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Grower Benefits from the Adoption of Genetically Modified Rice in California

by

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Genetically modified (GM) rice has not yet been commercialized anywhere in the world but may soon be available. We estimate that the economic gains to California growers from adoption of GM rice could be around $70 per acre. Besides the agronomic and economic benefits to the grower, there are significant environmental benefits for California.

California rice farmers are experiencing an "epidemic" of herbicide resistance in grassy weeds, and this resistance, especially in the case of watergrass, has resulted in annual herbicide costs of up to $200 per acre for some growers. The higher production costs associated with weed control lowers grower returns, and has led to considerable research effort to improve overall weed management through cultural, chemical and other management means. One strategy that is on the horizon is the adoption of genetically modified (GM) rice that is resistant to certain chemicals for which current weeds are not resistant. GM rice would not only reduce weed problems, but would lower chemical use in rice farming and simplify the management of rice production.

If accepted in the marketplace, there is good reason to believe that GM rice could lead to economic gains for the grower, as well as benefit the environment, given that conventional rice production in California involves heavy use of chemicals. Major rice producing and consuming countries, including the United States, China and Japan, are developing and testing this new GM technology. For instance, China has approved seven different GM rice varieties for environmental release. Many of these varieties have the potential to be of value to producers through reduced disease or pest control costs and of value to the environment through reduced chemical usage, thereby reducing runoff and water pollution. If GM rice is first commercialized outside of California, this will reduce California's competitiveness. So it is essential that the California industry identify the conditions under which GM rice would be successful in the state.

We have evaluated the potential short-run economic impact of the adoption of one GM rice cultivar on California rice growers. The cultivar is resistant to the broad-spectrum herbicide Liberty® (glufosinate), currently under development by Bayer CropScience, and is not commercially available at this time. Potential farm-level economic benefits, measured by net returns over operating costs, are calculated using a partial budgeting approach. Sensitivity analysis is then utilized to represent the heterogeneity in growing conditions in the state, as well as uncertainty regarding the yields, technology fee and other assessments on the GM seed.

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Background

The main farm-level effects of GM rice adoption in California would be lower herbicide costs and yield improvement. GM crops are not engineered to increase yields; rather, they are designed to prevent yield losses arising from weed infestation. As such, potential yield gains are dependent on the degree of the weed problem and the effectiveness of the treatment relative to the alternatives. Many adopters of GM crops have experienced yield effects ranging from zero percent to twenty percent, although some have reported small yield losses.

While herbicide costs are likely to decrease for a typical grower, it is probable that the cost of GM seed will be higher than conventional seed. Companies that sell GM crops typically charge a technology fee, either through direct agreement or pricing of associated products such as herbicides, in order to recoup their research investment costs. Using Monsanto's Roundup Ready® corn and soybeans as a reference point, the technology fee is approximately thirty to sixty percent of conventional seed costs per acre.

In addition to the technology fee, seed costs for GM rice will likely change as a result of the California Rice Certification Act (CRCA) of 2000. The CRCA classifies rice varieties that have "characteristics of commercial impact," defined by "…characteristics that may adversely affect the marketability of rice in the event of commingling with other rice and may include, but are not limited to, those characteristics that cannot be visually identified without the aid of specialized equipment or testing, those characteristics that create a significant economic impact in their removal from commingled rice, and those characteristics whose removal from commingled rice is infeasible." Under this legislation, any person selling seed deemed to have characteristics of commercial impact, which would presumably include any GM varieties, must pay an assessment "not to exceed five dollars per hundredweight (cwt)."

