

## Collaboration to increase the use of Mucuna in production systems in Benin

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V. Houndékon, V.M. Manyong, C.A. Gogan et M.N. Versteeg

### Abstract

In 1987, the leguminous cover crop *Mucuna pruriens* var. *utilis* was introduced on researcher-managed demonstration fields for novel technologies. The objective was to address the serious soil-fertility decline on the Adja Plateau in southern Benin. But farmers were more impressed by the ability of *Mucuna* to control the rampant weed *Imperata cylindrica* and requested seeds to use for their own experimentation. However, a clear soil-fertility bonus became highly visible, and this aspect was further explored by farmers with seriously depleted ("comatose") fields. Extension services and nongovernmental organizations, such as Sasakawa Global 2000, accelerated the spread of this dual-purpose technology to meet a 1995 target of having 100 000 farmers know about *Mucuna*. Adoption studies and econometric analyses carried out during 1993–95 indicated that the most important factor driving adoption was control of the *Imperata* weed. Eight more factors contributed significantly: three related to field characteristics, that is, soil fertility, clay content, and presence of young palms; four, to the farmer, that is, age, land-security situation, possession of fallow reserves, and contact with extension services; and one, to the technology, that is, farmers' reluctance to use the technology for regular soil-fertility management because it would result in unproductive fields during the short rainy season.

The farmers' reluctance stimulated researchers to look for ways to overcome this handicap. They set up trials to rotate maize–*Mucuna* relay crops with more conventional crop combinations in alternate years and began looking for ways to make *Mucuna* grains economically useful. Through interregional contacts, it was revealed that Ghanaian farmers regularly used small quantities of *Mucuna* grains in their daily food. This led us to investigate ways to promote consumption of larger quantities of *Mucuna* in flour preparations that are acceptably free of toxic substances and easily incorporated into staple dishes, as substitutes for maize flour. We found that cracking the seeds, soaking the cracked seeds overnight, boiling them for 20 min, and soaking them again overnight lowered the level of L-Dopa (the main toxic factor) from about 6% to about 0.4%. This is well below a threshold level of 1% for regular consumption of *pâte*, the most consumed staple dish in southern Benin and Togo. However, toxicologists recommend several more toxicological tests for other possible antinutritional factors before the flour is launched for large-scale consumption. Observation trials using *Mucuna* grains for animal feed for pigs and goats are under way in Benin, but no results are available yet. Other niches for *Mucuna* adoption were observed in northern Benin: use of *Mucuna*–maize relay crops for hay production (adopted by many Fulani herdsman around Nikki in eastern Borgou province) and for *Striga* control.

The essential impact of farmer interaction on the course of experimentation, results, and adoption is also highlighted in this paper.

### Résumé

L'histoire du *Mucuna* a commencé en République du Bénin en 1987, lorsque le *Mucuna pruriens* var. *utilis* a été introduit aux paysans du village de Zouzouvou sur le plateau Adja. Bien qu'au départ le *Mucuna* ait été présenté aux paysans pour restaurer la fertilité des sols, ceux-ci ont été plus impressionnés par la capacité de cette plante à étouffer le

chiendent (*Imperata cylindrica*). En une saison, le *Mucuna* semé en association avec le maïs de 3 à 4 semaines après le semis du maïs a ramené la densité du chiendent de 270 plantes  $m^{-2}$  à 32 plantes  $m^{-2}$ . La capacité du *Mucuna* à restaurer la fertilité du sol était également évidente. Le rendement grain du maïs produit après l'utilisation du *Mucuna* était de 70 % plus élevé que le témoin sans *Mucuna*. Les perspectives d'adoption de la technologie du *Mucuna* se sont accrues grâce à deux facteurs : ( 1 ) la rotation des cultures maïs-*Mucuna* avec les combinaisons conventionnelles pendant des années alternées, étant donné que la culture du *Mucuna* sur un terrain ne permet pas l'utilisation de ce terrain pendant la seconde saison de pluie ; et ( 2 ) le développement des méthodes de réduction de la substance toxique L-dopa contenue dans les graines de *Mucuna*, pour accroître la valeur nutritionnelle pour les hommes et les animaux. La production du *Mucuna* et la suppression de l'infestation de *Striga* dans les champs sont les nouvelles voies pour son adoption dans le nord du Bénin.

