The Impact of Crop Improvement Research on Rural Poverty:
A Spatial Analysis of BGMV-Resistant Bean Varieties in Honduras
by

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1. Introduction

In the 1970s, bean golden mosaic virus (BGMV) began to spread throughout Middle America, threatening the production of beans, an important food crop in the region. Controlling BGMV became top priority among bean breeders in the region, and by the late 1970s, their efforts had resulted in the release of a first generation of virus-resistant bean varieties to farmers. These varieties were quickly and widely adopted. By 1996 an estimated 40 percent of the bean area in Central America was planted to resistant varieties, often reaching as high as 80 percent in BGMV-affected regions (Viana, 1998; Viana et al, 1997). In 1984, CIAT was awarded the King Badouin Prize for its work on BGMV in Central America.

The cumulative value of the increased production that resulted from the new varieties has been estimated at over $200 million dollars in 1998 (Johnson, 1999).[2] In 1998 alone the impact was estimated at over US$17 million. While these benefits far surpass the costs associated with bean breeding research over the years, they are likely to underestimate the real benefits of disease resistant bean varieties.

One reason is that conventional *ex post* impact assessment is based on observed differences in yields of traditional and improved varieties in farmers fields. Since one of the main benefits of a disease resistant variety may be to maintain existing yields in the face of disease pressure, it is difficult to capture the full benefits of the new varieties by looking at observed yields alone. The appropriate comparison is between the observed yields of improved varieties and the yields that we would have observed with traditional varieties under similar circumstances in the absence of improved varieties. Since collecting survey data on the latter is not possible, this paper attempts to estimate the magnitude of the production losses that were averted as a result of BGMV-resistant varieties by looking at experimental data and at the results of a climate-based GIS statistical technique that created risk maps of BGMV incidence. The analysis is done for the case of Honduras, an important bean producer in Central America.

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[2] Value is in 1990 dollars.

Another reason why the economic value of the observed increase in bean production that resulted from improved varieties may not capture their full social benefit is that the dollar value alone does not tell us about who received benefits nor how they were used. Since IARC's goals include both increasing agricultural productivity and reducing poverty, if a technology can be shown to have contributed to poverty alleviation, then this is an important impact over and above the economic value of production. To understand the relationship between the new varieties and poverty, we need to go beyond monetary value and look at where the impacts occurred, who benefited from them, and how the beneficiaries' wellbeing was affected. Using the results of recent studies on how to define, measure, and map poverty in Honduras, this paper will identify where and how improved bean varieties have contributed to the alleviation of poverty among bean producers.

The paper is organized as follows. Section 2 looks at bean production in Honduras, with particular reference to the problem of whitefly and BGMV. Section 3 presents the model and results of an estimation of the expected benefits from improved varieties based on the expected value of production with and without improved varieties. The results are then compared with those of conventional impact analysis. Section 4 relates this economic impact to poverty alleviation in Honduras. Section 5 summarizes the results of the analysis and discusses their implications for research and for policy.

2. Bean Production and Producers in Honduras

Beans are one of the two most important crops in Central America in terms of both production and consumption. Beans are a traditional part of the diet in Central America, and beans, along with maize, often form the main food source of the poor. In 1997 per capita consumption is reported to be between 9 and 21 kilos per year, however it varies greatly depending on the economic level of the consumer (Viana et al, 1997). Within the category of basic grains, beans are second only to maize in area planted, and are the number one source of farm income (Viana, 1998).

Honduras is the third largest bean producer in Central America following Nicaragua and Guatemala. In 1998, 83,000 hectares were sown to beans, slightly more than in 1970 but less than the high of nearly 120,000 ha planted in 1994 (Chart 1). Production has been similarly variable (Chart 1). During the period 1970-1998, the area planted increased by a total of 16 percent and production increased by 18 percent with the difference due to small increases in yield (Chart 2).

The main bean production area is in the central and central-eastern part of the country, where approximately 60 percent of production occurs (Map 1; Martel and Bernsten, 1995). A 1993 study by the Bean/Cowpea CRSP conducted in this zone found that a third of Honduran farmers planted beans (ibid.). The farms were generally small--average area planted to beans was 1.08 has—and were considered non-commercial in the sense that their production was primarily for home consumption, though surpluses were sold on the market. The degree of market participation of bean farmers has grown over time (Schoonhoven and Pachico). In the past most farmers produced primarily for their own consumption, however, according to the survey, in 1993 only 13 percent of farmers neither bought nor sold beans. Half reported selling and 37 were net buyers (Martel and Bernsten.)

The survey also found that smaller farmers plant relatively more beans than larger farmers, suggesting that it is a more important crop for the smaller farmers. Big farmers are more commercially oriented, but the income earned from beans is relatively more important to the small farmers since it makes up a greater portion of their income. In terms of production practices, there is no difference in chemical use between small and large farmers (Martel and Bernsten).

