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BIOTECHNOLOGY: ECONOMIC FARM INCOME GAINS FROM COMMERCIALIZATION OF BT COTTON AND MAIZE IN THE COMESA REGION

The last two issues of the newsletter carried excerpts of presentations by Prof. Robert Paarlberg and Dr. Isaac Minde at a regional biotechnology-biosafety workshop organized by the Common Market for Eastern and Southern Africa (COMESA), Association for Strengthening of Agricultural Research in Eastern and Central Africa (ASARECA), African Centre for Technology Studies (ACTS) and Programme for Biosafety Systems (PBS) held in Nairobi on 30-31 May. Prof. Paarlberg urged countries in the region to harmonize their policies in order to minimize risks associated with Genetically Modified Organisms (GMOs). Dr Minde concluded that the non dis-aggregation policy of GM and non-GM food by major food aid donors present a big challenge to saying no to GM foods and that possibly, GMOs is an option worth considering in accelerating agricultural development. In this third and last article on biotechnology, James Mbwika, writes that genetically modified organisms (GMOs) could provide an answer to the declining per capita production in SSA.

Introduction

Sub Saharan Africa (SSA) is the only region in the world where livelihoods and food security continue to deteriorate. If the current trends do not change, 39.3 percent of the population will remain below this line by 2015. SSA will be the only developing region where the number of poor people will increase from the 1990 levels. While per capita food production globally has increased by 10 and 20 percent, it has been on the decline in Africa.

This paper looks at the potential farm income gains that may result from introduction of GM maize and cotton within six countries considered in the Regional Approach to Biotechnology and Biosafety Policy in Eastern and Southern Africa (RABESA initiative): Egypt, Ethiopia, Kenya, Tanzania, Uganda and Zambia. Although none of these countries has started commercial production of GM crops, inference can be made from South Africa, the only country in Africa that has adopted and is producing GM maize (white and yellow) and cotton commercially.

Evidence from countries that have started to produce GM crops commercially show income gains from savings on pesticide costs, labour and improved yields. Since there is little spraying of maize among small scale maize producers in Africa, the potential gains in this case would come from improved yields. The case for cotton could be different because some spraying takes place and the gains would accrue from savings in spraying, labour and improved yields.

Adoption of GM seeds was determined by a number of factors which include existing seed systems, the levels of stalk borer and bollworm infestation, access to credit, cost of the GM seeds compared to conventional seeds and perceived consumer attitude to GM technologies.

Adoption of GM technologies was assumed to start at a low level but increase as benefits to early adopters become visible to other farmers. In South Africa, 1, 215 ha of GM maize were planted in 1998, this shot to 20,000 ha in the following year and to 250,000 ha by 2004. GM maize varieties accounted for 3 percent of harvest in 2003 and are estimated to account for 8 percent and 16 percent in 2004 and 2005 harvests respectively. By 2010, it is estimated that 50 percent of the total harvest of maize will be GM maize. Although one cannot assume that conditions experienced in South Africa would apply to the rest of SSA, it is plausible to assume that since farmers who are likely to adopt GM maize are commercially oriented farmers, similar or close relationships would be experienced.

Estimating potential farm incomer gains from use of GM maize and cotton

In estimating the gains from use of GM crops, the following parameters were considered; the level of damage caused by stalk borers in maize and by bollworms in cotton, and costs associated with control stalk borers in maize and bollworms in cotton;

- Assuming an initial 3 percent (the initial adoption of GM maize in South Africa) of the total area under maize in the RABESA countries would be grown with GM maize initially, and that this would increase by 10 percent annually under different scenarios determined by the level of infestation of the stalk borer. The annual increments are lower than those achieved in South Africa. Yield increases are assumed to be the same as the losses occasioned by stalk borer infestation. This assumption implies that GM technologies are capable of providing 100 percent stalk borer control. Ideally, it is assumed that the area currently under improved maize in the study countries is the one likely to switch to GM maize. It is for this reason that this analysis starts with a smaller adoption rate and assumes a modest level of growth to reflect imperfect seed systems existing in most RABESA countries.

- The benefits from adoption of GM seeds were calculated on the basis of yield increases resulting from control of stalk borers, savings on chemical sprays (cost of chemical and labour). Actual costs should ideally include costs of equipment (a depreciated cost) and water. Because data on actual stalk borer infestation in all countries in the region were not available, three scenarios with different levels of infestation were used.

- It was assumed that use of GM crops would achieve an 80 percent effectiveness in control of stalk borer;

- The extra costs of using GM seeds were estimated at US $ 5 per ha. Costs on savings on labour and spray are different for each scenarios and increase with level of infestation.

