



ABSTRACT

Genetically-modified (GM) rice is an important technology surrounded with controversy and uncertainty, hence it warrants more in-depth analysis. While GM rice is considered by its supporters as having promising potential, many still remain passionately against its use.

This study assesses the impacts of GM rice commercialization on the global rice market. We use the Arkansas Global Rice Model (AGRM) and the RICEFLOW model to provide stochastic and dynamic analyses. Scenarios of adoption, diffusion and acceptance of *Bt* (*Bacillus thuringiensis*) rice by Bangladesh, China, Indonesia, Nigeria, and the Philippines are compared against baseline projections.

The results focus on world trade, world and domestic prices, resource savings, domestic production, consumption, stocks and imports.

Bt rice adoption has the potential to significantly impact the global and national rice economies of *Bt* rice adopters and net rice exporters. Total rice trade, international price, and domestic prices decline as global rice production, consumption, and stocks expand.

INTRODUCTION

The GM technology has been broadly adopted worldwide except in food grains of rice and wheat and has generated sizable economic benefits, many of them in the developing world.¹ Despite the benefits associated with this technology, to date, no GM rice has been commercialized.²

Ex ante analysis of adoption of *Bt* rice by selected major global rice importers has a market logic as these countries are hypothesized to be the most likely early adopters of the technology to satisfy domestic use. On the other hand, major rice exporters are unlikely to adopt given current policy in key importing nations, which reflects the market risks associated with the consumption of GM rice as outweighing the potential benefits.

Some of the benefits associated with the adoption of *Bt* rice are yield improvement from reduced pest damage, lower costs of production with reduced application of insecticide, and improved health outcomes of producers' less exposure to insecticide contamination.^{2,3}

METHODOLOGY

The AGRM and RICEFLOW are used as frameworks of analysis^{4,5}

The framework of analysis using the AGRM

Two scenarios are analyzed.

➤ **Scenario 1:** *Bt* adoption rate of 40% of the rice area in Bangladesh, China, Indonesia, Nigeria, and the Philippines.

➤ **Scenario 2:** *Bt* adoption rate of 20% for Nigeria and 40% for the other four countries to assess the effect of asymmetric adoption of technology.³

The adoption function of *Bt* rice is assumed to follow the same pattern as GM crops in the U.S.⁶ for a 9-year projection period up to 2023.

The framework of analysis using RICEFLOW

RICEFLOW is updated to year 2023 using forecasts for key exogenous variables, from which a stochastic baseline is generated based on historical yield data from USDA. A stochastic *Bt* scenario is generated from the stochastic baseline adding the assumption that *Bt* rice is adopted in 40% of the acreage in the 5 selected countries, generating a 5-percent yield gain, and a 50-percent reduction in pesticide use.

RESULTS

AGRM Analysis

The international rice price declines on average by nearly 6% annually under both scenarios as a result of a lower demand for imports in *Bt* rice adopting countries.

Production expands in all adopting countries to varying degrees, leading to a marginal global increase in production.

Consumption increases in adopting and non-adopting countries alike as a result of lower equilibrium prices, leading to a marginal increase in global consumption.

There is significant import substitution in adopting countries, which is only partially offset by higher imports by non-adopters as a result of lower international prices.

Table 1. Scenario impacts on selected global rice market variables^a

Variable	Scenario	2015	2023	9-Year Average
International Reference Price	Baseline (US\$/mt)	404	422	412
	Scen 1	-1.36	-8.68	-5.67
	Scen 2	-1.35	-8.60	-5.62
Production	Baseline (mil. mt)	483	520	502
	Scen 1	0.11	0.55	0.41
	Scen 2	0.11	0.55	0.41
Consumption	Baseline (mil. mt)	487	519	504
	Scen 1	0.11	0.62	0.41
	Scen 2	0.10	0.61	0.40
Total Trade	Baseline (mil. mt)	42	49	46
	Scen 1	-0.51	-2.69	-1.78
	Scen 2	-0.51	-2.66	-1.77
Ending Stocks	Baseline (mil. mt)	103	84	92
	Scen 1	0.02	0.09	0.39
	Scen 2	0.02	0.16	0.41

^aScenario results expressed in % changes from baseline

While scenario 2 has no significant impact on the global market, it does for Nigeria, which expands its imports due to smaller output gains than under scenario 1.

