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Actual and Potential Cost Reductions from Renting GM Crops

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I. Introduction

The introduction of the first commercially successful Genetically Modified (GM) crop varieties occurred in 1995.[1] As we approach the tenth year of the "Gene Revolution" in crop varieties, an assessment of the developments over the decade has merit. In conducting this assessment, I have organized this paper around three topics. The first is an assessment of mechanisms for GM crop cost reductions. The second is an evaluation of the actual cost reduction gains from the adoption of GM crop varieties. The third is the development of estimates of cost reduction gain potential for GM crops.

I. Mechanisms for Cost Reductions in Developed and Developing Countries

Five mechanisms are specified in this section.

1. GMOs for Rent: Developed Country Suppliers

This mechanism entails negotiations between private agro biotech suppliers of crop GM products and farmers in developing countries. The supplier provides the GM product in return for a technology fee or a seed price premium. The supplier may incorporate the GM product (e.g., a Bt product) in more than one crop variety (e.g., several cotton varieties). These varieties may have been developed by public NARS or IARC-NARS programs or by private seed companies. The supplier may even provide the rDNA technical services, so that little or no rDNA technical skills are actually required in the host economy.

2. GMOs for Rent: Developing Country Suppliers

This mechanism is similar to mechanism 1 except that a private firm or public NARS program in a developing country is the GM product supplier. Public NARS suppliers may choose to set different technology fees for domestic and foreign purchasers.

3. GMOs for Rent: International Agency Purchase

For this mechanism, an International Donor Agency negotiates with a GM product supplier to provide specific GM products to farmers in specific countries. The International Donor Agency makes payments to the GM product supplier. Farmers may then utilize the GM product without paying a technology fee.

[1] Earlier GM crops, the "ice-minus" crops and Calgenes "flavor-saver" tomato varieties were not commercially successful. Bovine Somatotrophin Hormone (BST) was introduced in 1993.

4. GM Product Germplasm Conversion

Most GM products being marketed today can be converted to germplasm in the form of "breeding lines". Once the initial "transgenic" incorporation of DNA into a breeding line is made, the GM product is expressed in the variety and in most cases will be expressed in progeny varieties where the transgenic line is utilized as a parent in a conventional cross. This effectively converts the GM product into a form where "conventional" breeding methods can be utilized to replicate the GM product. This germplasm conversion could be utilized by IARC programs in much the same way that wide crossing methods were used to incorporate "wild" (i.e. uncultivated) species" DNA into breeding lines.

5. Quantitative Enhancement: Genomics, Proteonomics Research

This mechanism entails "quantitative" trait breeding. Some prospects for quantitative trait locus (QTL) breeding have been developed to date, but the science of genomics and proteonomics is still in its infancy. There are, however, prospects for important gains in achieving gains in photosynthetic efficiency in plants. This research is very demanding of skills and creativity.

It should be noted that at present, GM products are basically "qualitative trait" products. And qualitative trait products endow plants with specific cost advantages that vary from environment to environment, but are "static" in nature. That is the cost advantage gains are of a "one-time" nature. They do not grow over time. It is possible to "stack" more than one GM product in a crop variety, but stacking does not produce cumulative gains.

It is sometimes said that the Gene revolution will replace the Green Revolution. But this will not happen until and unless mechanism 5 enables breeders to produce "dynamic" gains in generations of varieties. Until such time the Gene Revolution GM products can only complement conventional Green Revolution breeding. This complementarity takes the form of installing "static" GM products on the dynamic generations of varieties produced by conventional Green Revolution methods.[2]

It should be noted, however, that Marker Aided Selection (MAS) techniques enable conventional breeders to achieve breeding objectives faster. There is a need to "upgrade" breeders in the use of these techniques.

[2] The Roundup Ready product produced by Monsanto has been "installed" on approximately 1500 soybean varieties produced by 250 seed production companies.

II. Estimates of Cost Reduction Gains for GM Crops

A number of cost studies have now been undertaken and can form the basis for estimates of cost reduction gains when GM crops are introduced. Tables 1[3] and 2[4] summarize consensus estimates from these studies for the two major GM traits, herbicide tolerance and insect resistance. Note that these estimates are related to adoption levels. At present few rice GM products are available to farmers, but estimates of cost reduction are available (I will use these in computations of potential gains presented below).

Most soybean, cotton, canola and rice varieties are actually "modern" varieties in the sense that they have had significant breeding activity over the past 40 years or more. But not all maize varieties are modern. Many are landrace selections by farmers. It is unlikely that the addition of GM traits to landrace selections by farmers has any cost reduction value.