- In South Africa, yield gains of up to 10 percent were realized for farms planted with GM corn compared to those with conventional seeds. Studies elsewhere have shown that GM corn could lead to yield increase of 5 percent in temperate maize growing areas and 10 percent in tropical areas.

The approach used in this paper differs from that used in RABESA Economic Analysis Reports I and II in that area under which GMOs was assumed to be adopted was derived from the expected levels of stem borer or bollworm infestation. The potential gains per hectare were also calculated from expected gains and savings from spraying and labour costs. The analysis was done on a country basis for the RABESA and other countries. Data used in the analysis were generated from in-depth studies in the six countries, complemented with data from the Food and Agriculture Organization of the United Nations (FAO). Information from other studies on the economic benefits of the GM crops is used to supplement and support key assumptions.

Potential farmer income gains in adopting GMO maize

In this analysis, three levels of infestation of stalk borers of 10, 15 and 25 percent were assumed. It was further assumed that by adopting GM maize, farmers would realize a yield increase equivalent to existing level of stalk borer infestation and that in all cases, the initial adoption rate taken by the study countries would be 3 percent. The adoption rate was then assumed to increase annually by 10 percent over the next ten years. The savings on spraying and labour costs were assumed to be US $ 18.50 per hectare while the price of maize was assumed to be US $ 200 per metric tonne.

Studies elsewhere have shown the following income gains for farmers who switch to GM maize: South Africa, a net income gain of $ 36 per hectare under irrigated conditions and a net income gain under dry land conditions of US $ 27 per hectare. In 2003-2004, planting season in Philippines, GM farmers' experienced 37 percent increase in yields, reduced insecticide costs by 60 percent and increased their profitability by 88 percent ($ 170 per hectare), despite seed costs being roughly twice as much as those of conventional hybrids. In Spain, farmers who switched to GM seeds experienced an income gain of $ 205 per hectare.

The benefits of agricultural technologies accrue to farmers, technology developers, input suppliers and consumers. It was estimated that even with a strong Intellectual Property Rights (IPR) 59 percent of benefits from adoption of GM cotton in USA went to farmers, 21 percent to the technology developers and IPR holders, 9 percent to consumers, 6 percent to the rest of the world consumers, and 5 percent to suppliers of germplasm. These benefits-share-ratios were adopted for analysis in this paper.

The level of damage caused by stalk borers or bollworms was used to give an estimate of the level of farm benefits that could accrue from adoption of GM seeds. In Kenya for example, a loss of 13.5 percent due to stem borers valued at between US $ 25 and US $ 59.8 million was reported in 2002, while an earlier study reported a 15 percent stem borer loss, equivalent to 400,000 metric tonnes of maize per year valued at some US $ 90 million.

Estimating the impact of GMOs on maize farm incomes

Benefits from adoption of GM crops include; improved productivity as a result of reduced insect damage, savings on spraying and improved yields resulting from use of GM seeds. The income gains would fluctuate year-by-year depending on level of stalk borer infestation, but in most years, they would exceed by a safe margin the higher cost of purchasing the GM seed as explained below.

Scenario One: Assume 10 percent stalk borer infestation

With a stalk borer infestation of 10 percent and assuming that GMO would only effectively control 80 percent of infestation then, the yield gains would be 80 percent of the 10 percent gain of using

the GMO crops (8 percent yield gain) and a modest US $ 10.50 per ha savings on labour, water and spray costs. Under this scenario Egypt experienced the highest income gain of US $ 3 million in the first year of adoption and US $ 7.3 million in the tenth year. The cumulative income gain over a ten-year period was US $ 49.5 million. Zambia experienced least income gains of US $ 540,000 in the first year and US $ 1.3 million in the tenth year and cumulative income gains over a ten-year period estimated at US $ 8.6 million. Assuming 59 percent of the income could accrue to farmers, the total farm income gains for Egypt over the 10-year period would be US $ 29.2 million and US $ 5.1 million in the case of Zambia.

The gains per hectare for all the three scenarios and for the different countries showed that Egypt would have the highest gains per hectare by adopting GMO crops. This was derived from the fact that the potential yields gains would be much higher in Egypt compared to the other countries. The lowest gains were estimated at US $ 20 per ha for the aggregate of all the COMESA ASARECA countries outside the RABESA countries.

