The Green Manure Revolution in Atlantic Honduras[1]

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Introduction

Land degradation and corresponding productivity declines is a major cause of hardship for several million small farmers on the hillsides of tropical Mexico and Central America. The complex technical and socio-economic factors contributing to natural resource degradation are frequently intertwined in diverse social contexts and farming systems. Competing land uses, population growth, migration, and the unequal distribution of quality land apply increasing pressure on the natural resource base of both intensively cultivated lands and the forest frontier. In many regions traditionally characterized by shifting cultivation, the management of soil fertility, weeds, and erosion through bush-fallow rotations is no longer feasible. Fallow periods are typically short or non-existent, crop residues are burned to control weeds and pests, and grassy weeds have replaced tree species in fallow fields. The decline of the bush-fallow has resulted in lower maize yields, weed invasion, reduce moisture conservation and increased soil erosion in many Mexican and Central American farming systems.

In spite of extreme poverty and low levels of formal education, hillside farmers have not been passive in the face of these problems. This paper examines the use and diffusion of a productivity enhancing, resource conserving technology for hillside maize based on the legume velvetbean (*Mucuna deeringiana*). The

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[1] Prepared for The 3rd Wye International Conference on Sustainable Agriculture "Soil Management in Sustainable Agriculture", 31 August - 4 September, 1993, Wye College, University of London. This paper is based in part on the survey report "Tierra cobarde se vuelve valiente: el uso y difusión del frijol de abono (*Mucuna deeringiana*) en las laderas del Litoral Atlántico de Honduras," D. Buckles, I. Ponce, G. Sain and G. Medina, CIMMYT, 1992.

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objective of the paper is to document the basic features and impact of the technology in Atlantic Honduras and identify key factors influencing adoption.

Methods

The current study is one of the results of collaborative research between the Honduran Secretariat of Natural Resources (SRN) and the International Maize and Wheat Improvement Center (CIMMYT), initiated in 1982 with a diagnostic study of maize practices in the region.[3] At that time, researchers observed a small number of farmers planting velvetbean in rotation with winter maize. By the late 1980s it became clear that the diffusion of the technology was an important regional development and a research priority for the Agricultural Directorate in Atlántida. A research program for Atlántida was subsequently developed by the Regional Maize Program for Central America and the Caribbean (PRM).[4]

The data presented in this paper were derived from a 1992 survey of 128 families in 16 villages concentrated in the municipalities of Jutiapa and Tela, Atlántida. The survey sample included eleven communities in the Jutiapa area[5] and five communities in the Tela area[6] located on the hillsides of the mountain range Nombre de Dios. Approximately 13,000 families live in the hillside communities between the municipalities of Jutiapa and Tela, the two extremes of

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3 PNIA-CIMMYT "Informe de la Encuesta Formal en el Area de Jutiapa," unpublished manuscript, 1983.

4 Studies produced by the PRM include: Buckles, Daniel et. al. "Resultados de la Encuesta Exploratoria sobre el Uso de Frijol de Abono *(Stizolobium deeringianum)* en Laderas del Litoral Atlantico de Honduras", in *Analisis de los Ensayos Regionales de Agronomia, 1990*, PRM, 1991; Avila Najera, R. and J. A. Lopez P. "Sondeo Preliminar en la Asociación Maíz Frijol de Abono (*Mucuna spp.*) en el Litoral Atlántico de Honduras," paper presented to the XXXVI Annual Meeting of the PCC-MCA, San Salvador, El Salvador, March 26-30, 1990; Duron, E. et. al. "Avances Sobre Investigacion de Abonos Verdes en el Litoral Atlantico de Honduras," in *Proyectos Colaborativos de Agronomía, Desarrollo y Mejoramiento de Germosplasma en Maíz (Zea Mays L.)*, PRM, 1989. Sain, G.E.; I. Ponce and E. Borbón "Rentabilidad del sistema de abonera en el litoral Atlántico de Honduras", paper presented at A Workshop on Slash/Mulch Practices, October 12-16, 1992, CATIE, Turrialba, Costa Rica.