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## Introduction

In 1987, *Mucuna* (*Mucuna pruriens* var. *utilis*) was introduced to farmers in the village of Zouzouvou, Benin, by the International Institute of Tropical Agriculture (IITA), the Royal Tropical Institute of the Netherlands, and the National Agricultural Research Institute of Benin (NARIB), as one of the possible low-input technologies to counter declining soil fertility in Mono province, southern Benin. Zouzouvou was chosen by the researchers because its problems were representative of most common agricultural problems of a key ecological zone in the region. Since then farmers have rapidly picked up this attractive dual-purpose technology that enriches the soil and effectively smothers the noxious weed *Imperata cylindrica*, which widely infests many fields in the region. Since 1990 Benin's Regional Action Centres for Rural Development (RACRDs), in close collaboration with the nongovernmental organization (NGO) Sasakawa Global 2000 (SG 2000), have accelerated this spontaneous adoption process. The target for 1995 was to reach 100 000 farmers all over Benin. Even so, several indications show that *Mucuna*'s propensity to leave the field unproductive during the second, short rainy season will hamper regular use of *Mucuna*. This paper describes the environment in which the use of *Mucuna* started and discusses the *Mucuna* story as it has developed and is still evolving in Benin.

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## The environment

Benin has an erratic bimodal rainfall that peaks in June and October and averages about 1 100 mm  $year^{-1}$ . This pattern allows for a long growing season (mid-April to the end of July) and a more variable, short one (September–November) and makes it possible to grow two annual crops of intermediate or short duration, such as maize, cowpea, or groundnut. Crops of longer duration, like cassava and cotton, are usually mixed or relay cropped with a crop of shorter duration. The dominant soil is sand to sandy loam, locally known as *terre de barre*, classified as Sol Ferralitique Appauvri according to the INRA–ORSTOM system (Institut national de la recherche agronomique – Office de la recherche scientifique et technique d'Outre-Mer). It resembles a degraded Ultisol and has a pH of around 6.0. The research was done mainly on the Adja Plateau, which has a high population density (200–350 persons  $km^{-2}$ ).

The traditional system of restoring soil fertility, based on a 12- to 15-year densely planted oil-palm fallow (800–1 500 trees  $ha^{-1}$ ), is economically attractive because, at clearance, the trees yield palm wine, which is usually distilled into marketable *Sodabi* liquor. However, demographic pressure has shortened the oil-palm fallow period to such an extent that soil recovery is barely taking place, and decline in soil fertility is a major concern (Kang et al. 1991). Analyses of such fields invariably show low organic C ( $0.8 \pm 0.4\%$ ), low K ( $0.15 \pm 0.05$  meq  $100\ g^{-1}$ ), and low cation-exchange capacity ( $5.6 \pm 1.1$  meq  $100\ g^{-1}$ ) (Kater, unpublished results **(1)**).

For sustainable soil-fertility management, small mineral-P and -K inputs to compensate for nutrient losses from harvests and leaching are indispensable. Because most farmers have very limited financial resources, they cannot afford fertilizer treatments to keep the nutrient balance neutral. This aspect is not covered in this paper; the results presented are averages from farmers' unfertilized controls and from fields with minimal mineral amendments equivalent to 100 kg "cotton fertilizer" ha<sup>-1</sup> (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O, 14 : 23 : 14); this fertilizer is usually the only available P-K source in most regions of Benin.

### **The short-season *Mucuna*-mulch technology**

The short-season *Mucuna*-mulch technology consists in seeding velvetbean (*Mucuna pruriens* var. *utilis*) in relay with tall crops of short to intermediate duration, such as maize. *Mucuna* is planted about 5 weeks after the maize is sown, as earlier planting provokes smothering of the young maize plants by the aggressively developing *Mucuna*, resulting in serious yield losses. After the maize harvest, the legumes rapidly cover the field, producing a significant amount of aerial-canopy biomass, which smothers weeds and is converted into 6–12 t ha<sup>-1</sup> organic manure (dry weight) for the following year's first-season maize. Legumes such as *Mucuna* and *Canavalia* are easy to establish, but the technology precludes the growing of ordinary food or cash crops during the second season.