Scenario two: Assume 15 percent stalk borer infestation

With a stalk borer infestation of 15 percent and assuming an 80 percent effective control, it was expected that yields would increase by 12 percent and modest savings on labour, water, and spray chemicals of US $ 12 per ha. The farm income gains over a ten year horizon under this scenario show that Egypt would experience the highest income gain of US $ 4.7 million in the first year of adoption and US $ 11 million in the tenth year. The cumulative income gain over a ten-year period would be US $ 74.3million. Zambia would experience the least income gains of US $ 810,000 in the first year and US $ 1.9 million in the tenth year. The cumulative income gains over a ten-year period for Zambia were estimated at US $ 12.9 million. Under the assumption of 59 percent of the income gains accruing to the farmer, the share for Egyptian farmers would be US $ 43.8 million and US $ 7.6 million for Zambian farmers. The gains per hectare for all the three scenarios and for the different countries show that Egypt would have the highest gain at US $ 192 per ha. The lowest gains were estimated at US $ 29 per ha for the aggregate of other COMESA ASARECA countries outside the RABESA countries.

Scenario three:Assume a 25 percent stalk borer infestation

With a 25 percent level of infestation and assuming 80 percent effective control of stalk borer by adopting GM crop varieties, a 20 percent improvement in yields wais expected, and modest savings on labour, water, and spray chemicals of US $ 14 per ha. The farm income gains over a ten year horizon under this scenario show that Egypt would experience the highest income gain of US $ 7.8 million in the first year of adoption and US $ 18.3 million in the tenth year. The cumulative income gains over a ten-year period for Zambia would be US $ 123.7 million. Zambia would experience the least income gains of US $ 1.4 million in the first year and US $ 3.2 million in the tenth year. The cumulative income gains over a ten-year period for Zambia were estimated at US $ 21.5 million. The share accruing to farmers in Egypt would be US $ 7.3 million initially and US $ 12.7 million over the ten year period.

In terms of income gains per hectare under this scenario, Egypt had the highest gain at US $ 317 per ha. The lowest gains were estimated at US $ 45 per ha for the aggregate of COMESA ASARECA countries.

The above yield increases as a result of adoption of GM seeds were very conservative. Studies show that in the case of GM cotton in South Africa, yield increases of 18.5 percent for large scale

farmers under irrigation, 13.8 for large scale farmers under dry land conditions and 45.8 percent increase for small scale farmers under dry land conditions were recorded. However, in absolute terms, large-scale farmers under irrigation had the highest yield gain of 633 kg per ha, while large scale, under dry land conditions gained 115 kg per ha and small scale under dry land conditions gained 181 kg per ha. This analysis shows that the benefits from use of GM seeds are closely linked with levels of stalk borer infestation.

Expected farm income gains per hectare GM cotton

Cotton is one of the most grown commercial crops in Sub-Saharan Africa. Within the six study countries 1,684,431 metric tonnes of seed cotton was produced from an estimated 1,901,647 hectares in 2005. The annual average yields of seed cotton from the COMESA/ASARECA states were estimated at 0.86 metric tones per hectare.

GM cotton is one of the commercially produced commodities in countries that have embraced GM technology. United States of America is the world's leading producer of GM cotton with 42.8 million ha of cotton followed by Argentina with 13.9 million ha in 2004. Other countries include Australia (0.1 million ha), China (2.8 million ha), Columbia (0.05 million ha), India (0.5 million ha), Indonesia (0.05 million ha), Mexico (0.05 million ha), and South Africa (0.4 million ha). South Africa started commercial production of GM cotton in 1997, and within 5 years had roughly 45 percent of total cotton area planted with GM seeds. By 2004, adoption rate of GM cotton in South Africa had reached 85 percent.

To control bollworms in cotton, 6-8 sprays are recommended per season, leading to high production costs, estimated at 59 percent of total cost of production. In South Africa, spray costs in none GM fields for cotton have been estimated at R 220.48 per ha, while sprays in the GM fields were estimated at R 22.61 per ha. The yield difference was a 27.3 percent (388 kg per ha) yield increase per hectare on the GM field. In terms of savings for sprays these were estimated at R 5.8. Using the same assumption as in GM maize, but assuming high infestation rate and high adoption rates for the GM cotton, one arrives at the following results for benefits of adopting GM cotton.

i) Reduced need for spraying water in labour constrained households can be a welcome relief. The adoption of the GM technology could also reduce the risk of poor handling of chemicals, which could be harmful to environmental and human health.

ii) GM offers a window of hope for cotton farmers to save on spray and labour costs in cotton production. Considering the high cost of insecticides and related labour costs for spraying, there are potential income gains that should accrue from adoption of GM cotton. The highest gains have so far been reported in China at US $ 357– 650 per ha. In South Africa the benefits have been calculated at US $ 27-36 per ha, with higher gains being reported under irrigated farmers.

