



INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR



PROGRAM FOR BIOSAFETY SYSTEMS

A partnership program for biosafety capacity development

PBS, a program managed by the International Food Policy Research Institute (www.ifpri.org), supports partner countries in Africa and Asia in the responsible development and safe use of agricultural biotechnology. PBS effectively addresses biosafety through an integrated program of research, capacity development, and outreach. PBS is funded by the U.S. Agency for International Development (USAID).

BRIEF NO. 1 OF 5

ASSESSING THE POTENTIAL ECONOMIC IMPACT OF GENETICALLY MODIFIED CROPS IN GHANA

A METHODOLOGICAL FRAMEWORK

Edited by Daniela Horna, Melinda Smale, and Jose Falck-Zepeda, International Food Policy Research Institute

In many countries, economic considerations are an important factor in government decisionmaking on the introduction of genetically modified (GM) products. However, reliable information on their actual or likely economic impact is often lacking. This brief illustrates the use of a methodological framework to assess the potential economic impact of introducing GM varieties of tomato, cabbage, garden egg, and cassava in Ghana. The framework consists of four interrelated levels of analysis, corresponding to four sets of actors in the economy: (1) farm (smallholder producers); (2) market (processors, traders); (3) the pertinent industry or sector of the national economy (consumers and producers, linked by markets); and (4) international trade.

Ghana Study Case

Agriculture in Ghana is characterized by low yields and productivity, which are compounded in the long run by production shocks due to environmental stresses such as drought, pests, and diseases. Vegetables are more susceptible to these biotic constraints than other crops. Chemical pesticides and, to a limited extent, integrated pest management (IPM) practices have been applied to control the pests and diseases but with limited success. Pesticide use has been ineffective, leading farmers to apply high dosages. In this context, the use of GM crops to address pest and disease problems is an option worth examining in terms of its feasibility, cost effectiveness, and long-term impact on productivity and yield stability.

Crop Selection and Research Design

Four commodities (tomato, cabbage, garden egg, and cassava) were selected for evaluation as GM crops based on their roles in the economy, the availability of and public access to the technology, and the magnitude of their productivity constraints.

1. Tomatoes are an important food commodity in Ghana, as they are consumed almost daily and are traded by a broad range of market participants. During the rainy season, the country is able to cover domestic tomato demand. During the dry season, however, the lack of irrigation facilities, together with the higher incidence of the tomato yellow leaf curl virus (TYLCV), drastically reduces total production, with major consequences for farmers. Tomatoes are imported from Burkina Faso during five to six months of the year. The USAID West African Regional Program has identified research on virus-resistant (VR) tomatoes as a priority. Ghana is included in a seven-member regional investigation of the tomato virus disease complex.

2. Cabbage is an emerging crop in Ghana and a means of earning a living for migrants in urban areas. Cabbage is consumed fresh and in sauces and is used by the growing fast-food, hotel, and restaurant industry. The diamondback moth (DBM), *Plutella xylostella*, severely limits cabbage production, causing farmers to use chemical pesticides. DBM has now developed resistance to almost every known or approved insecticide. A gene from the soil bacterium *Bacillus thuringiensis* (Bt) confers resistance to a range of lepidopteran species including the DBM. The transfer of the Bt gene to the genome of several cultivated plants is probably the most studied and used genetic modification. Thus, Bt cabbage, a technology that is readily

available for use, could solve a major productivity constraint and generate positive health, economic, and environmental benefits for urban areas.

3. Garden egg (*Solanum aethiopicum*) is an indigenous species produced mainly by smallholders and consumed frequently in local dishes. Garden egg may be attacked by disease and several pests, including fruit and shoot borers, which can cause major economic loss. A Bt garden egg that is resistant to fruit and shoot borers would be relatively easy to develop, given the vast experience of scientists in the use of Bt in genetic modifications. However, almost all garden egg seed is recycled by farmers from the previous season. To improve seed quality standards, more formal seed systems will have to be developed.

4. Cassava is widely grown in Ghana as a staple crop. The Ghana Living Standards Survey estimates that in 1998/99, about 1.5 million households produced the crop. Cassava is produced in all but two regions in the northernmost part of the country. Although several diseases affect the crop, cassava mosaic virus (CMV) is the most difficult to control. CMV disease is present in all areas of cultivation and currently there is no economically viable way to control this disease. Virus-resistant (VR) cassava could increase the performance of the crop and contribute to country goals with respect to starch production.

At the farmer level, we base our evaluation on partial budget analysis. Market chain analysis, economic surplus, and rapid trade analysis cover the other sectors of the economy. The analysis of cassava is based on an extensive literature already produced by research institutions in Ghana, while the analysis of vegetable crops is based on primary data collected in selected sites in Ghana by agro-ecological zone, region, and district. With the help of agricultural extension officers, we identify specific town or production areas and weigh them by their number of producers. For each crop, a random sample of farmers is drawn. Primary data collected through interviews with traders in markets are supplemented by statistical data.