Soybeans were planted to 88 million hectares worldwide in 2003/04, with global production estimated at 190 million metric tons, and the world price averaging $250 per metric ton. The top five biotech countries represented 84% of the land area planted to soybeans and 90% of production.[5] More than half (54 percent) of soybean production in the top five biotech countries is from biotech varieties (Table 3). Total biotech soybean market value in 2003/04 was $23.5 billion – the highest of any biotech crop. The United States had the largest area in soybeans and highest biotech crop value ($13.3 billion). Brazil had the next largest biotech soy area, but due to a low (official) adoption rate, generated only $1.6 billion in biotech market value. Some reports suggest that the real biotech adoption rate in Brazil is as high as 30%. Argentina grew $8.3billion in biotech soybeans in 2003/04. China grew 8.7 million hectares of conventional soybeans, but had no biotech production. The Canadian soybean area is just over a million hectares, and about half were biotech varieties.

Maize was grown on 140 million hectares worldwide in 2003-2004, producing 614 million metric tons, at an average world price of $100 per metric ton. The top five biotech countries represent 70 percent of worldwide maize production and 49 percent of the global maize land area. Biotech varieties are grown on 19 percent of maize production land in the top five biotech countries, which collectively produced $11.2 billion in biotech maize (Table 4).

[3] Herbicide tolerance estimates are from Carpenter and Gianessi (2001), Fernandez-Correjo and McBride (2000) and Qaim and Traxler (2004).
[4] Insect resistance estimates are based on Traxler et al (2003), Qaim and de Janvry (2003), Qaim and Zilberman (2003, Pray and Huang (2003), Gianessi et al (2002) and Falk-Zepeda et al (1999).
[5] These data are from Runge and Ryan (2004).

The United States is the leading biotech maize producer, with $10.3 billion in production market value. Argentina has a modest area of land planted to maize, and an estimated $500 million in biotech soybean market value. Canada grew $384 million in biotech maize.

Cotton was planted to 32.6 million hectares worldwide in 2003/04. Production (lint only) is estimated at 93.5 million bales of 480 pounds each. The adjusted world price averaged 59 cents per pound. Half of the world's cotton production takes place in the top five biotech countries, and 61 percent of that is from biotech varieties (Table 5).

The global value of the biotech cotton in 2003/04 was $7.8 billion. China has the most area in cotton, the highest production and yields, and generates the most biotech cotton market value. The United States has almost as much area as China, higher adoption, lower yields, but essentially the same biotech production value. Argentina grew $75 million in biotech cotton on a relatively modest land area. This assumes a 60% adoption rate, although some reports suggest it may be as low as 20%. Brazil has more area in cotton production than Argentina, but no biotech adoption.

Canola (or rapeseed) was planted to 26 million hectares worldwide in 2003/04, with total production estimated at 39 million metric tons, and an average world price of $285 per metric ton. The top five biotech countries account for half the worldwide land area devoted to canola and half the global production (Table 6).

Among these top five countries, 28 percent of canola was a biotech variety. In 2003/04 the worldwide market value of the biotech canola crop was $1.4 billion. China grows the most canola among the five countries, but none in biotech varieties. Canada has the next largest land area planted to canola worldwide, but the majority of this crop is biotech, generating nearly $1.3 billion in biotech market value. The United States by contrast, has modest canola production, but still produces $1.38 million in biotech canola value. Argentina and Brazil have no meaningful canola production and no biotech varieties in use.

Other countries grow biotech varieties of soybeans, cotton, and maize, apart from the five leading nations, and James identifies 13 countries with biotech crop production, with 8 of these at meaningful levels.[6] Combined, these countries grew more than 600,000 hectares of biotech crops commercially in 2003/04, producing an additional $160 million in global biotech crop value.

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[6] James is the Director of ISAA. Annual reports are submitted. See James (2002).

III. Estimates of Potential Gains from Renting GM Crops

Estimates of potential gains possible from "renting" GM crops in maize, cotton, canola, soybeans and rice are computed and reported in Table 7. Insect resistant (B_T) GM rice varieties will be available to farmers in 2005 or 2006. China is likely to release B_T rice in 2005 and this will be the first publicly released GM crop variety.

The estimates reported are made for each country based on 2004 production data.[7] The estimates presume 80 percent adoption levels. That is, no gains are computed for adoption levels above 80 percent. Table 7 reports gains as a percent of crop value. This percentage is roughly proportional to the area planted to the 5 crops. Estimates of annual cost reductions in millions of US dollars are reported.

