Mucuna cover cropping: Benin

ABSTRACT

In Benin, the soils of the southern plateaux have been under increasing pressure in recent years. As population density has increased, fallow periods have become too short to maintain soil productivity. The numerous smallholder farmers in the area have rarely used fertilizer and even when they have, the benefits have been reduced by a degraded soil resource base. One notable consequence of the reduced fallow periods has been the encroachment of *Imperata cylindrica* – an aggressive weed which requires substantial labour to eradicate by hand and which has forced farmers to abandon fields to fallow.

In 1986-87, researchers with the development-oriented RAMR[1] (Applied On-Farm Research/Recherche Appliquee Milieu Reel project proposed alleviating low soil nutrient supply in the Adja Plateau in Mono province by cover cropping with mucuna *(Mucuna pruriens)*. Farmers cooperating in the cover-cropping tests discovered an additional benefit of mucuna – its ability to smother and suppress imperata. They found that use of the mucuna crop reduced the need for weeding or herbicide for subsequent crops of maize, which is the staple crop in the region.

Tests on mucuna cropping were begun by other partners in the RAMR project, the Royal Tropical Institute (KIT) of the Netherlands and the International Institute of Tropical Agriculture (IITA) in Nigeria. Researchers established the first small demonstration plots of mucuna in public places such as school grounds, so that the technology would not be completely unknown to farmers volunteering to test it. Good contact between extension workers, researchers and farmers was the key dissemination strategy. Researchers lived in the small number of villages involved and were trained to listen to farmers.

Farmers adopting mucuna cover cropping benefited from higher yields of maize with less labour for weeding. Many of the early adopters also earned additional revenue by selling mucuna seed as the technology was disseminated. Development organizations became interested in the farmers' adoption of mucuna: in

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[1] The RAMR project is a farming systems research project of the national agricultural research service, INRAB. It is a collaborative activity of the DRA (Agronomy Research Directorate/Direction de la Recherche Agronomique) of the Ministry of Rural Development (MRD), IITA and KIT.

1990, the government extension services tested the system in 12 villages in Mono province and then extended these trials to other southern provinces in 1991. Some non-governmental organizations (NGOs), such as SG2000 (Sasakawa Global 2000), became involved in the diffusion of mucuna. In 1992, Sasakawa Global 2000 purchased about four tonnes of mucuna seeds from farmers benefiting from the **RAMR** project and distributed them to farmers facing spear grass invasion and/or soil depletion in every province of the country.

The estimated number of Benin farmers testing mucuna grew to ***3*** 000 in 1993 and nearly 100 000 in 1996. Some of the testing was undertaken in northern Benin, where land was not scarce. **As** a result, adoption was lower in those areas, although some farmers discovered that mucuna made good fodder for livestock and, importantly, others observed that mucuna appears to reduce the most devastating parasitic weed **of** the savannah zone, *Striga hermonthica.*

Two different management systems have been developed and recommended for the integration of mucuna into cropping systems. For severely degraded fields, a sole cover crop fallow is used. The plot is slashed before seeding mucuna and a second slashing may be necessary to allow the mucuna seedlings to overcome the fast-growing imperata. When the imperata infestation is not severe, a maize/mucuna relay is used: maize is planted at a normal spacing, followed by mucuna seeding either between or within the rows 40-45 days after planting the maize and just after the second weeding.

The current adoption rate of mucuna in Benin is promising, especially in the south of the country, where there is an urgent need to destroy imperata and enhance soil fertility. **A** survey was conducted during the 1996 growing season of 142 farmers who were exposed to the technology over a period of five years. The results showed that 71 percent of the participating farmers used the technology for at least three consecutive years. Conclusions about the future viability of mucuna cover cropping may be drawn from an economic analysis based on some of the yield and adoption data. It indicated that positive returns are achieved at both farmer and regional levels in the second year after adopting mucuna. It is estimated that adoption of mucuna throughout Mono province would result in savings of about **6.5** million kg **of** nitrogen or about **US$1.85** million per year.