Main Results

The use of genetically resistant varieties would generate benefits both for individual growers and for Ghanaian society as a whole. Still, study findings indicate that while farmers currently tend to use higher than recommended doses of pesticides, the reduction in pesticide use may not be as great as expected. This is because farmers' investments in pesticides, as a percentage of total production costs, are low for tomato, garden egg, and cassava. Only in the case of cabbage is the prospect of reducing the costs of pesticide use through growing GM crops likely to be a critical determinant of adoption. Nevertheless, any technology that will reduce yield variability (in the case of vegetables) or yield losses from damage (cassava) will contribute to long-term poverty reduction among vulnerable groups. At the trade level, Europe (the main destination of Ghana's agricultural exports) has tight regulations on GM foods imports, but generally, export levels of the studied crops are rather low. Therefore, the benefits at the farm level might be higher than potential losses in trade.

Policy Implications

Whether successful outcomes would be achieved from GM crops on farms depends on a number of factors. One critical factor is the variety chosen by innovators for genetic modification. Except for garden egg, the other crops have limited diversity and farmers depend on a small selection of varieties. Ideally, the variety selected for transformation should have attributes demanded by producers and consumers. Even if the trait transfer is effective, farmers may not realize the full benefits of growing resistant varieties, unless farmers are knowledgeable about the appropriate use of pesticides. Hence, appropriate extension support and the implementation of IPM practices would be critical to ensure success.

Even when the GM technology comprises all of the attributes demanded, widespread adoption of GM varieties depends on institutional factors. For example, the technology fee reflected in the seed price is amenable to policy formulation and would directly affect the distribution of benefits among actors. Who will provide the GM technology? Under which institutional and property right arrangements? It is clear that both the public and private sectors must be involved. The public sector could be responsible for GM variety development, as this will entail the establishment of basic infrastructure, collaboration with other countries, and importation of material for initial testing. The private sector should play a dominant role in seed multiplication and distribution of vegetable crops.

Contributing authors: Ramatu M. Al-Hassan (Department of Agricultural Economics & Agribusiness, University of Ghana), Walter S. Alhassan (West and Central Africa Coordinator, Program for Biosafety Systems), Kwasi O. Bonsu (Crops Research Institute, Kumasi, Ghana), Jose Falck-Zepeda (Research Fellow, IFPRI), Guillaume Gruère (Research Fellow, IFPRI), Daniela Horna (Postdoctoral Research Fellow, IFPRI), Melinda Smale (Senior Research Fellow, IFPRI), Samuel E. Timpo (Biotechnology & Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana).

FOR MORE INFORMATION

Horna, D. et al. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report, October 2006. Available upon request (dhorna@cgiar.org).

PBS publications are issued by individual partner institutions and undergo review procedures specific to each issuing institution. This publication has undergone at least one internal or external review prior to publication by IFPRI.

Copyright © 2007 IFPRI. All rights reserved. Sections of this material may be reproduced for nonprofit use without written permission but with acknowledgment to IFPRI. For further information: ifpri-copyright@cgiar.org.



INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR



PROGRAM FOR BIOSAFETY SYSTEMS

A partnership program for biosafety capacity development

PBS, a program managed by the International Food Policy Research Institute (www.ifpri.org), supports partner countries in Africa and Asia in the responsible development and safe use of agricultural biotechnology. PBS effectively addresses biosafety through an integrated program of research, capacity development, and outreach. PBS is funded by the U.S. Agency for International Development (USAID).

BRIEF NO. 2 OF 5

ASSESSING THE POTENTIAL ECONOMIC IMPACT OF GENETICALLY MODIFIED CROPS IN GHANA

VIRUS RESISTANT TOMATO

Edited by Daniela Horna, Melinda Smale, and Jose Falck-Zepeda, International Food Policy Research Institute

In many countries, economic considerations are an important factor in government decisionmaking on the introduction of genetically modified (GM) products. However, reliable information on their actual or likely economic impact is often lacking. This brief illustrates the use of a methodological framework to assess the potential economic impact of introducing genetically modified tomatoes in Ghana. The framework consists of four interrelated levels of analysis, corresponding to four sets of actors in the economy: (1) farm (smallholder producers); (2) market (processors, traders); (3) the pertinent industry or sector of the national economy (consumers and producers, linked by markets); and (4) international trade.