Table 7 reports wide diversity in the cost reduction values of GM crop renting as a percent of the crop value of the country. This percentage figure suggests that many countries have little stake in renting GM crop varieties. Specifically, only 5 of 15 countries in Western Europe have more than a 1 percent potential for cost reduction gains. For all 15 Western European countries the potential gains are only 1 percent of crop value.

Contrast this with the US value of about 9 percent and with Latin American potential gains. Argentina, Brazil, Paraguay, Bolivia and Costa Rica all have significant cost reduction potential. For Latin America as a whole, potential cost reduction gains are roughly 5 percent (as in Canada).

By contrast, potential gains in Eastern Europe and Oceania are modest.[8] West Asia appears to have modest potential as well. But South, Southeast and East Asian countries appear to have significant cost reduction potential.

North African countries also have low potential gains. East and Central African have modest potential for GM cost reduction. Several West African and Southern African countries have significant cost reduction potential from renting GM crops.

IV. Policy Implications

Western European countries have little to gain from GM crop approval. The US, Canada, Argentina, Brazil, Paraguay, Bolivia and Costa Rica have much to gain. Several countries in

[7] The estimated cost reduction calculations were: 14 percent for maize, 17 percent for cotton, 10 percent for soybeans, 10 percent for canola and 8 percent for rice. These were applied to 80 percent of production and valued at international prices.

[8] Data from former Soviet Republics do not allow calculation of this figure.

South, Southeast and East Asia do as well and most of these countries are further along in regulatory system development.

But, for a number of countries in Africa, it appears that cost reduction potential is high, but regulatory systems in many countries (South Africa being an exception) are not well developed. These countries may be paying a high price for following the “precautionary principle” advice of West European countries. This circumstance is further accentuated by the fact that Western European countries have very low stakes in terms of cost reduction potential. But they do have influence over both aid and trade support.

References

Bennett, R., S. Morse and Y. Ismael (2003). *The benefits of Bt cotton to small-scale producers in developing countries: the case of South Africa.* Paper presented at the 7th ICABR International Conference on Public Goods and Public Policy for Agricultural Biotechnology, Ravello, Italy, June 29 to July 3 2003 (available at http://www.economia.uniroma2.it/conferenze/icabr2003/papers/papers.htm; accessed March, 2004).

Carpenter, J.E. and L.P. Gianessi (2001). *Agricultural biotechnology: updated benefits estimates.* Washington, DC: National Center for Food and Agricultural Policy.

Evenson, R.E. and D. Gollin (1997). "Genetic Resources, International Organizations, and RiceVarietal Improvement," *Economic Development and Cultural Change*. 45(3): 471-500.

Falck-Zepeda, J.B., G. Traxler and R.G. Nelson (1999). *Rent creation and distribution from the first three years of planting Br cotton.* ISAAA Briefs No. 14, Ithaca, NY, USA, International Service for the Acquisition of Agri-biotech Applications.

Fernandez-Cornejo, J. and W.D. McBride (2000). *Genetically engineered crops for pest management in US agriculture: farm level effects.* Agricultural Economic Report No. 786, Washington, DC: Economic Research Service, United States Department of Agriculture.

Gianessi, L.P., C.S. Silvers, S. Sankula and J.E. Carpenter (2002). *Plant biotechnology: current and potential impact for improving pest management in US agriculture: an analysis of 40 case studies.* Washington, DC:National Center for Food and Agricultural Policy.

James, C. (2002a). *Preview: global status of commercialized transgenic crops: 2002.* ISAAA Briefs No. 27, Ithaca, NY, USA, International Service for the Acquisition of Agri-biotech Applications.

Pray, C.E. and J. Huang (2003). "The Impact of Bt cotton in China," In: N. Kalaitzandonakes, ed., *The Economic and Environmental Impacts of Agbiotech: A Global Perspective*. New York, USA:Kluwer-Plenum Academic Publishers.

Qaim, M. and D. Zilberman (2003). "Yield effects of genetically modified corps in developing countries," *Science* 299:900-902.

Qaim, M. and A. de Janvry (2003). "Genetically modified crops, corporate pricing strategies, and farmers' adoption: the case of Bt cotton in Argentina." *American Journal of Agricultural Economics* 85(4):814-828.

Qaim, M. and G. Traxler (2004). “Roundup Ready soybeans in Argentina: farm level, environmental, and welfare effect,” Agricultural Economics (in press).

Runge, C. Ford and B. Ryan. "The Global Diffusion of Plant Biotechnology: International Adoption and Research in 2004." A report prepared for the Council on Biotechnology Information, Washington, DC December 8, 2004.