5 Piedras Amarrillas, La Danta, Los Olanchitos, Aguacate Linea, El Cantor, El Naranjo, Descombros, Las Delicias, El Paraiso, Pueblo Nuevo, Santa Fe.

6 San Francisco del Saco, Planes de Hicaque, Las Metalias, Los Laureles, El Zapote.

the department of Atlantida. Villages were selected to provide a basis for comparison with the 1982 PNIA-CIMMYT survey in the municipality of Jutiapa and to include villages in Tela identified as strategic in the 1990 department-wide survey. Villages in the 1982 PNIA-CIMMYT survey and 1990 SRN-CIMMYT survey were originally chosen at random with the chance of selection in rough proportion to the estimated population of the village. In each village, heads of households were randomly selected for inclusion in the survey from the family census data of the Health Secretariat. An additional requirement for farmer selection was that they have planted maize during the current winter cycle or the previous summer cycle. The survey questionaire was tested and revised, enumerators were trained during a three day workshop, and each questionaire was reviewed by the coordinators of the survey at the end of each day. The survey was completed within a three week period. The results reported here represent typical maize farming practices in hillside communities in the department of Atlantida.

The Study Area

The department of Atlántida is characterized by two basic agro-ecological zones, the coastal plain and the hillsides of the mountain range Nombre de Dios that run parallel to the coastline (Map 1). The climate is hot and humid, with bimodal rainfall between 2,000 y 3,300 mm per year and an average temperature of 28^{o}C (Figure 1). The coastal plain is characterized by fertile aluvial soils while on the hillsides relatively undeveloped, thin soils derived from sedimentary materials are common. The hillside topography is broken, with slopes ranging from 10% to more than 100%.

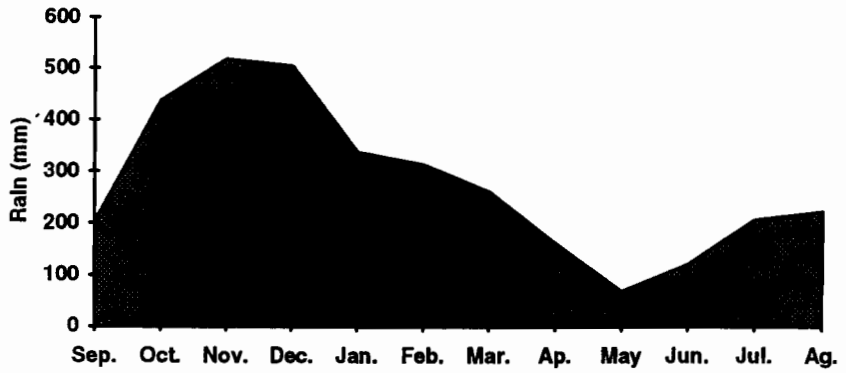

Figure 1: Ten-year average annual rainfall (1980-89), La Ceiba, Atlántida, Honduras.

The agricultural year is divided into two seasons, the summer planting in June (primera) and the winter planting in December (postrera). High annual rainfall and temperatures are conducive to a wide range of crops. Nevertheless, the coastal plain is mainly dedicated to export plantation crops (bananas, pineapple, and African palm), dual purpose cattle and some rice while the hillsides specialize in maize, beans and summer pastures. Small-scale production of manioc, rice, cocoa and coffee is also common on the hillsides. Traditionally, the summer was the most important maize season, although as we will see, winter maize has become dominant on the hillsides due in part to diffusion of the *abonera* system.