The assumption here was that a higher proportion of cotton farmers use commercial cotton seed than the proportion of maize farmers using commercial maize seed, and that bollworm was a much bigger problem to cotton producers compared to stalk borer problem to maize farmers. Data on levels of infestation of bollworm in cotton farming in the six study countries is limited. However, percentage infestation was estimated for Egypt at 80 -90%, Ethiopia 36-60%, and Uganda 40-70%. In Kenya, it was estimated that 57 percent of cotton production cost at the farm level was attributed to pesticides and spraying cost.

For this paper the assumptions were; that an initial adoption rate of 5 percent for GM cotton on actual area planted with cotton in 2005, and that subsequent adoption was at the rate of 15 percent over ten years for scenario one and 25 and 35 percent for scenarios two and three respectively. These were considered to be conservative estimates as cotton was more likely to be adopted faster than maize, first because it was largely a commercial crop and two because it did not have major consumer concerns as maize. Third, cotton farming involves a lot of insecticide use. Evidence from other parts of the world also indicates a faster adoption of GM cotton compared to that of GM maize. Evidence from South Africa supports this agreement. For projection purposes this analysis assumed the area under cotton would grow at 5 percent over the next ten years. The projection shows that in the tenth year, 3,097,583 ha would be under cotton.

In all scenarios, in the first year of adoption 95,082 hectares (5 percent of the estimated 2005 area under cotton in the RABESA countries would be under GM cotton. In the tenth year under scenario one 334,488 hectares (11 percent), 708,419 hectares (23 percent) in the second scenario and 1,416,132 hectares (46 percent) under the third scenario.

In order to calculate the benefits from the use of GM cotton, potential yield gains associated with improved control of the bollworms were calculated on assumption that majority of the farmers use some form of chemical control and are able to achieve 50-80 percent of bollworm control. The yield increase would therefore be 20–50 percent of the level of bollworm infestation. The actual yield increase would be 10–25 percent depending on the level of infestation and assumed level of control previously achieved through spraying.

Conclusion

The approach used for this analysis is different from that used in calculating farm income benefits in the RABESA Economic Analysis Report II, in that this paper attempted to calculate the benefits in US dollars per hectare, whereas in the RABESA Report II, a US $ 50 per ha gain was assumed. The calculations were based on an assumed infestation rate of bollworm. In this paper a projection over a ten year period was calculated using an assumed growing adoption rate of GM cotton after an initial adoption of 5 percent and savings on chemical sprays (US $ 80 per ha) and labour (US $ 6 per ha) would apply in all cases, and that the price of seed cotton would be US $ 200 per metric tonnes. This analysis further assumes that the proportion of farmers' benefits of the total income benefits is 59 percent.

In conclusion, the benefits for GM maize and GM cotton have been demonstrated to be positive and increase with level of risks of the respective insects. Adoption of GM cotton and maize has the potential to improve farmers' incomes and overall food production situation in the SSA.

This is an abridged version of Mr. James Mbwika's paper. This presentation as well as those of Prof. Robert Paarlberg and Dr. Isaac Minde, and RABESA documents quoted here are available in full at www.asareca.org/ecapapa

COMMUNICATION

Scholarship opportunities

The African Development Bank (ADB)/Government of Japan Fellowship Program offers twelve (12) scholarships for the 2006/2007 academic period to African scholars who wish to pursue a Masters level graduate of studies (MBA, DEA, DESS) in a field related to the promotion of Economic Development in their home country. Eligible candidates must have secured admission to a master's

degree program at a university in a member country of African Development Bank. The university should be recognized for its research and teaching in its selected development field. Scholarships granted under ADB/Japan Fellowship Program provide the following benefits: full tuition, Installation allowances, monthly subsistence allowance, book allowance and economy class round trip Air ticket. For application forms, please contact in person: a.ramoul@afdb.org Completed application forms should be submitted by **15 July 2006.**

ECAPAPA received this information from Prof. Willis Oluoch-Kosura, the Programme Director, Collaborative Msc in Agricultural and Applied Economics. He is gratefully acknowledged.