Tomatoes and Tomato Yellow Leaf Curl Virus

Tomatoes are a popular food item in Ghana. A main source of vitamins A and C, they are consumed on a daily basis in many households. Moreover, tomato production is an important source of income for smallholder farmers. While domestic tomato production has intensified across the country in recent years, it still does not meet the high demand, so tomatoes are imported from Burkina Faso five to six months of the year. This situation is attributed to a number of constraints in the production and marketing chain. One such constraint is a virus, transmitted by the white fly (*Bemisia tabaci*). If the fly is not controlled at the early stages of tomato cultivation, it can cause tomato yellow leaf curl virus (TYLCV), a disease that devastates crop yields and critically affects farmers' livelihoods. Farmers often use pesticides to control the white fly, but they may be ineffective if the plant is already infested. Also, the use of clean new seed is strongly recommended to help control the disease, but seed recycling is common practice. Unfortunately, this further reduces the genetic diversity among tomato varieties making crops more susceptible to pests and diseases and farmers more vulnerable to disastrous yield losses.

Constraints to Tomato Production

Several factors affect tomato production and ultimately the cost of tomato cultivation. For one, farmers obtain seed either from their own fields, from neighbors and friends, or from women's groups that maintain and distribute varieties that are in high demand in the marketplace. This recycling drives down seed price, but has a negative effect on seed quality. Also, most tomato varieties used in commercial production are introduced varieties, which are not well adapted to local conditions in Ghana. This, along with the seasonality of tomato production, creates periods of abundance and scarcity, which dramatically affect market prices. On average, labor (land preparation, transplanting and harvesting) represents more than 50 percent of total production costs, but farmers who use family labor are hardly aware of this. Services and equipment costs together account for only 6 percent of the total expenses incurred by a tomato producer. Manure is often used as fertilizer by producers across the region. During the rainy season, fungal diseases and pests are common. Because synthetic insecticides and fungicides are generally too expensive for the average farmer to use, such expenses represent on average only 2 percent

of the total costs. Access to irrigation facilities also conditions production. Still, despite these constraints, farmers consider tomato production to be a profitable activity.

Farm level

Seed for GM virus-resistant (VR) tomato is expected to cost as much as 50 percent more than the typical certified seed. A small part of the research costs might be transferred to the consumer as a technology fee. In the case of a private provider, the firm would be able to charge higher seed prices if it had a monopoly in seed provision. The main reduction in costs from the use of VR tomato seed is from inputs and labor. VR tomato seed would require lower doses of pesticide to control the vector. Since the resistance is built into the plant, the population levels of white fly could be high. Karate, a wide-spectrum insecticide, is the major pesticide used by tomato farmers in Ghana. A total halt to the use of pesticide is not a realistic scenario because several other pests that also attack tomato plants need to be controlled.

Market level

The seasonality of tomato production together with the distance of the production areas from the consumption centers has favored the development of a vertically integrated market chain. A highly organized network of itinerant and sedentary wholesale traders, called “market queens,” controls the transportation and distribution of tomato from producing areas to just about every village, district and city in Ghana. Margins to farmers are lower than to the other actors in the chain. While prices are more affected by season than by quality, the variety of tomato produced in Burkina Faso is preferred to the local tomato. Tomato quality deteriorates as a result of inappropriate postharvest practices, such as lack of storage and cooling facilities and unsuitable commercial containers. Breeding efforts (conventional or GM) should pay attention to market demands.

Industry level

Under the assumptions made in our simulations, investments in a VR tomato would yield benefits to the society. Even considering an irregular adoption path and accounting for costs of technology development and adaptation, the average return to investment in VR tomatoes is 76 percent. The benefits would be higher with a higher adoption rate. We have assumed a conservative 35 percent rate of adoption, which is equivalent to the percentage of farmers using new seed from the formal system. Notably, these farmers do not necessarily buy seed every season, but may buy seed one season and recycle it for four or five years. Maintaining this practice will only be possible if the introduced GM varieties are open pollinated, not hybrids.

Trade level

As Ghana is currently a net importer of tomato products, and the volume of exports of fresh or chilled tomatoes represents a very small share of total production, the introduction of GM tomato, if associated with a rise in farm productivity, could help satisfy the large and increasing domestic demand. Also, since Ghana is a net importer of processed tomato products, there appears to be no risk of immediate export losses in tomato due to market restrictions and lack of consumer demand in Europe. So, if Ghana were to commercialize GM tomatoes in the near future, trade issues would depend on the existence and application of future regional agreements related to the approval for imports of GM commodities. At the same time, the local need for tomatoes might encourage neighboring countries to agree on regional biosafety standards.

Policy Implications

Given the importance of tomatoes to the Ghanaian economy, the introduction of GM tomato varieties resistant to TYLCV would create substantial economic benefits for farmers and society. However, since TYLCV is not the only disease that affects tomatoes in this system, and since it is transmitted by a vector that would still be present in the fields, it is possible that farmers would continue to require pesticides and maintain the same level of application. As such, this technology may not significantly reduce grower investment in pesticides. Notably, other crop attributes may have to be introduced to tomato varieties to increase their productivity and economic viability, and decrease imports from Burkina Faso. Heat resistance is the attribute most in demand by growers in the southern part of Ghana, while resistance to transportation damage or delayed ripening are crucial for the northern regions. A tomato variety that is not customized for each region does not appear to be a viable economic alternative for farmers.