Traxler, G., S. Godoy-Avila, J. Falck-Zepeda, and J. Espinoza-Arellano (2003). “Transgenic cotton in Mexico: economic and environmental impacts,” in: N. Kalaitzandonakes, ed., *The Economic and Environmental Impacts of Agbiotech: A Global Perspective*, New York, USA:Kluwer-Plenum Academic Publishers.

Table 1: "Estimates" Of Cost Reduction For Gm Crops

I: Herbicide Tolerance

		Adoption Level (Percent Reduction in Costs)			Adoption Level 2003 (Percent)	
Crop	Country	0-30	20-50	50-75	75-100	
Soybeans	US	15	15	12	10	81
	Argentina	15	12	10	10	99
Cotton	US	10	7	5	5	59
Canola	Canada	12	10	8	8	75
Maize	US	12	10	8	8	15

Table 2: "Estimates" Of Cost Reduction For Gm Crops

II: Insect Resistance (Bt)

		Adoption Level (Percent Reduction in Costs)			Adoption Level 2003 (Percent)
Crop	Country	0-30	20-50	50-75	
Maize	US	13	10	6	29
	South Africa	10	8	8	3
Cotton	US	15	13	12	41
	China	30	25	20	58
	India	30	20	10	10
	Mexico	30	20	10	20
	South Africa	30	20	10	20
Other Crops					
Rice		8	8	6	0

Table 3: Global Biotech Soybean Value: Leading countries.

Soybean 2003/04 Price = $250/MT	Crop Area (1) M Ha	Production (2) MMT	Biotech Adoption Rate	Biotech-Related Crop Value (3)	Estimated Cost Reduction
Five Countries:	**74.2**	**171.8**	**54%**	**$23.5 billion**	**$3.52 billion**
United States	29.2	65.8	81%	$13.3 billion	1.86 billion
Brazil	21.3	53.5	30%	$4.0 billion	.60 billion
Argentina	14.0	34.0	98%	$8.3 billion	.97 billion
China	8.7	16.2	--	--	--
Canada	1.1	2.3	50%	$284 million	.085 billion
Rest of the World	*13.8*	*18.3*	--	--	--

(1) area in million hectare; (2) production in million metric tons. (3) assumes world price $250/metric ton. Source: Runge and Ryan (2004).

Table 4: Global Biotech Maize Value: Leading countries.

Maize 2003/04 Price = $100/MT	Crop Area (1)* M Ha	Production (2)* * MMT	Biotech Adoption Rate	Biotech-Related Crop Value (3)* * *	Estimated Cost Reduction
Five Countries:	**68.5**	**434.5**	**19%**	**$11.2 billion**	**$.685 billion**
United States	28.8	256.9	40%	$10.3 billion	.66 billion
China	23.5	114.0	--	--	--
Brazil	12.6	41.5	--	--	.--
Argentina	2.1	12.5	40%	$500 million	.016 billion
Canada	1.2	9.6	40%	$384 million	.009 billion
Rest of the World	*71.9*	*179.5*	--	--	--

*** Area in million hectares; * * Million metric tons; * * * Average world price of $100/metric ton**
Source: Runge and Ryan (2004).

Table 5: Global Biotech Cotton Value: Leading Countries

Cotton 2003/04 Price = $0.59/lb.	Crop Area (1)* M Ha	Production (2)* * MMT	Biotech Adoption Rate	Biotech-Related Crop Value (3)* * *	Estimated Cost Reduction
Five Countries:	**11.2**	**46.7**	**61%**	**$7.8 billion**	**$1.67 billion**
United States	5.1	22.4	62%	$3.9 billion	1.02 billion
China	4.9	18.3	73%	$3.8 billion	.53 billion
Brazil	1.0	5.7	--	--	.--
Argentina	0.3	0.4	60%	$75 million	.02 billion
India	--	--	20%	$500 million	.6 billion
Rest of the World	*21.4*	*46.8*	--	--	--

*** Area in million hectares; * * Million metric tons; * * * Assumes world price of $0.59 per pound**
Source: Runge and Ryan (2004)

Table 6: Global Biotech Canola Value: Leading countries.