This innovative experience is one of the first instances of substantial adoption of cover cropping in West **Africa,** as well as one **of** the most important examples of a sustainable cropping-system development with farmers. **It** should be noted, however, that the conditions prevailing in the area, though right for adoption of mucuna cover crop fallows, may not be uniformly present in West Africa or even other parts of southern Benin. The critical circumstances surrounding adoption of mucuna cover cropping – a decline in soil fertility, lack **of** fertilizer, land scarcity and weed encroachment – combined to force farmers to adopt an agricultural innovation which might not otherwise have been accepted.

A common reason for non-acceptance of mucuna is that it occupies land that could otherwise be used to grow a food crop. For this reason, there has been some testing of mucuna as human food, which has involved taking some Beninois farmers to Ghana, where small amounts are traditionally consumed. Mucuna beans require substantially more preparation than traditional beans to make them edible. Considerable testing of preparing mucuna for local dishes would thus be necessary to make it a feasible option for human consumption.

One of the key lessons learned is that soil management techniques like cover cropping should have multiple benefits to be acceptable to farmers. It is helpful if one or more **of** these benefits is highly visible. In the case of mucuna cover cropping, the weed problem was often more obvious than the poor soil fertility and farmers could therefore better appreciate the impact of the new technology.

It should be noted that even after mucuna cover cropping, imperata regains its original strength. This suggests that mucuna cover cropping alone is not enough to eradicate the weed. Destruction of imperata will therefore require an integrated approach, using cover crops combined with other management techniques such as tillage or herbicides. Furthermore, mucuna cover cropping may not be the best soil-management practice for all farmers. Other resource management systems, based on cover crops or multipurpose trees, integrated with judicious use of fertilizers, may have to be developed elsewhere.

Promising developments in soil management practices, however, continue to be made in Benin and neighbouring countries. To assist beneficiaries in decision making, a user-friendly database of 100 cover crop, grain and forage legumes has been established and shared with scientists from national agricultural research systems (NARs) in sub-Saharan Africa. In addition, IITA in Ibadan, Nigeria, has established a clearing house of information and seeds of cover crops in West Africa (CIEPCA) to improve dissemination of knowledge on cover crops throughout the sub-region.

INTRODUCTION

Soils on the plateaux of southern Benin and Togo are nearing exhaustion. The soils are locally known as “terres de barre” and classified as *sols ferralytiques* in the French system. They are Acrisols (low base saturation) or Lixisols (moderate base saturation) according to the Food and Agriculture Organization of the United Nations (FAO) classification, with sandy topsoil and clayey subsoil. They are thus physically stable (not prone to erosion) but chemically very poor.

The plateaux have supported some of the earliest human agricultural settlements in the area and some of the highest population densities. While population densities in southern Benin are 100-200 people/km2, the soils on these plateaux have supported high population densities of 220-350 people/km* for a long time. The high population density has resulted in considerable land pressure and fallow periods have become too short to maintain soil productivity. It has been found that more than *S0* percent of farmers in the southern provinces of Benin possess less than two hectares of land. One of the oldest human settlements is the Adja plateau in the Mono province of southern Benin. Fertilizer use is low among the large class of smallholder farmers. Even if fertilizers were available, the benefit from their use is declining because of a degrading soil resource base. Another consequence of the reduced fallow periods is the encroachment of imperata.

Mono province has a bi-modal rainfall pattern, resulting in a first growing season from April to July and a second season from September to November. Two crops per year of maize, the staple crop, are possible there and throughout southern Benin. However, the second season is risky for maize because of erratic rainfall, which has also been observed in southwestern Nigeria. In southern Benin, the major cropping system is oil palm/maize-based, with oil palm, maize, cassava, cowpea and groundnut as major crops. Fire is used to clear land and hand hoeing is common. There is little or no use of fertilizer, except where cotton is grown. Major field problems are insects, soil fertility and weeds – especially imperata.