Contributing authors: Ramatu M. Al-Hassan (Department of Agricultural Economics & Agribusiness, University of Ghana), Walter S. Alhassan (West and Central Africa Coordinator, Program for Biosafety Systems), Kwasi O. Bonsu (Crops Research Institute, Kumasi, Ghana), Jose Falck-Zepeda (Research Fellow, IFPRI), Guillaume Gruère (Research Fellow, IFPRI), Daniela Horna (Postdoctoral Research Fellow, IFPRI), Melinda Smale (Senior Research Fellow, IFPRI), Samuel E. Timpo (Biotechnology & Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana).

FOR MORE INFORMATION

Horna, D. et al. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report, October 2006. Available upon request (dhorna@cgiar.org).

PBS publications are issued by individual partner institutions and undergo review procedures specific to each issuing institution. This publication has undergone at least one internal or external review prior to publication by IFPRI.

Copyright © 2007 IFPRI. All rights reserved. Sections of this material may be reproduced for nonprofit use without written permission but with acknowledgment to IFPRI. For further information: ifpri-copyright@cgiar.org.



INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR



PROGRAM FOR BIOSAFETY SYSTEMS

A partnership program for biosafety capacity development

PBS, a program managed by the International Food Policy Research Institute (www.ifpri.org), supports partner countries in Africa and Asia in the responsible development and safe use of agricultural biotechnology. PBS effectively addresses biosafety through an integrated program of research, capacity development, and outreach. PBS is funded by the U.S. Agency for International Development (USAID).

BRIEF NO. 3 OF 5

ASSESSING THE POTENTIAL ECONOMIC IMPACT OF GENETICALLY MODIFIED CROPS IN GHANA

INSECT-RESISTANT CABBAGE

Edited by Daniela Horna, Melinda Smale, and Jose Falck-Zepeda, International Food Policy Research Institute

In many countries, economic considerations are an important factor in government decisionmaking on the introduction of genetically modified (GM) products. However, reliable information on their actual or likely economic impact is often lacking. This brief illustrates the use of a methodological framework to assess the potential economic impact of introducing GM cabbage in Ghana. The framework consists of four interrelated levels of analysis, corresponding to four sets of actors in the economy: (1) farm (smallholder producers); (2) market (processors, traders); (3) the pertinent industry or sector of the national economy (consumers and producers, linked by markets); and (4) international trade.

Cabbage and the Diamondback Moth (DBM)

Cabbage is a popular vegetable to grow and to eat in the urban and peri-urban areas of Ghana (particularly around Accra), where urban agriculture has boomed to meet a rising demand for fresh vegetables in the absence of appropriate refrigerating facilities. Growing cabbage is also an important source of income for migrant farmers. While convenient for farmers and consumers, cabbage production is associated with health and environmental risks due to contamination from pesticides and polluted water. Cabbage is often beset by insects. The primary pest is the diamondback moth (DBM, *Plutella xylostella*). The probability of farmers losing their entire crop to DBM could be as high as 75 percent if not properly controlled. DBM damage can be so profuse that farmers apply increasingly large amounts of insecticides to control it. (Pesticide application to control DBM represents the main cost to cabbage producers.) There is evidence that the indiscriminate and widespread use of pesticides has resulted in the development of pesticide resistance within DBM populations. This pest is especially serious in the Ashanti Region where some farmers have shifted to the production of less susceptible vegetable crops.

Constraints to Cabbage Production

There is almost no statistical information about cabbage production in the country. Average cabbage plot sizes are below half a hectare and represent almost 80 percent of the farmer's total cultivated area. Cabbage production can be a very profitable activity, with a quick return on investment. The total period that the crop is in the field varies from three to four months, but some varieties can be harvested in as few as 70 days. There is no seed recycling, but total seed cost for this crop represents only 5 percent of the farmers' total costs. Meanwhile, fertilizers and insecticides together account for 17 percent of total expenses, and labor costs a whopping 60 percent, with a high proportion being family labor. The main activities are land preparation, transplanting, weeding, watering, and harvesting.

Cabbage production tends to be very intense, with high levels of pesticides and fertilizers applied, which can run off into drinking water sources. This is a concern in the metropolitan area, as water is already scarce in Accra. Vegetable producers usually use low-quality water from drains, shallow wells, and streams to irrigate their fields. Many smallholder farmers have taken over so-called "open access" areas (or areas of restricted access, according to Ghanaian law), which are close to water

channels or water wells. As these areas should not be utilized, potential for conflict has increased over access to land. It has also been argued that water dugouts, wells, and channels used for vegetable irrigation represent potential breeding sites for the malaria vector.