The main production constraint in the region is BGMV (Martel and Bernsten). The virus arrived late to Honduras, where the first reported incidence was in 1985. In 1989, there were severe outbreaks with crop losses ranging 10 to 100 percent (Rodriguez et al, 1994). Whiteflies cause extensive crop damage both as a pest and a vector. Whiteflies are phloem feeders, hence they directly contribute to reduced plant productivity by consuming the nutrients carried in the phloem. In addition, they produce a honeydew that grows a sooty mould which contaminates fruit and vegetables and reduces plant productivity. Specific whitefly species also act as a vector of plant pathogens and transmit plant diseases, such as *B. tabaci* transmitting BGMV. *B. tabaci* transmits the virus in a semi-persistent persistent manner. This means the virus needs time to be acquired and transmitted (Morales, 1994). The virus is retained when the vector moults but it does not multiply in the vector and it is not transmitted congenitally to the progeny of the vector. It can be transmitted by grafting but not by contact between plants, seed or pollen (Brunt *et al.*, 1996). Map 2 shows virus susceptible areas in Honduras.

The first resistant variety , Dorado, was released in 1990 and several others soon followed (Table 1). The varieties spread quickly, and by 1996 adoption rates were as high as 80 percent in some areas (Viana et al, 1997, Martel and Bernsten; Map 3). No association was found between adoption of Dorado and farm size, which suggests small farmers are just as likely to adopt the variety as large farmers (Martel and Bernsten). This makes sense since resistant varieties, unlike some high yielding varieties, are not dependent on costly chemical inputs or optimal growing conditions to make them perform. They can be adopted without significant changes to the production system. Martel and Bernsten do find an association between farm size and adoption of another improved variety, the high-yielding but non-resistant Catrachita which was released in Honduras in 1987. This may reflect greater risk aversion on the part of small farmers since it appears that yield alone is more attractive to larger than smaller farmers.

In terms of yield, which variety is highest yielding variety depends on many factors, and is therefore highly variable. Honduras has two growing seasons, the *primera*[3] and the *postrera*,[4] with the latter being the main production season. Martel and Bernsten found that Catrachita is highest yielding during the *primera* and Dorado during the *postrera*.

[3] *Primera* refers to the first growing season, which is from May to September.
[4] *Postrera* refers to the second growing season, from September/October to December/January.

These results are consistent with the fact that the virus is only a problem in the *postrera* (Rosas, 1999). Dorado offers no significant advantage over traditional varieties in the *primera* but does in the *postrera*. The fact that the resistant variety appears to offer a yield advantage only in the virus season supports the idea that it is not the variety's yield potential but rather its reduced yield variability that makes it valuable to farmers.

In terms of price, traditional varieties generally sell for higher prices than improved varieties. This reflects the fact that traditional varieties have been selected by farmers over generations to exhibit the desired production, processing and consumption characteristics of the region. Improved varieties must often sacrifice certain desirable characteristics in order to obtain high yield or disease resistance. In the case of beans in Honduras, for example, Dorado does not have the light red color that is most valued in the region, and is also reported to have some undesirable cooking characteristics. This accounts for the improved variety's lower market price relative to the traditional variety.

3. The Economic Impact of Virus-Resistant Varieties: Getting the Counterfactual Right

To evaluate the impact of a new variety we want to compare the situation with the new variety to what would have occurred had the new variety not existed. In many cases, if both traditional and new varieties continue to be planted, the yield of the traditional varieties can be used to represent the counterfactual, which is the situation that would have occurred if there had never been improved varieties. Many impact studies of improved resistant varieties have been done based on observed yield differences. In Honduras, yield advantage of BGMV-resistant varieties has been observed to be between 0 and 38 percent, averaging about 18 percent (Viana, 1998; Viana et al, 1977 ; Martel and Bernsten).

In the case of varieties whose main advantage is a high yield, the comparison between traditional and improved varieties may be appropriate because the observed yield increase is the main benefit of the variety. In the case of resistant varieties, however, observed yield differences may not tell the whole story. The value of a resistant variety may not be that it obtains higher yields than were possible with traditional varieties, but rather that it maintains its yield in the presence of pests and diseases. This suggests the need for a way to measure the losses that did not occur as well as the gains that did.

Data on observed yields are collected from farm-level production data. In experimental trials, trial plots are either selected randomly, or they are chosen with great care to ensure that different varieties are grown in comparable conditions in order to be able to compare the results. We would not expect farmers to make planting decisions based on either of these methods. Farmers decide what to plant where based on their own criteria, among them how they can obtain the highest output.

If the location of the field or choice of cropping pattern affects the expected damage from BGMV, then we would expect farmers to take this information into consideration when deciding what to plant where. For example, areas where the likelihood of virus damage is high would be expected to be planted to resistant varieties whereas areas where the probability of virus damage is low may be planted to the higher priced traditional varieties. In a sense what farmers are trying to do is minimize the observed difference between traditional and improved varieties, planting traditional varieties where possible and improved varieties where necessary.

Therefore we can say that if certain conditions exist—namely that farmers have a choice between traditional and improved varieties, that probability of virus is not random but rather correlated with farm characteristics, and farmers maximize profit—then it will not be appropriate to interpret the yields of traditional varieties, as observed in selected fields, as representative of what yield would have been if traditional varieties had been planted over the entire bean area. Observed yields of traditional varieties will be higher than what would have been observed in the absence of the option of a resistant variety.