The tall rainforests characteristic of the region have been ravaged by logging, shifting cultivation and the expansion of the regional cattle industry. Nevertheless, the region is still an agricultural frontier in several respects. First, many hillsides are still covered with forest species at various stages of growth. The grassy weeds characteristic of deforested and degraded hillsides are not dominant. Thus, shifting cultivation is still practiced, typically followed by the establishment of poor quality pastures that quickly degenerate once again into secondary forest vegetation. Second, extensive areas are owned by ranchers

who only exploit a portion of their landholdings at a time. Farmers rent uncultivated land for maize and bean cultivation at very low prices on the condition that they establish pastures after a few years. As a result of these conditions, farmers have relatively easy access to fallow land appropriate for shifting cultivation. The extensive character of land use patterns in Atlantida is reflected in the relatively large average farm size, 9.2 hectares per family according to survey data.

The *Abonera* System

An *abonera* is a field of velvetbean planted as a sole crop in rotation with winter maize (Figure 2). An *abonera* is established for the first time in a field as an intercrop 40 to 55 days after planting winter maize (mid to late February). Two to three seeds per hill are planted every metre or so between each row of maize. Winter maize is harvested between March and Abril and the velvetbean is allowed to develop as a sole crop throughout the summer season. Summer maize is planted in a separate field using the conventional technology of shifting cultivation. Meanwhile, the velvetbean develops into a thick mat of luxuriant growth some 1.5 metres deep. The legume reaches the end of its vegetative period by late November when seed is formed. Farmers slash the vegetation and a few weeks later stick-plant winter maize into the mat of decomposing leaves and vines. Two thirds of the farmers interviewed rely exclusively on natural reseeding of the *abonera* while the remainder replant velvetbean in the winter maize field every year. Farmers indicated that it takes three years to establish a 'self-sustaining' *abonera* that does not require reseeding and that provides maximum benefits to winter maize.

The *abonera* is a mult-purpose technology. Land clearing is greatly facilitated by this aggressive legume as it smothers virtually all competing weeds and is very easy to cut. The mulch left on the field conserves soil moisture and protects the soil from erosion while the decaying leaves, stems and roots provide nutrients to the subsequent maize crop. As one Honduran farmer put it, "cowardly land becomes brave again" when managed with "the fertilizer bean".

Adoption Patterns over Time and Space

The survey data and numerous interviews in the region indicate that the *abonera* system was transferred to Atlantida in the early 1970s by farmers migrating from the coastal region of Guatemala and neighbouring Honduran departments. The technology spread slowly in the first 10 years following its introduction to the region and explosively in the subsequent 10 years (Figure 3).[7] Adoption of the technology increased at a rate of approximately five percent per year, peaking at almost two thirds of all hillside farmers in the early 1990s. Adoption appears to have leveled off in recent years.

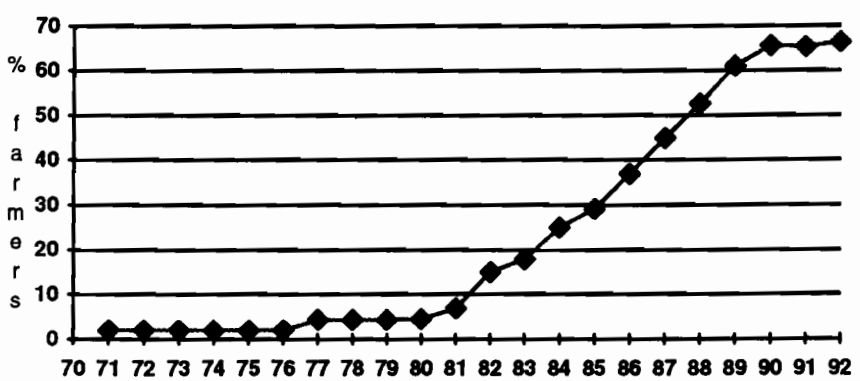

Figure 3: Accumulated percentage of farmers adopting the *abonera* system (adjusted for farmer age and migration history).

7 The adoption curve presented in figure 6 was adjusted to exclude in any given year farmers either too young to be farming on their own (< 20 years) or living outside of Atlantida at the time of adoption. This later factor is particularly important as more than two thirds of all farmers surveyed migrated to Atlántida from other parts of the country and may have adopted the technology elsewhere.