Farm level

The perceived yield lost to DBM is quite high (27 percent). While it is most likely that a GM solution would involve a combination of Bt seed with Integrated Pest Management (IPM) practices, developing a prototype budget for the combination is difficult without additional information. For the Bt scenario, the reduction in the level of pesticides applied is assumed to be 25 percent, although it could be much greater since DBM is the single most important pest for cabbage. By the same reasoning, the reduction in the use of labor for spraying chemical could be higher. The marginal rate of return shows that for each dollar invested in Bt cabbage, the average farmer surveyed would recover not only that dollar but an additional 30 cents, if the GM technology is 100 percent efficient. Use of IPM also provides a high marginal rate of return, suggesting that a combination could be very profitable for farmers.

Market level

Cabbage marketing and prices are determined by the seasonality of demand. Cabbage demand peaks around Christmas and continues throughout the dry season. Both cabbage demand and supply are elastic. The compact head of Oxyllus, the most preferred variety, transports and stores well. Lack of variety diversity, however, is a problem that needs to be addressed.

Industry level

Under the assumptions used in the estimations, investment in GM cabbage would generate benefits for society. Returns to investment however are rather low. The net benefit value is especially low considering that expected maximum adoption is 100 percent. Results also show that there are relatively high chances of negative net benefits. These occur mainly in scenarios where R&D and technology transfer costs are taken into account. High R&D and biosafety compliance costs can reduce the profitability of this investment. However, high percentage yield loss due to DBM might justify the investment in Bt cabbage. Net benefits increase significantly for each percentage unit increase in yield and consequently in total cabbage supply.

Trade level

Reports collected from the Ministry of Trade and Industry in Ghana and the United Nations COMTRADE show that, in recent years, Ghana has not been a large importer or exporter of cabbage. Exports of cabbage from Ghana do not go to Europe or other OECD countries with strict importing regulations for GM crops, but to other countries in the region like Burkina Faso. Given the low value of trade and the apparent disconnection with sensitive markets, we expect that the introduction of GM cabbage will not significantly disrupt trade. If cabbage were to become a main export, the commercial risk for exporters would depend on the evolution of regulations governing the approval of GM crops in the region.

Policy Implications

A GM cabbage resistant to DBM is a technology that represents an attractive alternative to farmers, particularly those in the urban areas. The relatively small areas cultivated could limit the economic impact of a GM variety. The environmental and health hazards of cabbage production with current practices appear to be large, which suggests that a GM cabbage could generate substantial economic benefits to society. In spite of the high visibility of cabbage in urban and peri-urban areas, there is almost no information available on cabbage production. Additional information would allow the public sector not only to quantify the real impact of cabbage production, but also to propose policy solutions and control the negative externalities associated with this activity.

Contributing authors: Ramatu M. Al-Hassan (Department of Agricultural Economics & Agribusiness, University of Ghana), Walter S. Alhassan (West and Central Africa Coordinator, Program for Biosafety Systems), Kwasi O. Bonsu (Crops Research Institute, Kumasi, Ghana), Jose Falck-Zepeda (Research Fellow, IFPRI), Guillaume Gruère (Research Fellow, IFPRI), Daniela Horna (Postdoctoral Research Fellow, IFPRI), Melinda Smale (Senior Research Fellow, IFPRI), Samuel E. Timpo (Biotechnology & Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana).

FOR MORE INFORMATION

Horna, D. et al. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report, October 2006. Available upon request (dhorna@cgiar.org).

PBS publications are issued by individual partner institutions and undergo review procedures specific to each issuing institution. This publication has undergone at least one internal or external review prior to publication by IFPRI.

Copyright © 2007 IFPRI. All rights reserved. Sections of this material may be reproduced for nonprofit use without written permission but with acknowledgment to IFPRI. For further information: ifpri-copyright@cgiar.org.



INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR



PROGRAM FOR BIOSAFETY SYSTEMS

A partnership program for biosafety capacity development

PBS, a program managed by the International Food Policy Research Institute (www.ifpri.org), supports partner countries in Africa and Asia in the responsible development and safe use of agricultural biotechnology. PBS effectively addresses biosafety through an integrated program of research, capacity development, and outreach. PBS is funded by the U.S. Agency for International Development (USAID).

BRIEF NO. 4 OF 5

ASSESSING THE POTENTIAL ECONOMIC IMPACT OF GENETICALLY MODIFIED CROPS IN GHANA

INSECT-RESISTANT GARDEN EGG

Edited by Daniela Horna, Melinda Smale, and Jose Falck-Zepeda, International Food Policy Research Institute

In many countries, economic considerations are an important factor in government decisionmaking on the introduction of genetically modified (GM) products. However, reliable information on their actual or likely economic impact is often lacking. This brief illustrates the use of a methodological framework to assess the potential economic impact of introducing GM garden egg in Ghana. The framework consists of four interrelated levels of analysis, corresponding to four sets of actors in the economy: (1) farm (smallholder producers); (2) market (processors, traders); (3) the pertinent industry or sector of the national economy (consumers and producers, linked by markets); and (4) international trade.

