Dry Grain Pulses CRSP

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Improved bean varieties in Central America and Ecuador generate economic benefits to farmers

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Between 1990 and 2010, the National Agricultural Research Systems (NARS) in Honduras, El Salvador, Nicaragua, Costa Rica, and Ecuador, in collaboration with international partners, such as the Bean/Cowpea and Dry Grain Pulses CRSP and CIAT, have released 90 improved bean varieties (IVs), some in more than one Central American country. Seventy-eight unique IVs were released, 45 of these small reds and 10 red mottled varieties. The economic impact of small red IVs in Central America and red mottled IVs in northern Ecuador constitutes the research addressed by a recent study conducted by Michigan State University, the results of which are summarized in this impact brief.

The bean crop in the Ecuadorian landscape. *Inset,* small red beans from Central America (left) and red-mottled beans from Ecuador (right)

Methodology

The economic impacts of bean improvement research are estimated using an economic surplus modeling approach in which the benefits from developing and releasing new varieties are attributed to producers, consumers, or both. The most critical variable to estimating the economic impact using surplus concepts is the effect of new varieties on bean supply (i.e., the supply-shift parameter). There are two types of yield gains derived from the use of IVs: Type I gains for areas where farmers replace traditional varieties (TVs) with IVs and Type II gains for areas where farmers replace old IVs with new IVs. Both were estimated and the total change in producer surplus is the sum of Type I and Type II benefits.

To generate the stream of benefits over time, a logistic diffusion curve was estimated for each country using total adoption rates of IVs at two times (1996 and 2010). A small, open economy surplus model was used to estimate research benefits. The assumption of a small open economy is justifiable since the amount of beans produced by each country is relatively small, ranging from 19,345 metric tons in Costa Rica to 138,915 metric tons in Nicaragua (1990−2009 average). Further, it was assumed that the quantity supplied by each country would not affect world prices, the demand

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Key Findings

- In 2010, improved varieties represented 67 percent of the small red bean area in Central America and 50 percent of the red mottled bean area in northern Ecuador.
- Research investments to develop these improved varieties have generated a regional net present value of US$359 million and an internal rate of return of 32 percent.
- The producer surplus from bean improvement research per hectare per year averaged $74/ha in the region.

curve is perfectly elastic, and that all benefits would accrue to producers because there is no research-induced reduction in price. It was also assumed that the supply curve is linear and that its shift (due to the use of new IVs) would be parallel.

The returns to research in each country were estimated using two economic measures: Net Present Value (NPV) and Internal Rate of Return (IRR) for the period 1991−2015, assuming a six-year lag between when the research activity began and when the new IVs were generated.

The study estimates the economic impact of research on small reds and red mottled varieties because (1) in the Central American countries of interest, approximately 76 percent of bean production corresponds to small reds and (2) in northern Ecuador, approximately 68 percent of the bean area is planted to red mottled varieties and most of the bean breeding program's efforts are concentrated in this region.

Data

Several sources of data were used to estimate the model parameters. Estimates of the Type I supply-shift parameter were obtained from previous research conducted in Honduras and Ecuador. Since no other studies have estimated this parameter in Central America, the Honduran parameter was used for the other countries. The estimates of Type I gains used in this study are 11.5 percent for Central American countries and 18.4 percent for Ecuador. The Type II supply-shift parameter was estimated using experimental yield data. These Type II gains averaged 0.49 percent per year in Central America, 0.56 percent in Honduras, and 1.68 percent in Ecuador.

Farmers in a bean field in Nueva Esperanza, Santa Barbara, Honduras

Adoption rates for 1996 were obtained from previous research conducted in the region. In contrast, adoption rates for 2010 were obtained from bean breeders in each country using a structured questionnaire and methodology for soliciting expert opinion. Adoption rates for all other years within the evaluation period were generated by the logistic curve. The supply elasticity parameter was obtained from previous research in the region and was assumed to be the same for all countries.

The bean area harvested each year was obtained from FAOSTAT and was weighted to reflect the area harvested to small red beans in Central America and red mottled beans in northern Ecuador. Furthermore, yield data for 1996 was estimated by averaging FAOSTAT yields for 1994−1998. However, FAOSTAT yield data for Ecuador was weighted to reflect yields in northern Ecuador. In the counterfactual scenario, yields were assumed constant at the 1996 level. Bean prices were obtained from secondary sources (in U.S. dollars) and were deflated using the U.S. consumer price index.