Table 1. Cost and Returns: Conventional Versus GM Rice

		Projected GM Rice Cost & Returns	
	High Cost Scenario[c]	*1 App. of glufosinate*	*2 Apps. of glufosinate*
Gross value of production	------per acre-------		
Primary product: Rice	$520	$520	$520
Farm Bill Provision	$264	$264	$264
Total gross value of production	$784.01	$784.01	$784.01
Operating costs			
Seed	21.00	21.00	21.00
Fertilizer	71.44	71.44	71.44
Insecticide and Fungicide	14.82	14.82	14.82
Herbicide[a]	98.01	16.03	32.05
Purchased irrigation water	59.13	59.13	59.13
Equipment Rent	14.67	14.67	14.67
Custom operations[b]	79.90	63.70	75.70
Contract operations	143.80	143.80	143.80
Labor	59.46	59.46	59.46
Fuel, lube and electricity	50.39	50.39	50.39
Repairs	13.00	13.00	13.00
Interest on operating capital	16.65	12.91	13.90
Assessment	7.20	7.20	7.20
Total operating costs per acre	$649.48	$547.56	$576.57
Net Returns above operating costs per acre	$134.53	$236.45	$207.44
Net Returns above operating costs per cwt	$1.68	$2.96	$2.59
Supporting information:			
Price ($ per cwt at harvest)	6.50	6.50	6.50
Yield (cwt per planted acre)	80	80	80
Farm Bill Provision Payments			
Direct Payments	$151.81	$151.81	$151.81
Counter Cyclical Payments	$112.20	$112.20	$112.20
Effective price per cwt	$9.80	$9.80	$9.80

a. Includes chemical material costs only.
b. Includes chemical application costs.
c. Changes from adjusted costs include 100 percent ground application, one additional application of grass herbicide on 50 percent of acreage, evaluated as mean cost, and 10% savings on chemical application from ground application.

An overriding issue affecting the farm-level returns from adoption of GM rice in California is market acceptance. Many California producers have voiced concern over the opposition to GM food crops in some markets–especially in Japan, the largest offshore market for California rice. However, Japan now imports substantial quantities of both GM and non-GM soybeans and corn from the U.S. and elsewhere. It is also the world's largest importer of GM canola. The non-GM grain brought into Japan is kept segregated in the handling, storage and marketing system. The segregation system works well, and Japanese importers pay a small price premium for non-GM cargoes to cover the segregation costs, as well as the higher production costs associated with non-GM crops. Under Japan's GM labeling regulations, there is a five percent threshold level for adventitious presence of (approved) GM material in non-GM shipments. Given the importance of the Japanese market, an adequate segregation system is therefore a necessary requirement for the commercialization of GM rice in California, as is food, feed and environmental approval for GM rice in Japan.

Table 2. Estimated Dollar Per Acre Potential Gains for Adopters of GM Rice

Technology Fee ($ per acre)	Percent Change in Yield with GM rice: 0%	5%	10%
$0	$64.46	$82.55	$100.64
2.50	61.85	79.94	98.03
5.00	59.24	77.33	95.43
7.50	56.63	74.72	92.82
10.00	54.02	72.11	90.21
12.50	51.41	69.51	87.60
15.00	48.80	66.90	84.99

Note: We assume two applications of glufosinate.

Farm-Level Potential Benefits of Genetically Modified Rice Adoption

To estimate the potential per-acre net returns of adoption for a single year, we utilize rice production cost estimates from the University of California Cooperative Extension and pesticide-use data from the California Department of Pesticide Regulation. The cost of production estimates were updated using the most recent pesticide-use data and prices, and compared to estimated costs of the Liberty Link® GM system, with yields, seed prices, assessments and rice prices held constant at the level of the conventional technology. See Table 1 for estimated costs and returns of conventional versus GM rice. Depending on the number of Liberty® (glufosinate) herbicide applications (one or two) necessary to control weeds, overall cost savings of adoption were estimated to be approximately $73 to $102 per acre, or about 11 percent to 16 percent of non-GM operating costs.