One way to more accurately estimate the benefit of improved varieties would be to use data from experimental trials which control for the biases described above (Smale et al, 1998; Morris el al, 1994). A sample of data for Honduras show that the resistant variety (Dorado) has a yield advantage of between 0 and 59 percent over the traditional local varieties.[5] Caution must be used in interpreting results of experimental trials since yield observed in trials are general much higher than in farmers fields. However the results of the experimental trials do suggest that in areas where disease pressure is high, the benefits of improved varieties may be greater than what we observe in the field.

Another way to estimate the benefits of improved varieties is to simulate what production would have been in the absence of improved varieties. If information is available about the determinants of disease incidence and intensity, it may be possible to estimate what production would have been in the absence of new varieties.

Klass et al (1999) describe several methods for predicting the probability of virus occurrence based on the geographical and climatic characteristics of an area. The dynamics of BGMV are complex and are determined my many factors, however geographical and climatic conditions are considered by virologists to be significant determinants of virus occurrence. Therefore statistical analysis can be used to predict the probability of occurrence based on where the virus has been observed in the past.[6]

Klass et al test several techniques for predicting the occurrence of BGMV in Central America. For the case of Honduras, the most accurate appears to be a Fourier transform with principle components analysis, a process developed to help scientists and other plant collectors identify likely areas for finding specific plant species (Jones et al, 1997; Jones and Gladkov, 1999). Map 4 shows the results of the analysis for Honduras. The map shows the spatial distribution of the probability of virus incidence throughout the country.

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[5] 1992 data from Voysest (add citation) and El Zamorano, nd, "*Tio Canela*."

[6] It should be noted that this GIS model will be expanded to include other factors that affect BGMV, perhaps most importantly cropping pattern in the area.

using this information we can calculate the expected value of production with and without improved varieties, we can get an estimate of the full benefit of improved varieties, including crop losses which did not occur because resistant varieties were available.

2.1 Empirical Estimation

In order to do the calculation, we need data on yields and on damage from the virus. In terms of virus damage, observed crop losses due to the virus range from 10 to 100 percent in Honduras. In the absence of information on the geographical determinants of virus intensity, we do the analysis for different levels of crop damage and compare the results. [7]

The other parameters used in the simulation are presented in Table 2. For simplicity, we will only consider the cases of one traditional variety, *Rojo de Seda*, and one improved variety, Dorado. Since the *primera*, there is no yield difference between traditional and improved varieties, we use yield from that season as base estimates of yield potential of the variety. As discussed earlier, the price of traditional varieties is generally higher than resistant varieties due to their market characteristics. In this case, the traditional variety sells for 19 percent more than the resistant variety.

In the absence of resistant varieties, we can estimate the total expected value of production as:

$$3_p\ [(1-p)*(Y) + p(Y)(L)]*\ H_p * P$$

where p is the probability that the virus occurred, Y is yield of the traditional variety, L is loss due to virus, H_p is the number of hectares with probability p , and P is the price of the traditional variety.

In the case where farmers have the choice to plant either improved or traditional varieties, if we assume that each farmer wants to maximize the expected value of his or her production, than we can determine aggregate production by setting expected value of production with traditional varieties equal to expected value with improved varieties and solving for the probability that makes the expected values the same. All the area with probability of virus occurrence higher than this threshold probability will be planted to the improved variety since the expected value of production is higher. All the area with probability lower than the threshold value will be planted to the traditional variety.

2.2 Results

The analysis was done for bean producing areas of the states of Francisco Morazán and El Paraíso (Map 5). The results are presented in Tables 3 and 4.[8] As shown in Table 3,

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[7] Results are only reported for an average loss of 50 percent however for the conference we will have results for different levels of crop loss.
[8] See Appendix 1, a technical note on the estimation procedure.

depending on the level of crop damage associated with the virus, the production gain with improved varieties ranges from 7 to 58 percent, which is above the range of field observations, and in line with what experimental data suggest.

According to the simulation results, the level of adoption of the new variety ranged from 61 % when crop damage was 90 percent to only 30 percent when crop damage was 25 percent. Actual adoption of improved varieties is about 73 %, with 50 percent of that area devoted to Dorado (Viana, 1997). Given that some of the improved varieties are not resistant, the actual adoption level of resistant varieties is slightly lower, in the range of 65 percent. These results suggest that the model, while highly simplified, does an accurate job of predicting adoption. It also implies that the expected crop damage is quite high.

Table 4 reports the average yields of the different varieties with and without resistant variety. By using data from farmers fields, we are comparing yields between traditional varieties ($Yield_{TR}$) and improved varieties ($Yield_R$) under Scenario 2. Under this scenario in which improved varieties are available, the average traditional yields were between 5 and 6 percent higher than the average improved yields. However when we compare the traditional yield under scenario 1 ($Yield_{TT}$) with the average yield under Scenario 2 ($Yield_A$), we see that the latter is up to 11 times greater than the former, depending on the level of crop damage. If the level of crop damage is low, then there is little difference between $Yield_{TT}$ and $Yield_A$ but when it is high, the difference is very large.

These results clearly demonstrate that appropriate specification of the alternative scenarios—with and without the technology—can be potentially very significant in estimating the impact of a new technology. Both the experimental data and the simulation results suggest that estimates based on observed data underestimate the total impact of resistant varieties since an important part of their contribution is to maintain yields.