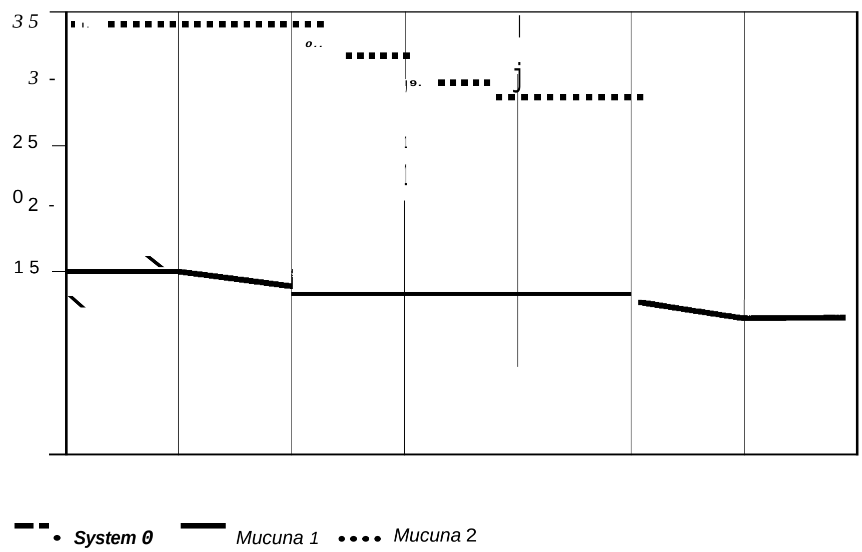
PRE-INNOVATION

In order to survive in a system where agricultural inputs are rare, farmers had developed a fallow system based on a dense stand of oil palm. This fallow system maintained soil fertility, reduced imperata and brought substantial revenue to farmers from economic products such as firewood, animal feed, palm oil, palm wine and whisky. The disadvantage was that the system was inflexible, since the fallow period was long – approximately 15 years. Only a few years of cropping were possible after the oil palm fallow.

Maize production was consequently insufficient to support the increased population. Yields of maize were typically about 500 kg/ha without fertilizer. Where imperata infestation occurred, farmers were forced to work harder – as many as five weeding operations in one cropping season – for declining yields of maize.

INTRODUCING INNOVATION

Mucuna cover cropping was adopted by farmers in southern Benin after being tested by farmers cooperating in a development research project. It was originally proposed to farmers for soil fertility improvement on the Adja plateau of Mono province. Researchers with the RAMR project proposed mucuna cover



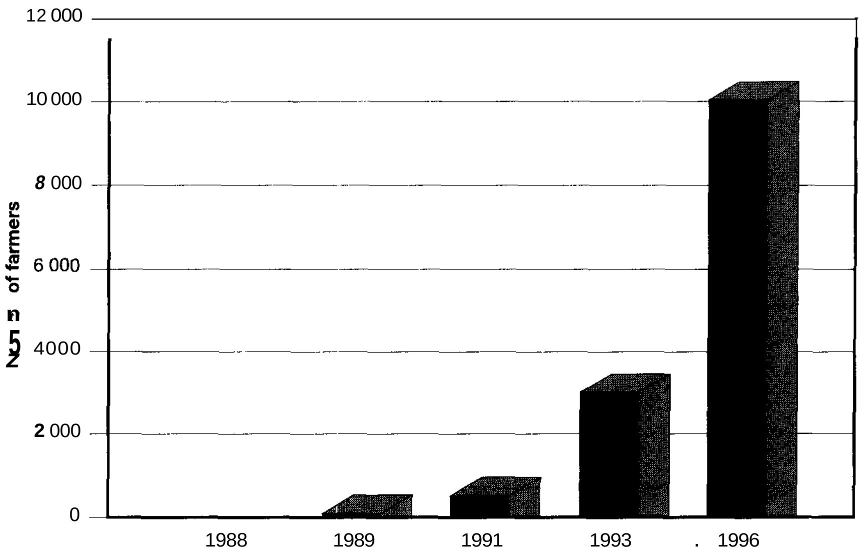
Note: System 0 = existing system; Mucuna 1 = only maize grain sold; Mucuna 2 = both mucuna and maiix grain sold.

cropping among a suite of methods to alleviate the constraint of low nutrient supply to maize. Farmers participating in the mucuna cover cropping tests especially appreciated mucuna's ability to suppress imperata and thereby reduce weeding requirements for subsequent maize crops. Extension services became interested and tested the technology in additional villages in Mono and other provinces.