While 34% of the farmers surveyed in 1992 reported that none of their current winter maize was planted in *aboneras*, many of these farmers had planted winter maize in a velvet bean rotation at some point in the recent past. Thus, an estimated 83% of farmers in the study area, totalling over 10,000 hillside farmers, have direct experience with the technology (Figure 4). Farmers reasons for discontinuing use of *aboneras* are mainly associated with insecurity of access to land, an issue examined below.

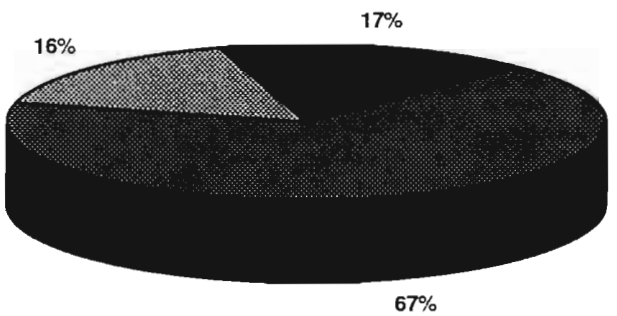

Figure 4: Percentage of adopters (67%), non-adopters (17%) and dis-adopters (16%).

The proportion of farmers' fields dedicated to the technology is very high. Approximately 78% of farmers with *aboneras* cultivate more than half of their winter maize in *aboneras* while some 55% cultivate all of their winter maize in this manner. For these farmers, the technology has virtually displaced traditional forms of winter maize cultivation.

While individual farmer decisions to plant an *abonera* may take some time, once the decision is made conversion to the system is immediate and relatively complete. Farmers do not seem to pass through a period of small-scale experimentation with the technology as is normally expected with new practices. Regression analysis with the survey data indicate that recent adopters plant just

as much of their winter maize in *aboneras* as farmers with many more years of experience.

Adoption of the technology is also relatively uniform across the hillside area. Villages in Tela, the municipality at the northern extreme of Atlántida, have slightly higher rates of adoption and average number of years using the technology than villages in other municipalities, but the differences are not statistically significant. This tendency is consistent, however, with reports that two Guatemalan migrants arriving in San Francisco del Saco and neighbouring villages were the first to plant velvet bean in the region. The movement of velvet bean seed into other parts of the department probably occurred largely from this initial point of origin.

Changes in the Farming System

Adoption of the *abonera* system has thoroughly transformed cropping patterns and other key aspects of the regional farming system. During the last ten years, winter maize has overtaken summer maize as a proportion of total maize production in the region (Figure 5). Winter maize production in *aboneras* in 1991 accounted for approximately 55% of the aggregate winter maize area and 65% of aggregate winter maize production on the hillsides of Atlantida.

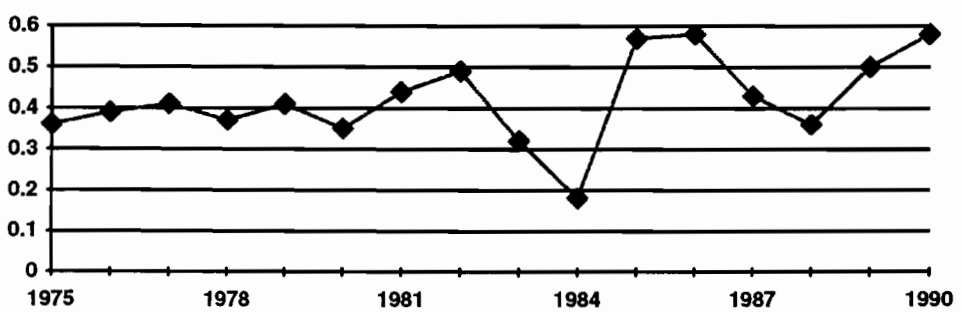

Figure 5: Proportion of winter maize area, Atlántida, Honduras

Dramatic increases in land area under winter maize established in *aboneras* reflect significant advantages of the system over conventional shifting cultivation. Yields reported in the survey average approximately 35% over the conventional fallow system, typically with less reliance on chemical fertilzers. On-farm field trials recently completed in the region document yields of 3-4 MT/ha. in *aboneras* compared to yields half this level under traditional management.[8]