Garden Egg and the Shoot and Fruit Borer

The African garden egg (*Solanum aethiopicum*) is one of the most important vegetable crops in West Africa and probably the third most consumed vegetable in Ghana. Medicinal properties are attributed to its roots and fruit. It is used as a carminative or sedative and for the treatment of colic and high blood pressure. The African garden egg also has potentially useful agronomic traits, such as drought tolerance. Furthermore, many varieties of garden egg are cultivated in Ghana. Garden egg represents the main source of income for many rural households in the forest zone of the country. Still, regardless of its importance, there is little accumulated knowledge about the plant. Research efforts to fill this gap have been limited.

Several pests and diseases affect the crop by reducing total production as well as product quality. The shoot and fruit borer (SFB, *Leucinodes orbonalis*) is one of the main pest problems. SFB is widely distributed across all areas in Ghana that produce garden egg. The damage caused by fruit borers affects the price significantly in local markets. Still, the vegetable sells in its damaged state at a discounted price. Fruits that show borer damage cannot be exported, however. If the SFB is not controlled, productivity is reduced and the chances of having net returns below zero could be as high as 75 percent.

Constraints to Garden Egg Production

Despite prices varying greatly throughout the year, garden egg is still a very profitable activity in Greater Accra, where yields and prices are both comparatively higher than in the rest of the region. Estimates from our survey suggest yields of around 8 metric tons per hectare. Seed costs vary across regions, but they generally represent a small fraction of the total costs. Seed availability is a major constraint to garden egg production. Ghana's Crop Research Institute has been working on improved lines, but no variety has been officially released. Expenditure on fertilizers is low, while pesticides represent 5 percent of the total costs. Harvest of garden egg is labor intensive. Unless the crop is harvested two times per week, the fruits mature on the plant, develop seeds, and change color.

Farm level

SFB is a pest that farmers can identify, and it is present in all the garden egg producing areas in Ghana. Either Bt-garden egg varieties or Integrated Pest Management (IPM) practices could represent viable alternatives for farmers to control this pest.

Farmers surveyed perceived that yield losses from SFB could be as high as 21 percent. When we compared Bt and IPM scenarios to the use of conventional seed and insecticides, we found that in the Bt scenario, seed costs could increase dramatically given that current seed prices reflect only the seed price produced by the informal system. In the IPM scenario, field sanitation is not a common practice among garden egg producers, but its implementation would reduce SFB infestations. Returns to investment are high for both scenarios. These results might suggest that farmers would prefer IPM over Bt seed, given its lower costs and high returns, but adoption of a complete IPM package is unlikely unless additional incentives are provided to farmers.

Market level

The garden egg has a well-developed marketing channel that links actors at different spatial locations from rural communities to national, regional, and international destinations. The value chain is composed of a number of actors that operate at different market levels. Mobile wholesalers move the produce from producing areas to major market and consumption centers, while retailers move it from larger to smaller markets. Farmers either travel to the market to sell their produce or sell at the farm gate. Consumers are satisfied with varying attributes and qualities. Although quality suffers considerably from postharvest handling and transport, consumers have adjusted not only to lack of uniformity in attributes but also to unstable supply and vast price fluctuations. GM or any other technology development that addresses poor shelf life, postharvest handling, and quality standards would likely have a positive impact on the livelihood of smallholder farmers in Ghana.

Industry level

Investment in Bt garden egg would mainly favor smallholders in rural areas. The distributions show only a small possibility of negative net benefits across all the scenarios. Returns to investment, however, are rather low. The relatively small area cultivated probably affects these results. Under the less favorable scenario (irregular adoption patterns including R&D costs), returns to investment are only 55 percent. We have assumed a 35 percent maximum adoption rate, using the case of tomato as a point of reference. Net benefits are mainly sensitive to the reduction in the rate of yield loss as a result of the GM technology. Benefits are much less affected by elasticity of supply and the percentage change in pesticide application.

Trade level

Garden egg is traded internationally on a limited scale. Bilateral data analysis reveals that most of these exports (80 percent) go to the European Union (COMTRADE), and largely to the United Kingdom (EUROSTAT). Consequently, the introduction of GM garden egg could result in small, but proportionally significant, export losses at least in the short run. Implementing a functional segregation system and preserving the identity of non-GM garden eggs for export could avoid trade disruption. This type of system would make sense if export demand remained the same, and if the cost of implementation was not prohibitive. With segregation, Ghana would take advantage of potential productivity gains while maintaining its niche export market in the European Union. We suggest that export losses be compared to potential benefits in order to assess whether the government should encourage a strict separation of non-GM garden egg to maintain export opportunities.