Cost data were collected from key informants, secondary sources, and previous research conducted in Honduras and Ecuador. Estimates of the costs include core funds (e.g., salaries) and donor funds.[1] While in most countries the total research costs were used (i.e., expenses in all market classes, which overestimates costs), in Costa Rica and Ecuador, total costs were weighted to only reflect expenses in small red and red mottled varieties, respectively; expenditures incurred prior to the research program were excluded. All benefits and costs were discounted to 2009 values. An inflation adjusted real discount rate of four percent was used to estimate the NPV of research costs and benefits.

Results

Adoption of IVs

The adoption of improved bean varieties in 2010 across the five focused countries is estimated at 67 percent of the area harvested to small red beans in Central America and 50 percent of the area harvested to red mottled beans in northern Ecuador. The one or two most widely planted IVs in 2010 for the focused market classes were (a) *DEORHO* (23 percent) and *Amadeus 77* (16 percent) in Honduras, (b) *CENTA San Andres* (40 percent) and *CENTA Pipil* (14 percent) in El Salvador, (c) *INTA Rojo* (70 percent) and *INTA Masatepe* (8 percent) in Nicaragua, (d) *Cabecar* (80 percent) in Costa Rica, and (e) *Portilla* (43 percent)

and *Paragachi Andino* (7 percent) in northern Ecuador. Furthermore, *Amadeus 77*, a variety developed by NARS through Bean/Cowpea and Pulse CRSP partial support and released under a different name in each country, was widely planted across all Central American countries included in the study and accounted for an estimated 235,028 ha of the 472,489 ha harvested with beans in these countries altogether—by far the most widely adopted IV in 2010.

For most countries, total adoption of red/red mottled IVs has increased since 1996 (fig. 1). In contrast, adoption rates of small red IVs in Costa Rica may have slightly decreased over time due to the strong consumer preference for light red beans (which is the color of traditional red bean varieties). Since most red IVs have dark seed, it is likely that this has driven adoption rates down over time.

Economic impact: NPV and IRR

In all countries except Costa Rica, investments in bean research have been profitable and have provided a return well above the assumed opportunity cost of capital because the NPV is positive and the IRR is greater than the discount rate used (Table 1). When the discount rate was increased to 10 percent, NPV was also greater than zero for all countries, except Costa Rica. The net losses found for Costa Rica are because the area planted to beans has decreased since 1996 and the adoption rates of red IVs between 1996 and 2010 have also decreased.

Excluding Costa Rica, NPV was highest in Nicaragua ($214 million), followed by El Salvador ($78 million), Honduras ($58 million), and northern Ecuador ($11 million.) As a region (i.e., all countries), investments in bean research have generated an NPV equal to $359 million (most benefits in Central American countries) and an IRR equal to 32 percent.

The estimated average annual economic benefit per hectare harvested (IVs only) during the period of evaluation was highest in northern Ecuador ($196/ha), followed by El Salvador ($84/ha), Nicaragua ($73/ha), and Honduras ($63/ha). Further, the IRR was highest in Nicaragua (42 percent) and lowest in Honduras (34 percent). In all countries, the IRR was well above the assumed opportunity cost of capital.

In Costa Rica, NPV would be zero if the value of Type II gains equals 1.048 percent instead of 0.49 percent; that is, if the per year yield increase derived from releasing new IVs is 114 percent higher than estimated.

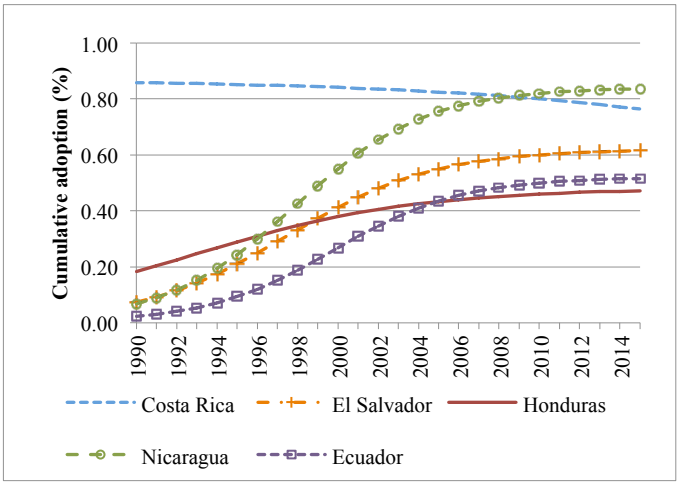

Figure 1. Adoption rates (%) of bean IVs

Since adoption rates have declined over time, Type I benefits are assumed to be zero in Costa Rica. Thus, if adoption rates were to remain constant or decline, new IVs would need to yield much more to generate enough benefits to offset research costs. For all other countries, even if Type II gains equal zero, the NPV would also be positive since adoption of IVs is assumed to increase over time, generating Type I benefits (from new adopters) that are enough to obtain positive NPV values.