Mucuna characteristics

According to FA0 and other experts, mucuna is adapted to a broad range **of** precipitation (optimum range: 1 000-2 500 mm/year) and elevation (0-1 600 m). It has a relatively narrow temperature range (19-27°C) but is still adapted to most of the humid and sub-humid zones of West Africa. Mucuna is reported to perform well in the forest and the forest-savannah transition zones of Ghana. In Benin – as in ***Cote*** d'Ivoire, Ghana, Nigeria and Togo – mucuna grows **well** in areas with bi-modal rainfall. **A** survey of the literature suggests that 5-8 tonnes/ha of mucuna dry matter can be expected in the bi-modal rainfall zone in the absence of soil limitations. Waterlogged and very infertile acid soils with a pH level of 4.5 or less are not suitable for mucuna growth.

FIGURE **2**
Approximate number of farmers testing mucuna cover cropping in Benin in recent years



Source: Vissoh *et ul..* 1998.

The life cycle of mucuna varieties lasts from 100 to 290 days. The varieties of mucuna that have been tested with farmers and disseminated in Benin and elsewhere are *M. pruriens* var. *utilis* and *M. pruriens* var. *cochinchinensis.* They are distinguished by their seed colour: the utilis are black and the cochinchinensis white. The life cycle is 130-140 days for cochinchinensis and 150-170 days for utilis.

Mucuna produces substantial quantities – roughly 1 kg/l 000 – of large seeds. Their protein content is high – approximately 25 percent – so they could make a contribution to human and animal nutrition. Indeed, mucuna seed was an important part of animal feed in the southeastern United States during the early part of the twentieth century. However, the seed contains compounds such as 3-(3,4-dihydroxypheny1)-L-alanine, known as L-DOPA, which are toxic in sufficient quantities. Human consumption of unprocessed beans can result in intoxication but the toxins can be removed by boiling and soaking the seeds in several changes of water or by other processes.

Mucuna fallow systems

Two different management systems – a sole crop and a relay intercrop – have been developed for the integration of mucuna into cropping systems. For severely degraded and imperata-infested fields, mucuna should be planted in a pure stand at the start of the rainy season. The plot is slashed with cutlass or sickle before seeding mucuna. Spacing is 0.8 x 0.4 m. If two seeds are planted per hole, approximately **60** kg of seed/ha are required. Three or four weeks after planting mucuna, a second slashing may be necessary to allow mucuna seedlings to overcome imperata, which is a fast-growing weed. If mucuna starts vining, however, a second slashing may cause damage to mucuna seedlings. In the bi-modal zone, mucuna is planted in March and April to maximize biomass accumulation, groundcover and seed production. Sowing can be extended to May if the rains are insufficient.

If imperata infestation is not severe, mucuna can be intercropped with maize. Maize is planted at a normal spacing of 0.8 x 0.4 m with two seeds per hole. Mucuna is seeded, either between or within the rows, 40-45 days after planting the maize, just after the second weeding. Seeding of mucuna earlier than 45 days after planting maize can result in reduced maize yields. Mucuna spacing is 0.8 x 0.8 m, with two seeds per hole; about **30** kg/ha are required. After maize harvest, the land is left to mucuna fallow, which prevents farmers from cropping the land during the second minor rainy season.

The implementation process

Mucuna species were grown in the 1920s in several experimental stations in Nigeria as an improved fallow and as a relay crop with maize and cassava, with a view to intensifying small-scale shifting agricultural systems. Long-term trials were conducted in Nigeria. However, it was reported that the use of *Mucuna pruriens* var. *utilis* in rotation did not gain any wide acceptance, despite wide publicity by the Ministry of Agriculture in Nigeria. This is probably typical of several locations in West Africa.