3. Poverty in Honduras

The results of the previous sections show that disease-resistant bean varieties have contributed to a significant increase in bean production, and in bean farmers' incomes. While the size of the economic benefits that resulted from the research is an important indicator of its impact, the dollar value alone does not tell us very much about the impact of the research on poverty. We need to do more analysis in order to understand how these benefits of increased production translate into changes in the lives of the poor.

Fortunately, in the case of Honduras several studies exist about to define, measure and map poverty. The results of the studies provide insights into who the poor are, where they are, and why they are poor. By carefully examining the conclusions of these analyses and comparing them to what we know about the diffusion and economic impact of improved bean varieties, we can identify where and how bean varieties have contributed to the alleviation of poverty.

3.1 How to define poverty

How to define poverty has become an important research question both conceptually and empirically. Traditional measures such as income or expenditure are increasingly being criticized as inadequate indicators of human welfare. While such monetary measures have advantages in terms of comparability across space and time, they often fail to capture non-monetary aspects of standard of living—very important in many developing countries—and can be difficult to estimate reliably due to a reluctance on the part of individuals to reveal how much they earn. Alternatives methods are being developed to more accurately identify and understand poverty.

3.2 Measuring and mapping poverty in Honduras

Honduras has been the focus of several different poverty measurement exercises in recent years. In one study, census data were used to create a national poverty map that ranks each village according to the degree to which residents' basic needs were satisfied (see Oyana et al., 1998). In another study, the focus was on identifying and understanding local people's perceptions of poverty (Ravnborg et al, 1998). While this study does not provide a national map of poverty, it does provide a more nuanced definition of poverty as well as clear and easy to observe indicators of wellbeing. Because the poverty indicators are in terms of local people's activities, assets and livelihoods, they make it possible to relate the impact of technical interventions such as new crop varieties to directly to changes in poverty. Together the results of the two poverty analyses allow us to identify where and how these impacts occurred in the case of improved bean varieties.

3.2.1 Material standard of living: the Unsatisfied Basic Needs (UBN) Approach

In 1996, CIAT undertook a project to measure and map poverty in Honduras basedon census data (Oyana, 1998; PE4 Annual reports, 1997 & 1998). The data come from the 1988 Honduras Population Census and are calculated at the *aldea* (village) level (SECPLAN, 1991). The approach was called the Unsatisfied Basic Needs (UBN) method and involves the selection of basic needs criteria, and the identification of measurable indicators of the level at which these needs are satisfied (Boltvinik). In the case of the CIAT study. The basic needs identified were quality housing, access to basic services, ownership of non-land assets, and education. For each of these basic needs, several measurable indicators were also identified. In the case of housing quality, for example, the measurable indicators were the materials used in construction of the walls, floor and roof. In the case of basic services, measurable indicators were water source, use of latrine, presence of electricity, and fuel source (See Oyana et al, 1998)

After selecting the criteria and indicators, minimum standards and level of unsatisfaction were identified. Communities were rated according to their average level of satisfaction of the minimum standards. Five levels of poverty were identified (Table 5). The poorest households, Level 1 in the analysis, had average unsatisfaction levels of 85 percent or higher. Level 4, the so-called threshold level, includes communities that on average meet the minimum requirements. In level 5 communities, an average of 55 percent of families exceed the minimum requirements. Map 6 shows the distribution of statistically-significant areas of poverty in Honduras according to the UBN criteria.[9]

3.2.2 Participatory poverty assessment

In 1996 a participatory poverty assessment (PPA) was carried out by BID/DANIDA/CIAT in three states in Honduras: El Paraíso, Yoro, and Atlantida (Ravnborg et al, 1998). The poverty index identified by the PPA has eleven components (Table 6). The components of this index have been statistically validated and can be considered representative of the larger population which the sample communities represent. Some indicators, like income, housing quality and asset ownership, are elements of more conventional poverty measures. However according to the PPA local people complement these measures with others such as the ability to contract day-laborers, degree of involvement with agricultural output markets, access to health and health care, participation in financial markets, and food security.

It is also interesting to note what potential indicators did not turn out to be significant in the PPA wellbeing index. In terms of agricultural production, production of basic grains alone was not a distinguishing factor between rich and poor households. This is likely due to the fact that most households were producers of basic grains. However the amount of land people owned and the extent to which they participated in the market were associated with well being. This is consistent with what Martel and Bernsten find, namely that the larger market-oriented farmers are better off than the small, subsistence-oriented farmers.

In a companion study for three Honduran watersheds (Río Saco in Atlantida, Cuscateca in El Paraíso, and Tascalapa in Yoro) aimed at understanding the relationship between poverty and natural resource management, residents were surveyed about agricultural and NRM practices (Ravnborg et al, 1999). Their answers were later classified according to well-being level, as determined by the participatory index described above. The analysis finds no significant difference between well being levels in terms of land use or production practices, as measured by land preparation, use of chemical inputs, or use of crop varieties. Rich and poor do not use different agricultural technologies, at least not in the production of basic grains such as maize and beans. This suggests that benefits of

[9] The statistically significant poverty areas were calculated using the geographical analysis machine (GAM) (Openshaw, 1997). GAM was developed to identify localized patterns in spatial data without prior knowledge of where to look. It treats all points equally and assumes all patterns are localised clusters without the need of additional information of scale or frequency of these patterns.
The final results illustrated the statistically significant poverty areas using the three and four basic factors as defined by Couillard et al (1997).

technologies such as improved varieties are not only being appropriated by the better-off farmers.