Policy Implications

A GM garden egg that contains the Bt protein so that the crop becomes resistant to SFB could have a positive impact in the Ghanaian economy. First, garden egg is a widely cultivated crop. Second, borers are a serious pest for garden egg, diminishing the quantity and quality of produce. Improving the quality of garden egg would benefit both the local and export markets. Since there are several pests affecting garden egg (as is also the case for tomatoes in Ghana), the use of pesticides may not decline substantially with the use of a variety resistant to the shoot and fruit borer.

To improve the likelihood of benefits accruing to farmers, more investment in garden egg research is needed. In particular, programs need to be developed that will generate improved varieties from local genetic resources. Garden egg is a highly diverse crop of African origin, the development or introduction of a GM garden egg variety should be done in a way that does not adversely affect local genetic diversity of the crop.

Contributing authors: Ramatu M. Al-Hassan (Department of Agricultural Economics & Agribusiness, University of Ghana), Walter S. Alhassan (West and Central Africa Coordinator, Program for Biosafety Systems), Kwasi O. Bonsu (Crops Research Institute, Kumasi, Ghana), Jose Falck-Zepeda (Research Fellow, IFPRI), Guillaume Gruère (Research Fellow, IFPRI), Daniela Horna (Postdoctoral Research Fellow, IFPRI), Melinda Smale (Senior Research Fellow, IFPRI), Samuel E. Timpo (Biotechnology & Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana).

FOR MORE INFORMATION

Horna, D. et al. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report, October 2006. Available upon request (dhorna@cgiar.org).

PBS publications are issued by individual partner institutions and undergo review procedures specific to each issuing institution. This publication has undergone at least one internal or external review prior to publication by IFPRI.

Copyright © 2007 IFPRI. All rights reserved. Sections of this material may be reproduced for nonprofit use without written permission but with acknowledgment to IFPRI. For further information: ifpri-copyright@cgiar.org.



INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty
Supported by the CGIAR



PROGRAM FOR BIOSAFETY SYSTEMS

A partnership program for biosafety capacity development

PBS, a program managed by the International Food Policy Research Institute (www.ifpri.org), supports partner countries in Africa and Asia in the responsible development and safe use of agricultural biotechnology. PBS effectively addresses biosafety through an integrated program of research, capacity development, and outreach. PBS is funded by the U.S. Agency for International Development (USAID).

BRIEF NO. 5 OF 5

ASSESSING THE POTENTIAL ECONOMIC IMPACT OF GENETICALLY MODIFIED CROPS IN GHANA

VIRUS-RESISTANT CASSAVA

Edited by Daniela Horna, Melinda Smale, and Jose Falck-Zepeda, International Food Policy Research Institute

In many countries, economic considerations are an important factor in government decisionmaking on the introduction of genetically modified (GM) products. However, reliable information on their actual or likely economic impact is often lacking. This brief illustrates the use of a methodological framework to assess the potential economic impact of introducing GM cassava in Ghana. The evaluation is based on analysis of secondary information at two levels: (1) the pertinent industry or sector of the national economy (consumers and producers, linked by markets), and (2) international trade.

Cassava and the Cassava Mosaic Virus (CMV) Disease

Cassava is perhaps the most important food crop in Ghana. The cassava tuber is produced in all but two regions in the northernmost part of the country. Average area cropped per year between 1999 and 2004 was about 750,000 hectares, with the primary producers being the Eastern, Brong Ahafo, and Ashanti regions. Total annual output of cassava during the same period was about 10 million metric tons. This crop is perceived to generate extensive farm and nonfarm linkages for rural development, since it is utilized in various forms. Apart from cooking the fresh root, it can be processed into *gari* (fermented cassava dough), tapioca (toasted starch), and cassava flour (crude and refined). All these products are used for human consumption. The cassava leaves are also consumed as a vegetable by some ethnic groups. Although dried cassava chips and cassava pellets are ingredients in livestock feed in Europe, this is not yet a common practice in Ghana.

The main diseases affecting cassava are cassava mosaic virus (CMV), cassava bacterial blight, cassava anthracnose, and root rot. Pests and diseases, in combination with poor agronomic practices, combine to cause high yield losses in Africa. While biological and chemical control practices are available for other pests and diseases attacking cassava, CMV is difficult to control. In severe cases, plants become stunted. In fact, this disease can cause up to 60 percent yield loss, and no biological or chemical control is now available to farmers. Given the vegetative propagation method used for cassava, availability of clean planting material for propagation is a major constraint, since white flies and contaminated material transmit the disease. The disease occurs throughout the country. At present, tissue culture (in vitro) propagation is too costly to be considered as an alternative for addressing this productivity constraint in Ghana. The use of varieties genetically modified that can tolerate the disease shows then great potential.