While yield advantages are important, system productivity is also greater over time. During the seven year cycle typical of a maize-bush fallow rotation, 3 maize crops in consecutive cycles are produced. In contrast, the *abonera* system produces one crop of maize per year in a continuous rotation with velvet bean. Farmers in Atlantida report continuous annual rotations of over ten years. These reports are promising but agronomic research on nutrient recycling in *aboneras* compared to bush fallow systems and chemical fertilizer technology is needed to determine the long term impact of the *abonera* system on the natural resource base and the sustainability of maize yields.

Savings in labour time during land preparations also favour the *abonera* system. The aggresive legume smothers competing vegetation and is much easier to cut than tough grassy weeds and other secondary vegetation. Labour dedicated to land preparations in the *abonera* system is reduced by about two thirds compared to a four year bush-fallow. Farmers cultivating maize in *aboneras* are consequently able to clear more land in the same amount of time as farmers clearing land in the conventional manner.

Adopters of the *abonera* system cultivate on average 40% more winter maize than farmers who do not use the technology. Much of the increased farm area is on steeper hillsides. *Aboneras* are located on fields with an average of 57%

[8] Bernard Triomphe, personal communication.

slope compared to an average slope of 45% on fields cleared from bush-fallow. This finding raises an important quandry. Are adopters of the technology cultivating land that would normally be cleared from forest for conventional cultivation or are they extending the agricultural frontier onto increasingly marginal forest land? The survey data is inconclusive, although preliminary analysis suggests that most *aboneras* are established on previously cultivated land, not directly from forest.

While *aboneras* offer considerable soil protection during the heavy rains of summer, the cultivation of steep slopes may present serious problems of landslides. Farmers and field observations indicate that the thick, shallow-rooting cover created by velvetbean destroys deeper rooting vegetation and loosens the soil, occasionally provoking landslides during heavy rainfall. The risk of landslides needs further investigation before conclusions can be reached regarding the suitability of *aboneras* on very steep slopes.

Farmer Evaluation

Honduran farmers are keenly aware of the advantages and disadvantages of the *abonera* system. They consider the fertilizer effects of Mucuna the most important reason for using the technology but recognize several other benefits as well including labour savings, soil moisture conservation and erosion control (Table 1). Ease of land preparations was rated by farmers as the second most important advantage over the conventional cropping system. Interviews in the region suggest that fifteen years ago when fertile land was more abundant in Atlantida, ease of land preparation was the main impulse behind the diffusion of the technology. The high rating given to savings in labour time underlines the centrality of labour considerations in farmers' decisions regarding technological

options. Resource poor farmers in Atlantida clearly value technologies that offer significant labour savings and give considerable weight to this consideration. Thus, when considering natural resource conservation technologies for resource poor farmers one cannot assume that labour-intensive technologies will be well received.

Table 1: Advantages of the *Abonera*

Characteristic	First selection		Second selection	
	N	%	N	%
Fertilizer effect	32	40	14	18
Ease of land prep.	18	23	21	27
Weed control	7	8	18	24
Moisture conserv.	17	21	20	26
Erosion control	6	8	3	4
Total	80	100	76	100

Among the problems with *aboneras* cited by farmers increased incidence of rats and landslides are the most important (Table 2). The closed-cover created by the *abonera* is a protected environment attractive to rats, although cyclical fluctuations in local rat populations are probably the most important factor affecting the intensity of this problem. Many farmers can identify communities where small landslides have been provoked by *aboneras*. The risks associated with these problems are considered less important, however, than the significant benefits to be gained from the *abonera* system.