3.3 Interpretation of different measures: the case of beans

In this analysis we are interested in the impact of improved bean varieties on poverty. Overlaying the poverty map and the bean production map reveals a significant area of overlap (Map 6). Adding the virus map shows that the target area for disease-resistant varieties also coincides with areas of moderate to extreme poverty. Since the poverty map is from 1988, before the release of the first resistant variety, it can be interpreted as the "before" picture upon which to base the design and targeting poverty alleviation efforts.

Given the way poverty is defined in the UBN indicator, however, it is difficult to draw conclusions about the direct impact of new varieties on poverty. We have shown that new varieties increase the expected value of production for farmers. Given that most bean farmers are small producers who produce for both home consumption and for sale, and given that we have evidence that both rich and poor producers adopt the same varieties, we can say that small farmers have increased their production and incomes as a result of the varieties. According to the results of the simulation in Section 3, 40 percent of the total economic benefits from new varieties occur in areas of statistically significant poverty.

While the geographical coincidence of poverty and economic benefits from a new technology is certainly suggestive of an impact on poverty, it alone does not guarantee that poverty was reduced. To make that conclusion we need to know more about what happened at the individual and household level as a result of the increased production and income. This is the type of information we can obtain through an analysis of the results of the PPA, which provides links between household economic activity to underlying determinants of poverty.

First, one of the components of the PPA well-being index has to do with market integration, particularly with respect to basic grains (maize and beans). Self sufficient producers and net buyers are considered to be less well off than net sellers. Since there is no evidence of a correlation between variety use and wellbeing level, and since the benefit of the technology is to increase production, the technology clearly had an effect on poverty by increasing net bean sales for adopting producers. Net buyers moved closer to self sufficiency, while self sufficient producers and net sellers increased their incomes. According to the PPA index, this change would represent an improvement in producers' wellbeing.

Second, to the extent that producers increase their cash income as a result of the new variety, the index offers several avenues for linking increased cash income to well being, for example, improving housing quality, purchase of animals, or savings. Similarly, to the extent that increased production reduces the chance of food shortage, it also contribute directly to poverty reduction. In some cases these conclusions appear similar to what the UBN analysis suggested, however the difference is that in this case community residents themselves identified the mechanisms that relate increased income to household well being. This makes the argument that the increases in production contributed to poverty alleviation much more powerful.

A third way that the disease-resistant varieties contribute to poverty reduction is to reduce the risk associated with bean production. There is a vast literature on the relationship between risk aversion, wealth, and agricultural production, in particular on how risk affects small farmers (Moscardi and de Janvry, 1977; Dillon and Scandizzo, 1978; Binswanger, 1980; Rose and Graham-Thomasi, 1986). Both theory and empirical evidence suggest that small, poor farmers are risk averse, which means that they would be willing to trade gains in average yield for reduction in variability of yield. A technology such as a disease-resistant bean variety whose main benefit is to reduce the probability of a large, negative outcome such as crop loss, would be particularly beneficial to small, poor farmers. As the empirical results of Section 3 suggest, this appears to have been the main benefit of the BGMV-resistant varieties in Honduras.

Several of the indicators in the participatory well being index directly link reduction of economic risk to increases in well being. In the indicators about health and food security, the thing that distinguishes the non-poor from the poor is their ability to cope with a crisis like an illness or a food shortage. Those who have the resources to handle these problems on their own without having to seek help from others are considered to be much better off than those who do not.

One of the ways that people handle these crises, according to the index, is by using savings or by selling assets such as land or livestock. Therefore the value of these assets—in themselves indicators of well being—is also related to risk reduction. Selling the assets allows households to smooth their consumption in the face of highly variable production and income.

The importance that poor people place on security and independence—on not having to ask for money, food or employment from family and friends—appears to be a very important aspect of well being that is not captured by conventional poverty measures (Ravnborg, 1998). Eight of the 11 participatory indicators have some element of risk coping or reduction, [10] reflecting the truly profound role that risk plays in determining the well being of poor households To the extent that disease-resistant bean varieties have contributed to the reduction of uncertainty and dependency by maintaining yields and reducing variability associated with bean production, they have contributed significantly to poverty alleviation.

5. Summary and Conclusions

This paper demonstrates the importance of disease resistant bean varieties in Honduras, both in terms of their economic impact and their impact on poverty reduction. By taking

[10] Land ownership, selling day labor, income, cattle, animals, money, health, and food security.

into account not only the production increases observed but also the losses that were avoided, we arrive at a significantly higher estimate of the economic contribution made by the disease resistant varieties.

The analysis of impact also went beyond monetary value to look at where and how the new varieties affected the lives of producers. By comparing maps of bean production and variety adoption with a poverty map based on unsatisfied basic needs, it was shown that a significant amount of the economic benefit from improved varieties was generated in areas where there are moderate to high levels of poverty.

To understand how the resistant varieties contributed to poverty reduction, the benefits of the new varieties are analyzed in light of the results of a participatory poverty assessment that was carried out in Honduras. The poverty indicators that resulted from this analysis link changes in agricultural production and income directly to poverty. Since empirical evidence shows that new varieties have increased production and income in bean growing areas, we can logically conclude that beans varieties have contributed to a reduction of poverty.