Call for papers

The International Centre for Tropical Agriculture (CIAT) in conjunction with the International Service for National Agricultural Research programme of the International Food Policy Research Institute (IFPRI-ISNAR), the International Livestock Research Institute (ILRI), the International Institute for Rural Reconstruction (IIRR-Africa) and the Promoting Local Innovation (PROLINNOVA) are organizing an international symposium on agricultural innovation systems in Africa to be held on **21–23 November 2006 in Kampala**. The organizers invite researchers and practitioners to submit abstracts for the symposium, drawing on diverse fields and disciplines of the social, agricultural and natural resource sciences, and presenting good practice in studying and in enhancing the process of innovation for effective agricultural research, development and education. Papers need not be directly linked to agriculture and NRM. Contributions are also sought for an interactive marketplace in the form of posters, videos, slides, photographs, websites, maps, group interactions for example, participatory theatre, and other lively ways of showing how work on innovation systems is being conducted in Africa and elsewhere. The intention is to acknowledge achievements and to encourage sharing of approaches, methods and insights among participants. The marketplace will be organised to maximize dynamic interaction in an open-space format, such as through on-the-spot discussion fora or mini-seminars. The marketplace will also feature the creativity and experience of farmers, farmer organizations and other local entrepreneurs and institutions. The closing date is 15 August 2006. For details, contact: innovationafrica@cgiar.org or p.sanginga@cgiar.org and ann.waters-bayer@etcnl.nl

Fellowship announcements

The **International Institute for Applied Systems Analysis (**IIASA) invites qualified candidates to apply for the annual postdoctoral program. Each year IIASA selects two post-graduate researchers to receive full funding for a 12-24 month stay at the institute. The application deadline is **15 August 2006.** The goals of the IIASA Postdoctoral Program are to encourage and promote the development of young researchers and offer them the opportunity to further their careers by gaining hands-on professional research experience in a highly international scientific environment; and to enrich IIASA's intellectual environment and help achieve research program goals. The Institute provides full funding for up to two postdoctoral researchers per year. IIASA conducts interdisciplinary scientific studies on environmental, economic, technological, and social issues in the context of human dimensions of global change. The work is organized in research programs and special projects. Candidates for the IIASA Postdoctoral Program can apply to work with any research program or special project. To explore productive synergies, candidates are encouraged to discuss, at an early stage of preparing their application, their scientific interests and research ideas with the intended IIASA hosts. For more information visit http://www.iiasa.ac.at/Admin/YSP/pdoc/index.html

The World Bank is now accepting applications from qualified candidates for its **Scholarship and Fellowship Programme,** for graduate studies leading to master's degree in development-related fields for mid-career professionals from the World Bank member countries, eligible to borrow. The Scholarship Program does not sponsor undergraduate studies, distance learning programs, short-term training, conferences, seminars, thesis writing, research projects, and fields of studies not related to development. For details, visit: http://web.worldbank.org

The Third World Organization for Women in Science with funds from the Department for Research Cooperation of the Swedish International Development Cooperation Agency has instituted a fellowship programme for female students from sub-Saharan Africa and least developed countries (LDCs), who wish to pursue postgraduate training leading to a PhD, at centres of excellence abroad in southern developing countries. The specific aims of the scheme are: to improve access to educational and training opportunities in science and technology for young and talented women graduates from sub-Saharan Africa and LDCs; to increase the scientific productivity and creativity of women scientists in sub-Saharan Africa and LDCs; and to empower a new generation of talented women to assume a leadership role in science and technology and their application to sustainable development. The minimum qualification of applicants is an MSc degree (or equivalent), or an outstanding BSc honours degree, in the following fields of natural sciences: agriculture, biology, chemistry, mathematics, physics, medicine, earth and environmental resources or engineering and technological sciences. The host institute where the applicant wishes to pursue her doctorate degree must be in a developing country other than her own. For details, contact: info@twows.org

Grant opportunity

The Bill & Melinda Gates Foundation will support a limited number of grants to evaluate strategies that improve market systems and lead to faster adoption of improved technology by small holder farmers. The proposed strategies will be validated through measurable outcomes and impact. The goal is to both; deepen understanding of how the agricultural value-chain affects smallholder and rural incomes; and identify, demonstrate, validate and establish income-raising strategies that can be dramatically scaled-up, both within a country and across country borders. The Foundation now calls for concept notes from sub-Saharan Africa and South Asia on the theme: **Raising income of smallholder farmers in the developing world by improving value chains.** The closing date is **31 July 2006.** For details, contact: gdrfpag.valuechain@gatesfoundation.org

ECAPAPA received this information from Dr. Luis Navarro, IDRC, Kenya. He is gratefully acknowledged.

This newsletter is an attempt to use e-communications to provide to a broad audience within and outside Eastern and Central Africa a mechanism for distribution and exchange of information relevant to agricultural policy issues. This newsletter is being sent to identified stakeholders of ECAPAPA. We want to respect your privacy and desire not to have your e-mail inbox filled with unwanted correspondence. If you do not want to receive this newsletter please send us a note at <ecapapa@asareca.org >, and we will remove your name from the distribution list. For back issues of this newsletter, go to 'View Archive' at www.asareca.org/ecapapa

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