### **Farmers' experiences with the *Mucuna* cover-crop technology**

In 1987, *Mucuna* was sown, alongside other novel technologies like alley farming and live-mulch cropping, in a village demonstration field on the Adja Plateau to monitor effects on soil fertility. Farmers were, however, most impressed by *Mucuna*'s ability to smother the rampant spear-grass weed (*I. cylindrica*). The next year, 15 farmers asked the on-farm research team for seeds to test on their own *Imperata*-infested fields. Most of these completely farmer-managed trials confirmed *Mucuna*'s value as a weapon against spear grass. It reduced the density of spear grass from 270 plants m<sup>-2</sup> to 32 plants m<sup>-2</sup> (-88%; Dovonou 1994). Fields that otherwise needed an estimated 60–80 person-days ha<sup>-1</sup> to eliminate the weed now needed only a fraction of that labour.

*Mucuna*'s ability to restore fertility to the soil also proved to be very important: a 70% higher maize yield was obtained with maize following *Mucuna* than under monoculture maize (Figure 1).

#### **Figure 1. Effect of previous field occupation on maize yield.**

Even in some very depleted fields, where maize yields had been almost nil, *Mucuna* seemed to perform much better than other legumes, such as *Leucaena* and pigeon pea. This observation prompted researchers to recommend *Mucuna* to farmers as an option for recovery of completely depleted soils. Farmers who chose *Mucuna* saw their maize yield increase from 0.48 t ha<sup>-1</sup> to 1.14 t ha<sup>-1</sup> (Figure 2).

#### **Figure 2. Maize yield before and after introduction of *Mucuna*. Note: , yield of depleted fields (average, 0.48 t ha<sup>-1</sup>); +, yield after regeneration with *Mucuna* (average, 1.14 t ha<sup>-1</sup>).**

Even before these results were measured, other farmers began joining the ranks of the *Mucuna* planters, attesting to its growing word-of-mouth popularity as a weapon against *Imperata* and as a soil improver. In 1990, the RACRD did a preextension test involving 180 farmers in 12 villages. The results were so satisfactory that *Mucuna* was taken up as a general extension solution for depleted soils or soil invaded by *Imperata*. In 1992, the

RACRDs, in collaboration with SG 2000, established demonstration plots nationwide, with several hundred farmers. This process progressed exponentially during the succeeding years, and the goal was to reach more than 100 000 farmers by 1995, grouping them around 10 000 farmers with observation fields.

The efforts of the government's development centres and this development NGO will undoubtedly accelerate the exposure of farmers to *Mucuna*. Nevertheless, in the long run, success in establishing this agricultural practice will depend on whether the farmers who adopt the technology continue using it. To get a better understanding of the adoption process, a researcher from NARIB, in close collaboration with IITA's Savannah Program, began a survey of nearly 280 farmers in four villages in 1993, aimed to reveal

- The actual uses of *Mucuna* in the area where it was first introduced;
- The magnitude of *Mucuna* adoption in this area;
- The processes that influence the diffusion of the *Mucuna* technology;
- The impact of *Mucuna* on Benin's agriculture; and
- The characteristics of zones with favourable conditions for *Mucuna* adoption.

So far, the first three investigations have been completed. From a subsample of 143 farmers who tried *Mucuna* at least once, a rather modest 24% were found to be "confirmed adopters" (defined as farmers using *Mucuna* twice or more to solve either a spear-grass or a soil-fertility problem). This percentage was lower than the calculated 35% who were "confirmed rejecters" (defined as farmers who used *Mucuna* once but did not use it again within 2 or more years, although they still had the problem in their fields). From both the survey and subsequent econometric analyses, it was determined that the most important factor in the adoption of *Mucuna* is its capacity to reduce or eliminate the spear grass in the field.

The econometric studies revealed eight more significant factors positively or negatively influencing adoption: three factors related to the field, that is, soil-fertility status, clay content, and the presence of young palms liable to be smothered by *Mucuna*; four factors related to the farmer, that is, land-security situation, age, possession of fallow reserves, and contacts with extension services; and one characteristic of the technology itself, that is, the fact that *Mucuna* precludes the use of the land for economic output during the second rainy season. The latter stimulated researchers to look for ways to overcome this problem. One possible solution considered was to rotate maize-*Mucuna* relay crops with more conventional crop combinations in alternate years, using small amounts of mineral inputs derived from cheap sources, such as the fine phosphate fraction of the Togolese phosphate mines, and inexpensive KCl fertilizer. Another possible solution was to make *Mucuna* grains economically useful as, for instance, animal feedstuffs or human food.