Constraints to Cassava Production

While cassava production demands few external inputs, labor and planting material are main costs of production. As a root crop, cassava requires a lot of labor to harvest. The production of cassava is dependent on a supply of good quality stem cuttings. The multiplication rate of these vegetative planting materials is very low, compared to grain crops, which are propagated by true seeds. Postharvest deterioration of cassava is a major constraint. Cassava stem cuttings are bulky and highly perishable, drying up within a few days. Consequently, roots must be processed into a storable form soon after harvest. Ghanaian farmers recognize postharvest loss as a major risk factor in cassava production. Nevertheless, the rapid

postharvest perishability might lead to comparative advantages for small-scale producers linked to small-scale processing units. Furthermore, many cassava varieties contain cyanogenic glucosides, and inadequate processing can lead to high toxicity. Various processing methods, such as grating, sun drying, and fermenting, are used to reduce the cyanide content.

Industry level

Given that cassava is extensively produced and consumed in Ghana, both consumers and producers would benefit from higher productivity and reduced damage to the crop. Results of the industry-level analysis show that a cassava resistant to CMV (VR cassava) would yield high social benefits to the country. The social net benefits are positive for all the scenarios evaluated. In fact, statistical analysis of the distribution of benefits confirms that the probability of social losses is insignificant. Benefits are high even assuming irregular adoption of the technology. Hence, the analysis suggests that there is virtually no downside risk for the industry as a whole.

Clearly, however, any factor that depresses adoption of GM crops in general reduces the expected benefits. Finding an effective means of disseminating GM plant material is critical. A sustainable seed production system needs to be built around a steady flow of new varieties, a primary multiplication point, and a distributed set of secondary and tertiary multiplication points. The cost effectiveness of tissue culture has to be examined. Given successful provision of GM planting material to farmers, factors that would affect the level of net benefits of GM cassava are (1) the elasticity of the supply or how responsive prices are to higher or lower production, and (2) the degree of disease abatement due to the genetic modification.

Trade level

Available data on international trade (Comtrade) suggest that cassava exports are relatively small, but targeted mostly to European Union (EU) countries, which have stringent import approval of GM products. Over 70 percent of total exports of fresh cassava go directly to the EU each year. Fresh cassava exports ranged from \$6,000 to \$500,000 per year, with an average of \$150,000 (or 6 million metric tons) during the period 1996–2003 and \$20,000 (or 60,000 metric tons) during 1998–2003. Because total exports are a small share of total production, one would need to compare the economic benefits for farmers with the potential loss in exports. If the technology has a high likelihood of returning more than \$100,000 of benefits per year, it could be considered beneficial for the production sector overall.

At a cost for preserving and monitoring identity, it would be possible to set up a segregation system for exports of non-GM cassava in order to avoid being subject to regulatory approval of the technology in the EU. The international market for cassava, however, is competitive. Consequently, EU buyers will most likely obtain their supply from other providers, at least during the approval process. Thus there are few economic incentives for market chain actors to set up a segregation system.

Policy Implications

Although VR cassava has received the support of the President's Special Initiative as a future target product for export, more research on cassava is needed at the farm and market levels to complement the GM technology and address industry needs. Farmers do not perceive CMV as a problem but rather as a factor that is inevitably present. They will only adopt VR cassava if the varieties show a clear technological advantage in terms of yield, higher storage capacity, or even higher starch content as well as disease resistance.

The use of VR cassava varieties with resistance to CMV would bring economic benefits to the general economy. Despite the evidence of positive net benefits, future GM research and development in cassava most likely lies in public hands. Cassava is a crop that links the farmer to the market, but overall it is a food security crop that needs public research investment. In addition, the vegetative propagation system of cassava does not create incentive for private participation, since they cannot profit from seeds. While it may be profitable for some private companies to invest in GM crops, there appears to be little scope for private intervention in the case of cassava. Despite Ghana's interest in transforming cassava into a major industrial crop, cassava is still a food security crop with a vegetative multiplication system.

Contributing authors: Ramatu M. Al-Hassan (Department of Agricultural Economics & Agribusiness, University of Ghana), Walter S. Alhassan (West and Central Africa Coordinator, Program for Biosafety Systems), Kwasi O. Bonsu (Crops Research Institute, Kumasi, Ghana), Jose Falck-Zepeda (Research Fellow, IFPRI), Guillaume Gruère (Research Fellow, IFPRI), Daniela Horna (Postdoctoral Research Fellow, IFPRI), Melinda Smale (Senior Research Fellow, IFPRI), Samuel E. Timpo (Biotechnology & Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana).

FOR MORE INFORMATION

Horna, D. et al. *Assessing the Potential Economic Impact of Genetically Modified Crops in Ghana: Tomato, Garden Egg, Cabbage and Cassava*. PBS report, October 2006. Available upon request (dhorna@cgiar.org).

PBS publications are issued by individual partner institutions and undergo review procedures specific to each issuing institution. This publication has undergone at least one internal or external review prior to publication by IFPRI.

Copyright © 2007 IFPRI. All rights reserved. Sections of this material may be reproduced for nonprofit use without written permission but with acknowledgment to IFPRI. For further information: ifpri-copyright@cgiar.org.