmers are still too poor to buy such technologies, and besides, they do not receive any incentives to produce more than their subsistence [21].

Genetic manipulation is relatively new and at an experimental stage; it is therefore an expensive treatment for farmers to undertake. It could take several decades before developing countries can capitalize on this technology. There are also concerns about possible dumping (i.e. setting the pricing of a product below its cost of production) by companies or nations in an effort to dispose of surplus stocks or to recoup money spent on costly transgenic research and development. For example, the Insect-Resistant Maize for Africa project is expected to cost $6 million USD within 5 years, and the transgenic sweet potato project asks for $2 million USD [8]. These research expenditures can be compared with the average cost of tissue culture and marker technology projects; that is, $300 000 USD [8]. If GM crops become available in Ethiopia, they will only be available to the wealthier farmers who can afford such technological innovations.

Furthermore, because of the patent rights on GM crops, farmers will need to buy new seeds every season, which the peasants are often unable to afford [1,7]. Considering the Ethiopian agricultural policy that primarily subsidizes the bigger, state-owned farms (Box 1), it does not seem likely that the government would subsidize the small farmers to buy improved seeds; thus, the peasants might obtain limited access to such crops. As a result, it seems probable that the application of GM crops in Ethiopia will only widen the socioeconomic gap.

Sustainability

For agriculture to be sustainable, it must have the capacity to deal with changes in the environment [8]; it is a crucial question of whether or not Ethiopian agriculture is able to do this. First, because of the short periods of fallow, mixed cropping, and long periods of drought, the soil has lost its nutrients and been degraded by overcropping. Poor peasants who do not have access to fertilizers will not be able to solve this problem. They are focused on short-term survival rather than protecting the soil for future use [9].

Second, only around 5% of the peasants apply modern irrigation systems; the rest are dependent on rainfall [10]. Ethiopia is faced with chronic drought, therefore, crops often suffer from this environmental setback. Again, most of the farmers are not able to solve this problem because there is simply no water available. This could be the reason why GM crops cannot be adopted by small farmers in Ethiopia. Even if they have access to the improved seeds, there are no optimal irrigation systems or enough precipitation for growing them. According to Rahmato [10], it is obvious that the development of the irrigation systems in Ethiopia could not involve the whole farming community. In the past, modern irrigation systems were delegated to a small portion of the community (i.e. technical and managerial elites who were working mostly for large-scale foreign interests), and later, for state enterprises. As a result, other alternatives can be considered in such a dry situation: scientists and policymakers might be interested in investigating "molecular breeding" as a feasible and therefore preferred approach over GM crops. The topic of molecular breeding is beyond the scope of this article, but has been reviewed extensively elsewhere [11–14].

The third challenge is plant diseases. In Ethiopia, nearly 95% of cultivable lands are worked by the peasants [7]. These smallholder farmers have little plots of land that are often close to each other, which give plant diseases (such as rust) the opportunity to spread easily. Only 8% of the Ethiopian peasants are able to apply pesticides [7]; the rest are too poor to afford them, therefore prevention can be appreciated as a feasible treatment.

Biotechnology can influence sustainability in Ethiopia by applying adapted GM crops to the Ethiopian environment. Such GM crops should be more resistant than conventional crops to plant diseases and environmental conditions such as drought. Also, they are able to deal with degraded soil [1] because they are more resistant to undesirable circumstances; for example, GM tomato that is able to grow in salty soil, or *Bt* (*Bacillus thuringiensis*) cowpea that can result in improved soil fertility. In such a situation, it seems more probable that biotechnology is able to contribute to a more sustainable agriculture.

Main considerations for using GM crops in Ethiopia

There are several remarkable advantages and limitations that result from the use of GM crops with respect to productivity, equitability and sustainability. Owing to the dry weather in Ethiopia and the fact that most peasants, regardless of their contribution to the agricultural sector, have no access to new agricultural technologies, the level of agricultural performance remains rather low. It seems that GM crops can make a significant difference here. When using GM crops, productivity can increase and agriculture can be more sustainable. However, as far as equitability is concerned, it appears that biotechnology cannot decrease the gap between the rich and poor. The current situation in Ethiopia indicates that those with big farms will benefit much more than the peasants from GM crops. Most of the money invested in agriculture goes to the large state-owned farms, while the peasants have to invest personally, usually without assistance from the state. Therefore, equitability is not being stimulated and GM technology does not appear to help here. Nevertheless, regardless of the equitability, it is important to note that such a biotechnological bias toward the larger farms can benefit Ethiopian society as a whole by solving the problem of *per capita* food insecurity in the country.

To make the transition from conventional to GM crops, a few important actions need to be taken. First, the biotech industry is mainly financed by a couple of large investors (e.g. Monsanto and Pioneer Hi-Bred International). For these investors, it is not profitable to develop biotechnology in the developing world [1]. In Ethiopia, >90% of the agricultural outputs are produced by subsistence farmers; around one-fifth of the output goes to the market [7]. Furthermore, there are only a small number of large commercial farms in which the investors are interested. This is not a profitable situation for the investors. Several other firms, including seed companies and business incubators, as well as government administrators are discouraged from conducting research on developing biotechnology in Africa because such research might provide evidence on the negative impacts of GM crops in Africa (e.g. exacerbating the gap between socioeconomic classes) and result in a ban of these crops [15,16]. Furthermore, biotechnology investors might be unwilling to support costly studies without the legal guarantee that their products can be commercialized [8].

Perhaps more important is that biotechnology is expensive. For most African countries, it is a huge investment, although the investment might quickly be recovered after the first harvest and other subsidies and credits might also help with that first purchase. In Ethiopia, only the state farms are subsidized. However, subsidies have not increased in recent years [17]. According to Grover and Temesgen [18], the government and non-governmental organizations should promote subsidiary activities. For example, the fertilizer subsidy in Ethiopia was 15% in 1993, 30% in 1995, and suddenly 0% in 1997. Therefore, the subsidy was first introduced, but later reduced and finally eliminated from 1997 onward [17]. In short, farmers will not be able to use GM technology if they are not subsidized by the state. Without subsidies, the peasants are unable to use the expensive, improved seeds: partly because the seeds, despite higher productivity, are not drought-resistant and therefore not designed for the Ethiopian environment; and partly because the peasants are not open to use these new technologies because they are afraid that their indigenous crops will be replaced by the GM crops and the local biodiversity will therefore be lost.

It will therefore remain difficult to inject GM crops into the Ethiopian agricultural system until the government changes its agricultural policy to invest more money in subsistence farming. Although not likely to increase overall performance, GM technology could be applied for increasing the performance of Ethiopian agriculture in general. In other words, GM crops can still stimulate the productivity and sustainability of the Ethiopian agriculture, even if they cannot stimulate equitability. Finally, it should be noted that before introducing such crops to Ethiopian agriculture, regulatory issues [22] and fostering public research toward affordable GM crops (e.g. Public Research and Regulation Initiative: www.pubregres.org) as well as *ex ante* values (i.e. expected techno–socioeconomic gains and losses that result from the adoption of GM crops) should be addressed in the framework of comprehensive risk assessment studies.

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