Specifically varieties contributed directly to the alleviation of poverty by increasing output, allowing producers to increase net bean sales and income. Perhaps more importantly, the risk reducing nature of the disease resistant varieties helped to increase the household food and economic security, reducing the probability that the household would have to cope with an emergency such as a crop loss. Economic security and the freedom from dependence on others for basic necessities form an important part of household well being, according to local poverty profiles.

These results have several lessons for research and for policy. The first is that accurate impact assessment requires accurate definition of the "with" and "without" situations. Many times the appropriate counterfactual is difficult to identify, and even harder to measure. More attention must be paid to measuring the benefits of varieties that are pest and disease resistant, rapidly maturing, low input, or easy to process. Non-yield characteristics are still often not accorded the importance that increased yields are in impact assessment, simply because there is no easy way to measure their benefits. Empirical implementation of these studies will also require new data collection and methods of data analysis.

The second conclusion is that it is possible to target research towards poverty alleviation by mapping poverty and areas of impact. In this analysis, the overlaying of bean production, virus incidence and poverty quite accurately identified the critical areas. Adoption studies show that these areas were in fact where impact occurred. Since there are many mechanisms by which agricultural research affects poverty, the geographical coincidence may not be necessary for a project to be well designed and successful. However if the goal of the technology is to benefit producers directly, then this type of spatial analysis can be very valuable. The increasing availability of data and sophistication of analytical tools is making this work much more efficient and effective.

Finally, the way a technology works may be as important as where it works in having an impact on poverty. The more detailed and dynamic definitions of poverty that are resulting from recent research on well-being and poverty can be very useful in identifying which types of technologies will most benefit poor farmers and why. In the case of beans, the fact that varietal selection was not something that was systematically related to wealth suggests that crop improvement may be an appropriate way to target agricultural technology to poverty. Similarly, technologies that reduce risk rather than simply increase average yield may be particularly beneficial to the poorest farmers since they reduce the chance that these farmers will face an agricultural or economic shock with which they are ill prepared to cope.

These concepts of risk aversion and biasing technologies towards small, poor farmers are by no means new (Pachico, 1983). What is new is our better understanding of what poverty is and our better ability, via new empirical methods, to identify specific characteristics of poverty in specific environments with sufficient precision that they can be useful in the process of developing agricultural technologies that contribute to the reduction of poverty.

Table 1 Improved Bean Varieties Released in Honduras

Variety Name	Year Released	Relation to CIAT
ESPERANZA 4	1984	GRU accession from CIAT collection
COPAN	1982	CIAT line
ILAMA	1982	CIAT line
ARAULI 85	1987	CIAT line
CATRACHITA	1987	CIAT line
DORADO	1990	CIAT line
DON SILVIO	1992	CIAT line
ACACIAS 4	1980	CIAT cross locally selected
ORIENTE	1990	CIAT cross locally selected
DICTA 122	1996	CIAT cross locally selected
DICTA 113	1996	CIAT cross locally selected
TIO CANELA 75	1994	NARS cross with CIAT parent
Desarural		Without connection to CIAT
Zamorano		Without connection to CIAT

Source CIAT Impact Assessment Data Base (www.CGIAR.CIAT/IMPACT)

Table 2 Simulation Parameters

Parameter	**Unit**	**Value(s)**
Yield of Traditional Variety in *primera* (Y_T)	T/H	.430
Yield of Resistant Variety *primera* (Y_R)	T/H	.430
Price of Traditional Variety (P_T)	US$/kg	.506
Price of Resistant (P_R)	US$/kg	.425
Crop Loss Due to Virus (L)	Pct	90,75,50,25

Source: Martel and Bernsten

Table 3 Estimated Quantity and Value of Increased Production Due to Disease Resistant Varieties with Different Levels of Disease Intensity

	L =90%	L=75%	L=50%	L=25%
Production with improved variety (t)	5736	5714	5744	5595
Production without improved variety (t)	3620	3991	4609	5227
Total production (t)	9356	9705	10353	10882
Pct change in production	58.5	43.2	24.6	7
Adoption rate (%)	61	56	55	30

Table 4 Estimated Yield Changes under Different Scenarios and Virus Intensities

	L=90%	L=75%	L=50%	L=25%
Scenario 1: No Resistant Varieties				
$Yield_{TT}$ (th/h)	.266	.294	.339	.385
Scenario 2: Resistant Varieties				
$Yield_{TR}$ (th/h)	.409	.408	.414	.404
$Yield_{R}$ (th/h)	.430	.430	.430	.430
$Yield_{A}$ (th/h)	.422	.420	.423	.412
Yield Advantages				
$Yield_{R}$ over $Yield_{TR}$	5.0%	5.4%	4.0%	6.5%
$Yield_{A}$ over $Yield_{TT}$	58.5%	43.2%	24.6%	7.0%
Magnitude of difference	11.6	7.9	6.2	1.1

R = resistant
A=average of traditional and resistant
TT = tradition when no resistant available
TR= traditional when resistant was available

