

Marker-Assisted Selection on Rice and Cassava: What is it Worth?!

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Abstract

Economic benefits were projected for GCP supported research aimed at (a) discovering genes for tolerance to saline and phosphorous-deficient soils to enhance rice productivity and (b) developing low cost technologies for pyramiding genes from wild relatives into elite progenitors of cassava. Economic benefits were projected based on the situation with and without the new traits. Benefits considered (a) area planted to crops affected by target stresses and production in specific countries, (b) nature of markets, (c) projected yield and cost changes, (d) time to develop and deploy the DNA marker technologies, (e) time to develop and disseminate new cultivars, and (f) the discount rate. Marker-assisted breeding (MAB) in rice is estimated to save 3-6 years compared to conventional breeding (CB) and result in significant incremental benefits in the range of \$50 to \$500 million depending on the country, abiotic stress, and lag for CB under base assumptions. Benefits almost double if the 3 year time advantage for MAB over CB is assumed to be 6 years. For cassava, benefits for MAB to incorporate resistance to cassava mosaic disease, green mites, white flies, and post harvest deterioration vary from \$34 to \$817 million depending on the country.

Introduction

The GCP portfolio includes several projects with potential near-term products such as candidate genes and DNA markers validated for traits of interest, and germplasm with specific attributes. Ex ante impact analysis of these products is needed to document GCP progress to donors, validate an assessment approach that might be used more broadly in the GCP, and assist with CGP research prioritization.

Project focus: GCP projects: "Revitalizing marginal lands: Discovery of Genes for Tolerance of Saline and Phosphorus Deficient Soils to Enhance and Sustain Productivity," and "Development of Low-Cost Technologies for Pyramiding Useful Genes From Wild Relatives of Cassava into Elite Progenitors" were chosen for assessment because they address significant problems on major crops with identifiable products.



Project Objectives

1. Design a methodology to assess economic impacts of GCP products
2. Economic impact assessment of the discovery and use of genes for tolerance to saline and phosphorous-deficient soils in rice
3. Economic assessment of developing and applying low cost technologies for pyramiding useful genes from wild relatives into elite progenitors of cassava

Methods

Steps in the ex ante economic impact analysis include:

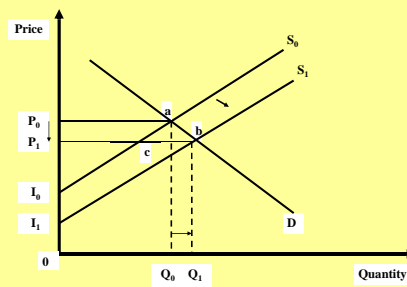
Construct technology-impact pathway -- Review project reports, draft a diagram of the pathway and discuss with the rice and cassava project leaders to ascertain product timing, intended geographic area of impact, and current status of development.

Gather data on prices, production, area, and trade -- Collect data down to the sub-regional level within Bangladesh, India, Indonesia, and the Philippines for rice, and Uganda, Nigeria, and Ghana for cassava.

Budgeting -- Data on yields and input costs gathered from field trials and experts

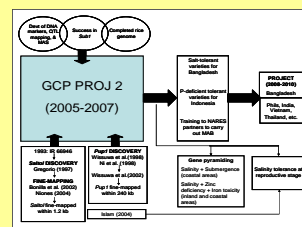
Economic Surplus Analysis -- Market level impacts are estimated using economic surplus analysis (ESA). ESA considers the nature of the market for the commodity and the fact that prices may fall as production changes and supply increases. Data on prices, production, trade; projected changes in area; estimates of the price responsiveness of supply and demand to changes in quantities; projected changes in yields (or savings in losses) and costs; and projected farmer adoption of the varieties over time are combined to project the total economic benefits. Adoption of a new technology shifts supply from S_0 to S_1 , resulting in economic benefits measured by area I_0abI_1 in the figure at the top right.

Benefit cost analysis -- The ESA provides information on projected benefits, year by year, for each crop and country. These benefits are discounted over time to take into account the fact that the sooner the benefits come the more they are worth. They are combined with discounted costs to obtain estimates of total net discounted benefits (present value) in millions of dollars over the time period.



Results

Example of technology pathway for rice technologies:



Salt tolerant and P-deficiency rice:

- Lower research cost and greater economic benefits:
- Quicker variety release
- Higher and faster adoption by farmers since in existing varieties
- Increased rice yield and larger rice area for salt tolerant rice
- Lower cost of production for farmers with P-deficiency rice
- Benefits go disproportionately to the poor

Low-cost markers and use of wild relatives to transfer resistance to green mites, white flies, CMD and delay post-harvest deterioration (PPD):

- Quicker variety release by moving directly from clonal evaluation to regional trials
- Higher cassava yield
- Savings in post harvest losses
- Benefits go disproportionately to the poor



Quantitative results

Crop, constraint, and country	Year of variety release	Net present value (NPV) over current varieties (\$million)	Incremental NPV over conventional breeding (\$million)
Rice			
Salinity			
Philippines	2017	227	49
Bangladesh	2014	3666	499
India	2015	6848	447
Indonesia	2017	896	194
P-deficiency			
Indonesia	2014	2070	282
Cassava			
CMD, green mites			
Nigeria	2009	1493	817
Ghana	2009	676	371
CMD, GM, Whitefly			
Uganda	2112	53	34
CMD, GM, WF, PPD			
Nigeria	2014	2899	NA
Ghana	2014	855	NA
Uganda	2018	280	NA

¹ GCP SP5 Project 2006-14: Ex Ante Impact Analysis of Marker-Assisted Selection Technologies Supported by the Generation Challenge Program (GCP)