The Impact of the International Rice Research Institute's (IRRI) Rice Breeding Program

Lawton Lanier Nalley[1*], Jesse Tack[2], Alvaro Durand-Morat[1], Valerine Pede[3], and Donald Villanueva[3]

[1]Department of Agricultural Economics. University of Arkansas. Fayetteville, Arkansas USA
[2]Department of Agricultural Economics. Kansas State University. Manhattan, Kansas USA
[3] International Rice Research Institute. Los Banos The Philippines

*Corresponding author: llnalley@uark.edu. 217 AGRI Building, University of Arkansas. Fayetteville Arkansas, USA, 72701. +1-479-575-6818.

Selected Poster prepared for presentation at the 2024 Agricultural & Applied Economics Association Annual Meeting, New Orleans, LA: July 28-30,

The Impact of the International Rice Research Institute's (IRRI) Rice Breeding Program

Relevance of Topic

Rice genetic improvement is a key component of achieving and maintaining food security across Asia and Africa, given population growth and climate change. The International Rice Research Institute (IRRI) continues to play a critical role in creating and disseminating rice varieties with higher productivity. The public-private relationships, which included IRRI that formed the Green Revolution, allowed crop yields to grow exponentially until the turn of the millennium. Globally, staple crops (maize, wheat, rice, and soya) yields increased by an average of 124% from 1961-2007, one of the greatest scientific achievements of mankind, but are only predicted to increase by an average of 33% from 2007-2050 (Fisher, Byerlee, and Edmeades 2011). Globally, cereal yield growth rates have begun to slow in several staple crops, and public investment in agriculture, including at IRRI, has begun to decline. As investments in public breeding programs have declined, a paradigm shift of human and financial resources from the public to the private plant breeding sector has unfolded in the last twenty years. This shift does not assert a misallocation of funds, as the private industry often can innovate quicker, think more entrepreneurial, and respond to changing market conditions faster. This paradigm shift in which human and financial capital now predominately flow into the private sector does beg the question: who will be left to conduct breeding research for the public good where financial gains are difficult to capture? The impetus of this study is to highlight the genetic gains, price impacts, and surplus changes brought about by the IRRI rice breeding program in the Philippines since the release of the IR8 (the miracle rice), which started the Green Revolution. Importantly, this study provides tangible results to governments and other funding sources of the continued importance of public breeding programs in an ever-changing funding environment. This is the first study of its kind to quantify both the yield and welfare impacts of the IRRI breeding program and its efforts to combat global food insecurity.

Research Methodology

Using 103 IRRI elite rice lines and yield trials, which took place between 2005 and 2022 across 19 countries and 117 locations for 12,045 unique yield observations, we set out to estimate the annual genetic gain from the IRRI rice varieties. While yield trials started in 2005, the data included IRRI elite lines released as far back as 1966 (IR8, the variety that started the Green Revolution), so the release year coefficient could be estimated. Release Year (RLYR) is not a time trend but rather a vintage of a variety. It represents a snapshot of the genetics available for that given year. This method is the standard procedure for measuring the impacts of technological change (Traxler et al., 1995). In this sense, we include both RLYR (the year a variety was released by IRRI) and Year (trial year) in our modeling efforts. A cluster-specific two-way fixed effects (CSFE) regression equation provides the platform to estimate yield changes during the period of 1966-2021 while clustering standard errors on year. From these models, increases in rice volume (yield) associated with the IRRI breeding program are derived based on historical IRRI varietal adoption from 1991 to 2021 in the Philippines and Indonesia.

The volume of rice produced in the Philippines influences global prices, altering demand and availability in other countries. Based on the volume contributions estimated from our regression, global price effects and welfare impacts were elicited using the RiceFlow trade model. The RiceFlow model allows us to answer. the counterfactual question: What would the implications be for global consumers and producers if the IRRI's rice breeding program had not been present from 1966 to 2021? The model disaggregates the global rice economy into 76 regional markets and nine rice commodities derived from the combination of rice type and milling degree. Notably, the RiceFlow model generates domestic and global

estimates of changes in rice production, consumption, trade, prices, and consumer and producer welfare in each region given a change in the rice supply brought about by the IRRI breeding program.

Results

The release year coefficient (RLYR) was found to be robustly significant regardless of model specification. In the preferred model, the RLRY coefficient suggested that for each additional year of breeding, IRRI elite lines increased yield by 0.578%. To capture total gains, we used IR8 (RLYR=1966) as our base. The average yield in the dataset across all locations for IR8 was 3.52 t/ha, so each additional release year was associated with a 0.02 t/ha (0.578%*3.52 t/ha) yield increase. Using the historical adoption of individual IRRI lines and annual Filipino rice prices, this yield increase would indicate that the average annual benefits from adopting IRRI lines in the Philippines were 661.47 million in 2022 USD. Assuming the 2021 per capita rice consumption of 133kg (OECD, 2023), the additional rice from IRRI elite line adoption in the Philippines would provide an average of 12.52 million rice rations annually. This additional rice would be equivalent to feeding 11% of the 2022 Filipino population. Importantly, the large benefits calculated here are the result of the adoption of IRRI elite lines only in the Philippines; this does not include the global adoption of IRRI elite lines, which will result in even larger benefits.

The RiceFlow model indicated that if the IRRI stopped releasing varieties after IR8 in 1966, the retail price would have increased by 11% in the Philippines, and imports would have had to increase by 24.9% to meet rice demand. From a global standpoint, rice prices would have increased by 0.4%.

Potential for generating discussion during the meeting.

The results of this study highlight the importance of public plant breeding, even in the face of decreased funding. Plant breeding has been pivotal in improving global food security and reducing poverty. As the world faces a growing population and increasing climatic stresses, there are concerns as to how the shifting dynamics of the plant breeding industry will affect future food security. As the private industry plays a more significant role in traditionally dominated public breeding spaces (rice, wheat, and others), a paradigm shift is unfolding, shifting from breeding for global food security to breeding for profit. While food security and profitability are not mutually exclusive, the marketability of some breeding traits may service producers in high-income countries more than producers in low-income countries. The results of this study should provide a lively discussion about how the public breeding sector fits into a plant breeding world that is becoming more privatized.

Fischer, T., D. Byerlee, & G. Edmeades. Crop Yields and Global Food Security: Will Yield Increase Continue to Feed the World? (2014) Canberra: Australian Centre for International Agricultural Research. Available at: http://aciar.gov.au/publication/mn158.

OECD. Rice Project: Consumption per capita. 2023. As accessed at https://www.oecd-ilibrary.org/docserver/agr_outlook-2015-table125-en.pdf?expires=1704810114&id=id&accname=guest&checksum=A1A798A12AAD568BF138AAF3AF656338

Traxler G., Falck-Zepeda, J., Ortiz-Monasterio, J.I., Sayre, K., 1995. Production risk and the evolution of varietal technology. Am. J. Agric. Econ. 77, 1–7.