In 1986-87, mucuna was introduced into Mono province in Benin, within the framework of the RAMR project. Some demonstration plots of mucuna fallow were established, often on school grounds, and farmers' visits encouraged, so that the technology would not be completely unknown to farmers who volunteered to test it. Contact between researchers and farmers was good, because the number of villages was small and some research staff lived in the villages. In 1988, the project offered mucuna cover crop fallow, nitrogen fertilizer, pigeon pea hedgerows and alley cropping to many farmers in an effort to explore ways to maintain or improve soil fertility and produce food crops – the problem identified as the priority. Twenty farmers chose to test the mucuna fallow system. Fourteen obtained a dense stand and cover of mucuna and observed reduced imperata infestation and less need for weeding in the subsequent maize crop. The advantage of using mucuna to suppress weeds, thereby reducing the need for manual weeding or herbicide, was an unexpected benefit identified by the farmer collaborators, resulting in some spontaneous adoption. Researchers had been trained to listen to farmers, so that when farmers reported their appreciation of mucuna's ability to smother imperata, the researchers were ready to learn from them. In 1989, the research team observed that 103 farmers in the neighbourhood had planted mucuna. This spontaneous adoption was based on what farmers had seen at project demonstrations in 1986 and 1987 and on other farmers' fields in 1988.

The government extension services, Centres d'Action Regional pour le Developpement Rural (CARDERs) of the MRD, became interested in this success and started testing the system with farmers. In 1990, the CARDER for Mono province tested the system in 12 more villages with 180 farmers. It was expanded to other southern provinces in 1991 and the number of farmers testing mucuna grew to approximately 500. Large NGOs became involved and the estimated number of farmers testing mucuna in Benin grew to *3* 000 in 1993 and nearly 10 000 in 1996 (see Figure 2). In addition to the CARDERS, some NGOs such as SG2000, CREDESA (Regional Centre for Development and Health/Centre Regional pour le Developpement et la Sante) and PDEBE (Borgou East Breeding Development Project/Projet de Developpement de 1'Elevage dans le Borgou Est) became involved in the diffusion of mucuna. SG2000's effort started in 1992, when it purchased about four tonnes of mucuna seeds from farmers who were already exposed to mucuna technology through the RAMR project in Mono province. These mucuna seeds were distributed free to 128 targeted farmers in all provinces facing imperata invasion and/or soil depletion. A technical bulletin on the establishment of mucuna fallow was developed to guide village extension agents, who were trained to give technical assistance to farmers. Close supervision was carried out by both MRD and SG2000 officers.

Farmers throughout the country were thus given the opportunity to try the technology, evaluate it and decide whether to adopt it. Effective communication between extension workers and farmers was the fundamental dissemination strategy. A spontaneous diffusion ratio of seven new farmers for every farmer reached by SG2000 was observed.

Despite the many possibilities for mucuna use, two approaches were recommended: mucuna in pure stands or improved fallow and mucuna in relay with maize, as described above. Stands of pure mucuna were recommended to improve degraded soil and reduce imperata infestation when it was serious enough to cause farmers to abandon fields to fallow.

From 1992 to 1994, the individual demonstration plot size was 5 000 m2. Some plots were also used for mucuna seed production but the drawback was that relatively few farmers were involved. This was perceived to be a major constraint to the diffusion of the technology. In 1995, the demonstration plot size was reduced to 500 m2, in order to multiply by ten the number of farmers reached by the technology: 10 000 plots of 500 m2 were planted, rather than 1 000 plots of 5 000 m2. Fifteen tonnes of mucuna seeds were distributed free to farmers, who were supposed to give back the same quantity. To avoid duplication of effort, SG2000 disseminated the mucuna fallow technology through the CARDERs. Thus, rather than competing, the government extension service and the NGO complemented each other. The CARDERs already had large numbers of village extension agents in contact with farmers. SG2000 had found from field surveys conducted in Benin that the government extension agents played an important role as sources of information and hence exerted considerable influence on the adoption of recommended agricultural practices.

SG2000 has repeatedly purchased mucuna seeds from collaborating producers to extend diffusion of the technology, an activity that constitutes an incentive to small-scale farmers to adopt mucuna, as the existence of a market for seeds adds value to the crop. It may turn out to be an artificial incentive if the market for seeds becomes saturated in the future but it was clearly justified at the outset.