To test the robustness of these results, a sensitivity analysis was carried out under two other possible scenarios: *Scenario A*, assuming that Type II yield gains and 2010 adoption rates were simultaneously 10 percent higher, and *Scenario B*, assuming that the same two parameters were simultaneously 10 percent lower, compared to the *base scenario*. While NPV was still negative for Costa Rica under the better scenario (*Scenario A*), for all other countries NPV was positive under both scenarios, suggesting that even if Type II gains and adoption rates were simultaneously lower than estimated, returns to investments would still be positive in these four countries.

Conclusions and implications

Farmers have adopted several improved bean varieties in the five countries included in the study. However, in 2010, *Amadeus 77* (small red IV) was widely adopted in more than one country and accounted for approximately 50 percent of the total area harvested with beans among the Central American countries.

The economic analysis of improved small red and red mottled bean varieties for the period 1991−2015 indicates that returns to investments by national and

Table 1. Summary of NPV and IRR (%) estimations for Central America and northern Ecuador, 1991−2015.

	Scenario (in constant 2009 US$)						For 1997−2015
	Base		Scenario A		Scenario B		
Country	NPV($)	IRR	NPV($)	IRR	NPV($)	IRR	Producer surplus per ha per year ($)
Costa Rica	-2,016,054	-5%	-1,610,978	-3%	Not estimated		26
El Salvador	77,510,816	40%	93,170,299	43%	62,688,130	37%	84
Honduras	58,250,437	34%	73,724,174	37%	43,698,030	31%	63
Nicaragua	214,002,964	42%	254,621,317	45%	175,583,202	39%	73
Ecuador	10,920,047	37%	13,216,135	39%	8,832,204	35%	196
Central American countries	347,748,163	32%	419,904,813	35%	281,969,362	32%	72
All countries	358,668,210	32%	433,120,948	35%	290,801,566	32%	74

international partners in bean research have been positive in all focused countries, except Costa Rica. The NPV of benefits from these research investments across all five countries was estimated at $359 million. The rate of return was negative in Costa Rica (negative five percent) and highest in Nicaragua (42 percent). The regional IRR was estimated at 32 percent, which suggests that investments in bean research in the five major bean producing countries have provided returns well above the opportunity cost of capital.

In Costa Rica, negative net gains were observed because both the total bean area and the area planted to IVs have decreased over time. Furthermore, small red beans represent a much smaller proportion (about 25 percent) of the total bean area planted, compared to black beans (which cover 75 percent of the total bean area). In Costa Rica, future bean research on small red varieties should give priority to developing varieties that are more acceptable (i.e., light reds) to farmers to increase adoption rates. Furthermore, since black beans are the most widely produced market class, increased efforts should be devoted to developing new black IVs. It is worth mentioning that the NARS of Costa Rica, in collaboration with the Dry Grain Pulses CRSP, are almost ready to release new black bean IVs.

In all other countries, bean programs should continue their current agenda since investments have paid off; however, the study also indicates that increased production of low-cost, high quality seed is necessary to develop a sustainable bean seed system in these countries. Some programs currently depend heavily on government subsidies to make seed available to farmers. Further, donors and governments should continue funding bean research programs in these countries since returns to investments have been positive and research has generated a steady stream of economic benefits to adopter farmers.

[1]Includes funding provided by the USAID-funded Bean/Cowpea and Dry Grain Pulses CRSP, *Profrijol* (a bean research network established by CIAT and supported by the Swiss Agency for Development and Cooperation), and *Agrosalud* (a project coordinated by CIAT and funded by the Canadian International Development Agency), among others.

About this brief

This brief is based on the Ph.D. dissertation by Byron Reyes entitled *The Economic Impact of Improved Bean Varieties and Determinants of Market Participation: Evidence from Latin America and Angola.* Specifically, it draws from the essay "The Economic Impact of Improved Bean Varieties in Latin America: A Surplus Analysis." The USAID-funded Dry Grain Pulses CRSP provided financial support for this research under the terms of Cooperative Agreement No. EDH-A-00-07-00005-00.

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