Canola 2003/04 Price = $285/MT	Crop Area (1)* M Ha	Production (2)* * MMT	Biotech Adoption Rate	Biotech-Related Crop Value (3)* * *	Estimated Cost Reduction
Five Countries:	**12.6**	**18.8**	**28%**	**$1.43 billion**	**$.17 billion**
China	7.5	11.4	--	--	--
Canada	4.7	6.7	68%	$1.29 billion	.15 billion
United States	..4	.7	73%	$138 million	.02 billion
Argentina	--	--	--	--	--
Brazil	--	--	--	--	--
Rest of the World	*13.4*	*20.2*	--	--	--

*** Area in million hectares; * * Million metric tons; * * * Average world price of $285/metric ton**
Source: Runge and Ryan (2004).

Table 7: Estimates of Cost Reduction Potential by Country

Country	Million $	Percent Crop Value
North America		
Canada	300	4.43
USA	6,000	8.95
Oceania		
Australia	78	1.14
New Zealand	2	.38
Papua New Guinea	1	.10
Japan	82	1.38
Latin America		
Southern Cone		
Argentina	1,055	8.43
Brazil	2,205	6.81
Chile	13	.62
Paraguay	137	9.14
Uruguay	15	2.60
Andean		
Bolivia	53	6.36
Colombia	44	1.00
Ecuador	56	2.80
Peru	49	2.81
Venezuela	26	1.93
Central America		
Costa Rica	43	9.93
El Salvador	1	.35
Guatemala	2	.60
Honduras	6	2.30
Mexico	271	2.34
Nicaragua	1	.48
Panama	1	.20
Caribbean		
Cuba	9	1.45
Dominican Republic	1	.16
Haiti	5	2.74
Jamaica	1	.87

Country	Million $	Percent Crop Value
Western Europe		
Austria	23	2.25
Belgium	7	.60
Denmark	8	.60
Finland	3	.60
France	270	1.87
Germany	119	1.92
Greece	81	1.96
Italy	145	1.22
Netherlands	3	.22
Norway	2	.85
Portugal	11	.97
Spain	74	.96
Sweden	4	.50
Switzerland	4	.92
United Kingdom	37	.83
Eastern Europe		
Albania	3	Na
Armenia	1	Na
Azerbaijan	12	Na
Bosnia-Hrzg	7	Na
Bulgaria	17	1.06
Croatia	22	
Czech Republic	23	na
Hungary	80	3.73
Poland	44	.66
Slovakia	9	na
Macedonia	2	na
Romania	121	3.45
Serbia	70	na
Slovenia	5	na
Africa		
North Africa		
Algeria	1	.09
Egypt	153	2.40
Morocco	3	.28
Tunisia	1	.17
		.13
East Africa		
Ethiopia	44	1.51
Kenya	38	2.49
Madagascar	24	1.93
Sudan	28	2.30
Uganda	51	1.83

Country	Million $	Percent Crop Value
Central Africa		
Burundi	1	.17
Cameroon	32	2.51
Chad	41	7.70
Congo (Zaire)	26	2.50
Central African Rep.	7	2.24
Rwanda	3	.49
West Africa		
Benin	77	11.00
Burkina Faso	72	10.25
C⊥te d'Ivoire	55	1.79
Guinea	12	2.00
Ghana	22	.89
Mali	85	12.14
Mauritania	1	1.36
Niger	1	.20
Nigeria	190	1.59
Senegal	15	2.45
Sierra Leone	2	.92
Togo	32	2.53
Southern Africa		
Angola	8	1.45
Botswana	1	1.42
Malawi	32	3.97
Mozambique	32	3.95
Namibia	1	.64
South Africa	130	4.06
Tanzania	85	3.80
Zambia	22	1.95
Zimbabwe	72	10.38
West Asia		
Afghanistan	1	.05
Iran	63	.82
Jordan	1	Na
Saudi Arabia	1	.13
Syria	32	1.43
Turkey	139	1.00
Yemen	4	1.10
South Asia		
Bangladesh	285	4.27
India	2,353	2.81
Nepal	51	3.21
Pakistan	471	4.57
Sri Lanka	22	1.16

Country	Million $	Percent Crop Value
South East Asia		
Cambodia	34	3.93
Indonesia	526	2.11
Laos	21	5.18
Malaysia	17	.37
Myanmar	219	Na
Philippines	152	1.48
Thailand	247	2.38
Vietnam	287	3.41
East Asia		
China	5,315	3.80
North Korea	40	Na
South Korea	52	Na
Mongolia	1	2.60
Former Soviet Union		
Belarus	2	Na
Estonia	2	Na
Georgia	6	Na
Kazakhstan	35	Na
Kyrgyzstan	11	Na
Latvia	1	Na
Lithuania	3	Na
Russian Federation	38	Na
Tajikstan	41	Na
Turkmanistan	103	Na
Ukraine	89	Na
Uzbekistan	201	Na