Table 3: Risks Associated with the *Abonera*

Characteristic	First selection		Second selection	
	N	%	N	%
Pests (rats, snakes)	37	46	10	12
Landslides	23	28	9	11
Loss of summer crop	9	11	12	15
Not important	12	15	50	62
Total	81	100	81	100

Technical and farmer evaluation indicate that the *abonera* system is a multi-purpose technology. In many ways, the *abonera* is consistent with the traditional model of soil, weed, and water management in shifting cultivation. In both systems, depleted soils regain fertility under rotation, weeds are reduced and water is conserved through mulching. The *abonera* technology builds on farmer knowledge of land degradation and restoration processes under shifting cultivation, an important factor behind rapid and widespread adoption. This finding suggests that the development and diffusion of new technologies in the region would benefit from an understanding of the strengths and weaknesses of the farmer knowledge base. Researchers may be able to develop technologies that draw on the farmer knowledge base, thereby facilitating subsequent diffusion of the new technology. In situations where this is not possible, extension services may target information in areas where farmer knowledge is limited.

Property Rights

The most important farm level factor limiting further diffusion of the technology in Atlantida is access to land. The survey data indicate that land owners are much

more likely to adopt the technology than farmers dependent upon rented land. Land rental arrangements are typically too insecure to justify the establishment of *aboneras* by landless farmers. This does not mean, however, that long term security of land ownership is a necessary condition for the adoption of the technology. Survey data from 1990 indicate that farmers with squatters rights and official land title are equally disposed to adopt *aboneras*. Interviews in the region suggest that a planning horizon of three or four years more than compensates for the initial investment in the establishment of the *abonera*.

The rotation of velvetbean and maize, while more land intensive than the conventional bush fallow system, depends in part on farmer access to additional land for the cultivation of summer maize and other crops. The survey data indicate that adoption increases among farmers with larger farms. Nevertheless, the minimum farm size for adoption of the technology in Atlantida is quite low, as little as 1.6 hectares according to the survey data. Furthermore, adoption rates are still relatively high (47%) among farmers with less than 1.6 hectares of land (Table 4).

Table 4: Adoption by farm size classes, land owners only

Farm Size	With *Abonera*		Without *Abonera*		Total	
	N	%	N	%	N	%
0 - 2	5	55.6	4	44.4	9	100
2 - 5	19	76.0	6	24.0	26	100
5 -10	17	70.8	7	29.2	24	100
> 10	31	86.1	5	13.9	36	100

These findings suggest that farm size is not an absolute limit on adoption of the *abonera* system. One must take into consideration, however, the relative abundance of fallow land in Atlantida and the well developed land rental market.

The landless and farmers with very small farms can rent land under bush-fallow, especially for summer maize, at low cost from ranchers interested in converting fallow land into pasture. They are consequently free to dedicate their own small parcels to the velvetbean-maize rotation. Furthermore, an *abonera* rental market has developed in some parts of Atlantida, with *aboneras* fetching roughly 70% more per hectare than a field under secondary growth. In short, it is the social system affecting access to land and not individual farm size or land tenure arrangements that is likely to be a determining factor in the diffusion of the technology.

Conclusions

A resource conserving, productivity enhancing green manure technology has been widely adopted in Atlantic Honduras, mainly as a result of farmer to farmer diffusion. Widespread use has in turn transformed key features of the farming system such as cropping patterns, yields and labour requirements. Specific features of the technology such as its ability to respond to multiple objectives and compatibility with the traditional model of land management are important economic and cultural factors facilitating adoption. Nevertheless, broader forces such as land rental markets favourable to this relatively land extensive system are also important conditions for adoption. As land use intensity increases in the region, new management practices will be needed to sustain agricultural productivity and conserve the natural resource base. Perhaps the greatest lesson to be learned from the use and diffusion of velvetbean in Atlántida is that green manures can be effective and adoptable components in hillside farming systems.