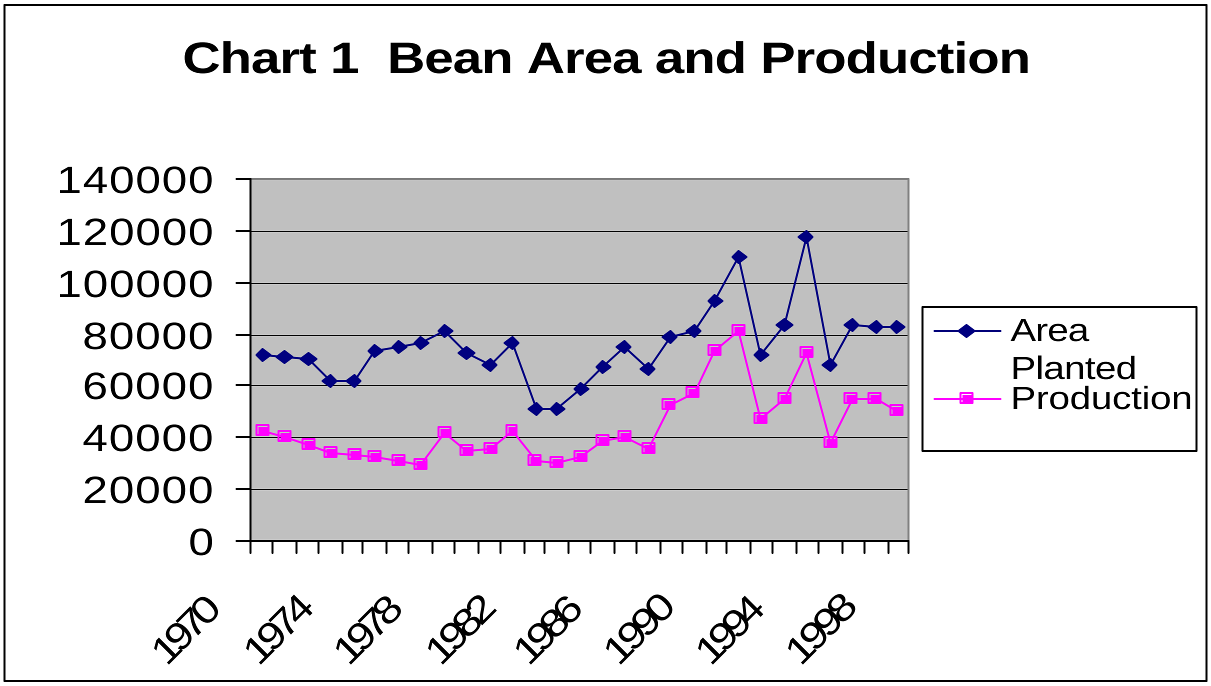
Table 5 Household Poverty Classes in Honduras in 1994 (Unsatisfied Basic Needs method)

Stratum Number	Definition of Poverty	Minimum value of index	Maximum value of index	Average non-satisfaction level of household basic needs (PCT)
1	Extremely Poor	.7	1	85
2	Poor	.4	.7	45
3	Moderately Poor	.1	.4	25
4	Threshold of poverty	-.1	.1	0
5	Non-Poor	-1	-.1	-55

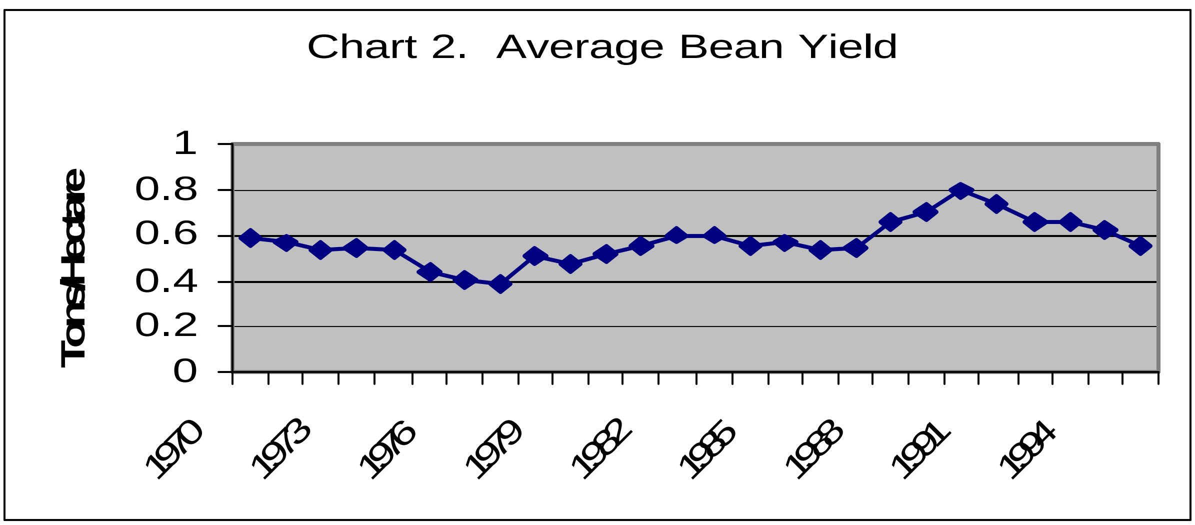
Table 6 Components of the Participatory Well-being Index