According to SG2000, the current rate of adoption of mucuna is promising, especially in the south, where there is a pressing need to eradicate imperata and enhance soil fertility. A survey of 142 farmers exposed to the technology over a period of five years was conducted during the 1996 growing season. The results indicated that in southern Benin, 71 percent of the participating farmers used the technology for at least three consecutive years. The remaining participants either used mucuna discontinuously or abandoned it. The discontinued use of mucuna implies that some farmers make use of the technology only when their plot is exhausted and/or invaded by imperata. This may be expected, given the result of the adoption study of 1996, in which field characteristics, especially imperata infestation and low soil fertility, were the major determinants in the use of the technology. Another small research project in southern Benin has estimated a 50 percent adoption rate in six research villages.

POST-INNOVATION

The adoption of mucuna in maize-based systems was reported to be approximately 24 percent in the villages where the innovation was originally introduced in 1986-87 by RAMR researchers. Farmers who adopted mucuna cover cropping benefited from higher yields of maize with less labour for weeding. In Mono, it was reported that a one-year fallow with mucuna reduced imperata density from 270 to 32 shoots/m2. In addition, the imperata stands are less vigorous after a one-year mucuna cover. In 1990 and 1993, there were reported increases in maize grain yield of approximately *500* kg/ha for a local maize variety and 800 kg/ha for an improved variety, following a one-year fallow with mucuna. Many of the early adopters earned additional revenue by selling mucuna seed as the technology spread.

The successful introduction of mucuna in Benin stimulated research in other West African countries. In research trials on fields in central Ghana, where there is bi-modal rainfall, average maize yields of 3-4 tonnes/ha were reported on fields with previous mucuna without application of nitrogen fertilizer, similar to yields normally obtained with recommended fertilizer levels of 130 **kg** N/ha. Yield on plots previously planted with maize and cowpea was 1.3 tonnes/ha. It was estimated that mucuna as an intercrop or as a sole crop provided an equivalent of more than 100 kg N/ha to the following maize. This is similar to an amount estimated in the bi-modal rainfall zone **of** southwestern Nigeria in 1996. That year, a 98 percent higher maize yield after mucuna fallow without chemical fertilizer application and a 179 percent increase with *5* 1 kg N/ha, 46 kg P/ha and 28 **kg** K/ha were observed. Nutrient management should thus be integrated with mucuna residue supplemented with moderate amounts of inorganic fertilizer for high maize yields.

Mucuna fallowing has additional benefits, such as soil erosion control and maintenance or improvement of the soil's physical, chemical and biological properties. These benefits have not yet been demonstrated in farmer-adopted systems but they have been shown in research stations or in research trials on farmers' fields. At the IITA station in Ibadan, increased soil porosity and water infiltration rates and decreased penetrometer resistance were observed as the amount of *in situ* mucuna biomass increased following mechanical clearing of land. There were estimated losses of 3-7.5 tonnes of soil/ha in a maize/mucuna plot, compared with 10 tonnes of soil/ha when maize was planted on contour ridges and 30 tonnes of soil/ha in the plot where sole maize was grown without contour ridges.

An economic analysis was conducted using some of the yield and adoption data. It indicated that at both farmer and regional levels, positive returns are achieved in the second year after mucuna is adopted. If mucuna seeds can be sold, the system is highly profitable from the first year of introduction of the technology. The benefit/cost analysis over a period of eight years indicated a ratio of 1.24 when mucuna was included in the system and 0.62 for the system without mucuna. The ratio was as high as 3.56 if mucuna seeds were sold (see Table 1). Yearly analysis of the benefit/cost ratio, however, indicated a declining trend over time for all systems, suggesting that external inputs (probably P

TABLE 1

Average future cost and returns over eight years in systems with and without mucuna-planted fallow in Mono province *(US$/ha)*

	With mucuna		Without mucuna
	Scenario 1	*Scenario 2*	
Gross returns	**354**	**836**	110
Total variable cost	**285**	**285**	**176**
Seed	**9**	**9**	**4**
Labour	**276**	**276**	**172**
Net revenue	**69**	**620**	**-66**
Benefit cost ratio	**1 24**	**3 56**	**0 62**
Marginal rate of return (%)	**124**	**629**	–

Note: In Scenario 1 only maize seeds are sold, while in Scenario 2 both maize and mucuna seeds are sold.

and K fertilizer) are required to achieve full sustainability (Figure 1). Adoption of mucuna throughout Mono province would result in savings of about 6.5 million kg of nitrogen or about US$1.85 million per year.