It is unlikely, however, that the individual producers will capture all of these cost savings, or that returns will be identical across growers. A technology fee, typically 30 to 60 percent of per acre seed costs ($6 to $13 for rice), is likely to be charged to adopters by developers of the technology, and the CRCA regulations will impose additional unit costs. Table 2 presents a range of estimates of per acre gains incorporating these uncertain variables, assuming that growers pay 100 percent of the CRCA assessments and use two applications of glufosinate per year on GM rice. Despite these conservative assumptions, the table indicates that adoption of GM rice will increase net returns per acre under most realistic scenarios. The most likely gains are shown near the bottom of Table 2. For instance, if the technology fee is $15 per acre and the yield gain is five percent, then the potential gain to adopters is almost $70 per acre.

Environmental Impact

Also of considerable interest is the effect of GM adoption on the industry's total chemical use. Most commercial rice production in the Sacramento Valley region is under flooded field conditions, and is heavily dependent on chemical herbicides and insecticides to control weeds and insects. Release of the standing water into the Sacramento Valley watershed is thus an important externality arising from rice farming, and one which will be affected by the introduction of transgenic varieties.

The California rice industry has a history of addressing water quality issues, beginning with implementation of the Rice Pesticides Program by the California Department of Pesticide Regulation in 1983. This program was originally designed to reduce herbicide pollution of local waterways, and was expanded in the early 1990s to include performance goals for additional herbicides and insecticides, as well as addressing damage done by drift and dust from aerial application of herbicides. Furthermore, the Central

Potential adoption of GM rice varieties is one way for growers to reduce chemical application in the Central Valley.

Photo courtesy of Dana Dickey, CA Rice Research Board

Valley office of the California Regional Water Quality Control Board passed an amended conditional waiver of waste discharge requirements for irrigated lands in 2003, which tightens quality standards for water released from agricultural uses in the Central Valley, as well as requires monitoring and reporting of water quality and implementation of management practices that improve discharged water quality. This conditional waiver expires in two years, and expectations are that standards for water quality will tighten further, increasing costs and reducing pest control options for rice growers. The courts are also encouraging rice farmers to reduce the use of chemicals. U.S. District Judge John Coughenour recently ordered the creation of pesticide-free buffers around streams and rivers to protect fish in California, Oregon and Washington. These buffers are expected to impact California rice growers who use aerial spraying.

Potential adoption of GM rice varieties is one way for growers to reduce chemical application in the Central Valley. Total poundage of chemical herbicides applied per acre is expected to decrease by at least 84 percent, and total poundage of active ingredients is predicted to decrease by at least 87 percent using the two-treatment Liberty® scenario.

Cultivation of GM rice in California could thus decrease total herbicide poundage by between 7.27 and 10.9 million pounds, and active ingredient poundage by between 1.69 and 2.53 million pounds, assuming 50 percent to 75 percent adoption. This is in accordance with previous studies that concluded cultivation of GM crops, in general, are consistent with increased environmental stewardship. However, this simple measure ignores toxicity, mobility and persistence of different chemicals in the soil and water, likely to significantly affect the external damage costs associated with chemical pest control.

Conclusions

This article reports our estimates of the potential short-run economic impacts of GM herbicide-tolerant rice adoption at the farm level, as well as the effects of adoption on the industry's herbicide use. We conclude that a weed management strategy including GM rice varieties will most likely lead to large economic benefits for the farmer, but these benefits will vary from grower to grower. However, this study does not thoroughly address market acceptance issues that may affect both domestic and export demand for conventional and GM rice, nor does it address the dynamic effects of adoption. Nevertheless, if California rice growers perceive that expected net benefits from adoption of the technology are positive and considerable, there is little doubt that the technology will be embraced by California rice growers and that a segregation system will be developed to allow the industry to supply non-GM rice to certain markets such as Japan. The environmental benefits for society from adoption of GM rice are also significant, but we do not estimate their exact magnitude. We note that agricultural runoff as a source of water pollution is becoming a heated issue in California, and changes to regulations regarding agricultural water standards will reinforce the arguments for introduction of GM rice cultivars in the state.

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