Variable	Well being level	Condition
Land Ownership	Highest	The household owns 4 manazanas or more, or has land in pasture or gives land in rent to other farmers
	Middle	Household owns land but fewer than 4 manazanas and doesn't have land in pasture nor land in rent to other farmers
	Lowest	Household doesn't own land or only owns the house and land upon which it stands
Sell Day Labor	Highest	Nobody in the household works as a day laborer and the housewife does not do housework for other families nor prepare food to sell
	Middle	Someone in the household works as a day laborer but either for fewer than 9 months or for more than 9 months but fewer than 3 times a week
	Lowest	Someone in the household works full-time for more than 9 months a year as a day laborer or if the housewife does house work for other families or sells prepared food
Income	Highest	Someone in the household is a professional, a businessman or a merchant or if children or other relatives send remittances
	Middle	Someone in the household is a skilled worker but no one in the household is a professional, businessman or merchant, and the household receives no remittances.
	Lowest	No one in the household is a professional, businessman, merchant or skilled laborer, and the household receives no remittances.
Hire Day Labor	Highest	Household contracts day labor
	Middle	Household does not contract day labor
Cattle	Highest	The household has cattle
	Middle	The household does not have cattle
Animals	Highest	The household owns horses, pigs or oxen
	Middle	Household owns chickens but not horses, pigs nor oxen
	Lowest	Household owns no animals
House	Highest	If the household owns its own house and the house is of good quality
	Middle	Household owns its own house but it is not of good quality
	Lowest	Household owns its own house but it is of very poor quality or does not own its own house
Market Participation	Highest	Household grows coffee or cacao or if household does not buy basic grains and sells half or more of its production of basic grains
	Middle	Household does not grow coffee but buys both buys and sells basic grains or if the household does not but basic grains and sells less than half of its production
	Lowest	Household does not grow coffee or cacao and it buys basic grains in addition to using all of its production for home consumption
Money	Highest	Household has a savings account or makes loans to others
	Middle	Household does not save nor make loans
Health	Middle	No one in the house was sick or if someone were sick he/she paid for adequate health care either with own money or by selling assets
	Lowest	Someone in the household has health problems and they were treated by asking relatives for money, borrowing money, or by going to the herbalist, or they were untreated for lack of money
Food Security	Middle	Household has not experienced a food shortage, or did for less than a week and solved it without having to ask others for food or money, to reduce number of meals, or to send the wife or children out to work
	Lowest	Household experienced a food shortage for more than a week, or of less than a week but had to solve it by asking for food, by borrowing money or by sending wife and children out to work

Source: adapted from Ravnborg et al, 1998



Source: FAO



Source: FAO

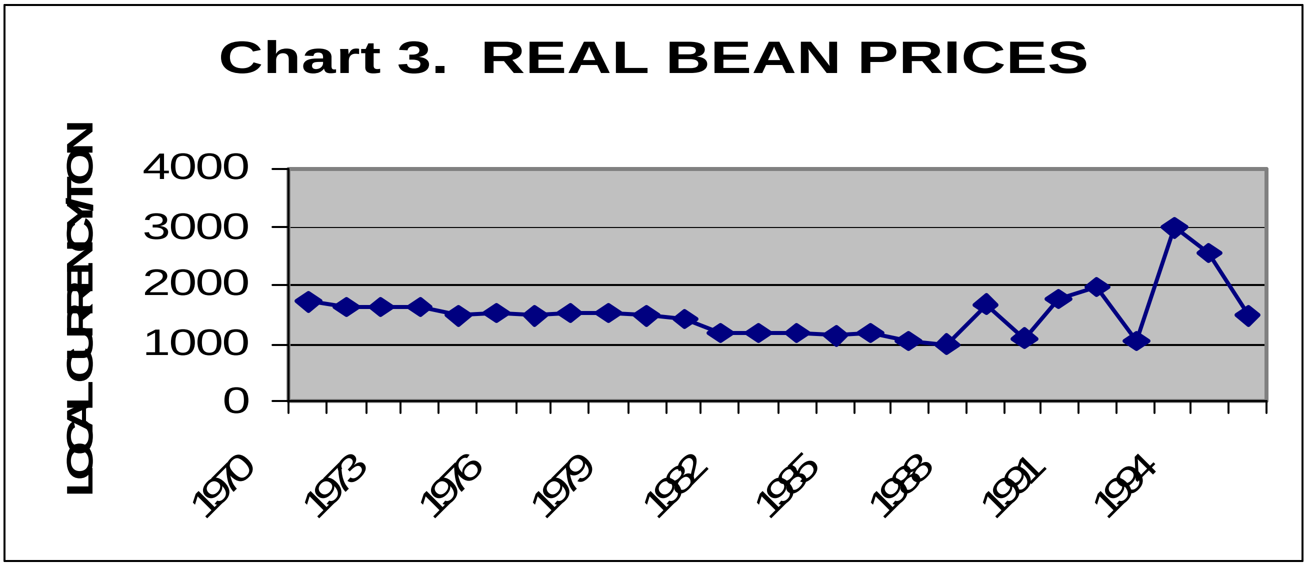


Chart 3. REAL BEAN PRICES
LOCAL CURRENCY/TON
4000
3000
2000
1000
0
1970
1973
1976
1979
1982
1985
1988
1991
1994

Source: FAO

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