LESSONS LEARNED

Field characteristics are the most important factors determining adoption of mucuna cropping. The most important of these – positively related to adoption – is the number of times a farmer needs to weed imperata prior to testing mucuna. If fewer than three weeding operations are required, imperata is not felt to be a serious problem, because farmers normally weed twice. Three, four or five weeding operations, however, are often needed to reduce damage from imperata. If more than five weedings are required, imperata is left in the field, cut off and sold in the market as roofing material.

The second determinant, negatively related to adoption, is the presence of young palm trees in the fields. Oil palm is a long-term fallow with several valuable products and mucuna would smother the young trees.

The third determinant of adoption is poor soil fertility as perceived by the farmer. This characteristic is positively related to adoption.

Other determinants related to the farmer and farm are:

- secure land tenure (positive);
- the amount of fallow land owned by the farmer (negative);

*** In 1994, the determinants for the adoption of mucuna were investigated from a sample of about 280 farmers in Mono province, using econometrics. Relationships between adoption of the technology and farmer characteristics, field characteristics and farmer perceptions of the technology were evaluated.**

- access to external research and/or extension institutions (positive).

Determinants related to the farmer's perception of the technology are:

- the fact that wild mucuna causes itching, thereby discouraging entry of strangers into the field (positive):
- loss of the second-season food crop on the field (negative);
- the possibility of a market for mucuna seeds (positive).

Some socio-economic and biophysical conditions were right for adoption of mucuna cover crop fallows in some areas of southern Benin. Declining soil fertility, shortage of fertilizer, scarcity of land and encroachment of weeds have forced farmers to adopt an agricultural innovation which in other circumstances might not have been accepted. **A** common reason for non-acceptance of mucuna is that it occupies land that could be used to grow a food or cash crop. Consideration of mucuna as a food or cash crop depends on the use of the grain for human or animal consumption. There is thus a need for further research on mucuna as human or livestock food. Since mucuna grain requires considerably more processing to be rendered edible than traditional beans, participatory tests of incorporating mucuna into locally acceptable dishes will be necessary.

It is recognized that soil-management techniques such as cover cropping should have multiple benefits in order to be acceptable to farmers. Adoption of these techniques is stimulated if at least one of the benefits is highly visible. In the case of mucuna cover cropping, the impact on the imperata weed problem was often more visible than the **effect** on soil fertility. In drier savannah areas, other benefits of cover crops, such as livestock feed and suppression of nematode and ***Striga*** *herrnonthica* may stimulate adoption of cover cropping.

Following mucuna cover cropping, imperata regains its original strength after one or two years of maize cropping. Farmers working with SG2000 reported complete elimination of imperata only after two to three consecutive mucuna crops, which suggests that mucuna cover cropping alone is not sufficient to eradicate imperata. Eradication will require an integrated approach using cover crops in combination with other management techniques, such as tillage or herbicides.

Mucuna may not be the best cover crop for all circumstances. **A** user-friendly database of 100 cover-crop, grain and forage legumes has therefore been developed and shared with scientists from national agricultural research systems in about half of the countries of sub-Saharan Africa. The software, called LEXSYS (Legume Expert SYStem), is being improved on the basis of feedback from users. Several teams have already used the programme to compile a shortlist of legumes to test within their mandate area.

Lack of information and seed are constraints to appropriate technology transfer in sub-Saharan Africa. In order to disseminate knowledge on cover crops more effectively, IITA has established CIEPCA, the clearing house of information and seed of cover crops in West Africa mentioned above, with support from the International Development Research Centre (IDRC). With CIEPCA and LEXSYS, similar successes in other areas of sub-Saharan Africa may be expected wherever cover crops are found to help satisfy farmers' needs.

Cover cropping is not necessarily the best soil-management practice for all farmers. Agroforestry techniques that provide shade for imperata suppression and mulch for soil may be better, especially if they also provide economic products like the oil palm fallow. *Acacia auriculiformis* woodlots have been shown to improve soil fertility within three years and furnish fuel or construction wood for sale or use at the farm. Farmers in southern Benin are increasingly adopting them.

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General Information

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