Table 2. Scenario impacts on Nigeria rice supply and use^a

Variable	Scenario	2015	2023	9-Year Average
Production	Baseline (tmt)	3,226	4,697	3,934
	Scen 1	0.23	1.91	1.23
	Scen 2	0.11	0.81	0.54
Consumption	Baseline (tmt)	6,611	8,487	7,545
	Scen 1	0.08	0.95	0.59
	Scen 2	0.08	0.94	0.59
Imports	Baseline (tmt)	3,402	3,792	3,619
	Scen 1	-0.05	-0.25	-0.12
	Scen 2	0.05	1.10	0.64

^aScenario results expressed in % changes from baseline

RICEFLOW Analysis

Adoption of *Bt* rice is likely to cause a marginal expansion in global production and consumption, and a slight reduction in global trade.

The dominant market effect of *Bt* rice across adopters is substitution of imports except for Nigeria, where the production boost is larger than the substitution effect.

Table 3. Impact on selected market variables in adopting countries

Country	Production		Consumption		Imports	
	Base 2023 ^a	Scen ^c	Base 2023 ^a	Scen ^c	Base 2023 ^a	Scen ^c
Global	733.1	0.26	488.5	0.13	45.1	-1.04
Bangladesh	55.5	0.17	37.5	0.05	0.05	-18.11
China	190.1	0.60	133.7	0.37	2.5	-9.48
Indonesia	60.5	1.33	39.9	0.90	0.5	-24.46
Nigeria	4.9	5.53	6.9	0.08	3.5	-2.30
Philippines	21.7	2.19	14.8	1.20	1.1	-10.24

^aMillion mt paddy basis. ^bMillion mt milled basis. ^c% changes from Base 2023

The adoption of *Bt* rice is expected to free up land for other uses and reduce land rental prices in all adopters except Nigeria, where production expands beyond the yield gain achieved.

Demand for labor and capital (both in elastic supply) is also expected to decrease in all *Bt* adopting countries except Nigeria.

Table 4. Impact on factor markets in adopting countries^a

Country	Land		Labor & Capital	
	Demand	Rental Prices	Demand	Wage/Price
Bangladesh	-4.42	-15.58	-3.87	0.00
China	-2.87	-11.00	-3.30	0.00
Indonesia	-3.46	-13.07	-2.75	0.00
Nigeria	1.05	5.23	1.28	0.00
Philippines	-2.52	-9.29	-1.93	0.00

^aAll results expressed in % changes from base 2023

All major exporters are expected to see marginal decreases in trade flows as a result of *Bt* rice adoption in the selected countries.

Table 5. Impact on exports of selected countries^a

Country	Export	Country	Export
Global	-1.04	Thailand	-1.18
India	-1.60	U.S.	-0.03
Pakistan	-0.34	Vietnam	-0.75

^aAll results expressed in % changes from base 2023

DISCUSSION

The results suggest that the adoption of *Bt* rice in selected importing countries will lead to lower demand and rental price for land (except in Nigeria), higher production, and a significant import substitution effect.

Land rental prices in large producing countries such as China can fall significantly by more than 10%, thus increasing the competitiveness of the whole domestic rice sector, not only of adopters.

At the global level, impacts are for the most part marginal except for the international reference price, which is estimated to decrease by 6% a year as a result of the *Bt* rice adoption rates and yield gains assumed in this study.

Lagging in *Bt* rice adoption can have significant welfare costs as estimated for the case of Nigeria. This provides the incentive for countries to keep up with the leaders in technological adoption.

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