### **The prospects for the consumption of *Mucuna* grain**

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The success of *Mucuna* in Benin attracted visitors to Mono province from many other places in Africa, and several returned home with seeds to introduce *Mucuna* in their own countries. In one case, this resulted in an interesting and important example of farmer-researcher interaction. When Ghanaian researchers from Kumasi were presenting the Beninese *Mucuna* seeds to farmers in Ghana, they were told that the same bean (called *adua apia* in local Ashanti language) was regularly used in common sauce and stew preparations. Some of these Ghanaian researchers eventually remembered having eaten *adua apia* when they were growing up in their native villages. This discovery was communicated to the researchers in Benin (Osei-Bonsu et al. 1996), who then went with some Adja farmers to Ghana to observe the magnitude of *Mucuna* consumption by the Ashanti farmers and to learn the recipes. Preparation is critical, as the seed contains a toxic chemical, 3-(3,4-dihydroxyphenyl)-L-alanine (Levodopa, or L-Dopa), which can induce acute psychosis. Infante et al. (1990) reported an outbreak of this occurring among 200 people in Mozambique. On the other hand, *Mucuna*'s protein content is high (around 26%), and its quality is comparable to that of soybean (Ravindran and

Ravindran 1988). Ghanaian farmers explained that grains were cracked and then boiled for 20–60 min and that the cooking water was thrown away before the seeds were ground up for the sauce or stew. The Beninese farmers, as well as the researchers, appreciated the taste of several *Mucuna* sauces and stews; the taste was similar when these were also prepared with Beninese grains.

Although *adua apia* is eaten regularly in soups and stews by many farmers in the forest and transition zones, *Mucuna* seeds are used in very small quantities (8–20 seeds per preparation), a consumption rate that would not put much of a dent in the large amount of seed produced in the maize–*Mucuna* system in Benin (200–600 kg ha<sup>-1</sup>).

Additional information on the preparation of *Mucuna* as food came from Mexico. Researchers at the International Maize and Wheat Improvement Center who were studying experiences with *Mucuna* in Mesoamerica (Buckles 1993, 1995) contacted the researchers in Benin and helped them to obtain a recipe for making *Mucuna* flour (Derpsch and Florentin 1992) and to make contact with the Judson College laboratory in Illinois, which has extensive experience in L-Dopa determinations.

First results by Myhrman (Myhrman, unpublished results<sup>(2)</sup>) indicated a limited variability (4.7–6.4%) in the L-Dopa content of *Mucuna* from Benin, Ghana, Mexico, and the southern United States. Flour was produced in Benin according to a South American recipe based on toasting dry seeds. Taste tests were carried out with *pâte* (the main staple dish in southern Benin) in which one-third of the maize flour had been replaced with *Mucuna* flour. Farmers appreciated the *pâte*, as well as porridge that was also made from the flour. However, the L-Dopa content of this *Mucuna* flour was still far higher than the calculated 1% threshold for twice daily *Mucuna* *pâte* consumption.

Researchers in Benin made a new flour from boiled *Mucuna* grains. Significant progress was made by cracking the seeds, soaking the cracked seeds overnight (to fill the cell structures with water), boiling them for 20 min (to destroy the cell walls of the swollen cells), and soaking them again overnight (to allow the toxic substances to diffuse into the water). A description of this procedure is given in Box 1.

**Box 1.** Procedure for preparing detoxified *Mucuna* flour

**1. First day**

Thoroughly crack dry *Mucuna* seeds. This can be done by hand, grain by grain, with the help of a stone or hammer (a very time-consuming operation). Alternatively, it can be done using the village mill, leaving the opening of the milling stones quite wide. (This goes very quickly and thoroughly breaks the seeds. The use of the mill results in about 5–7% loss of flour, but this can be collected and used as a protein additive in feed for goats, poultry, or pigs.)

Remove the cracked or broken seeds from the larger skin particles and put the seeds in a pot with ample water, leaving them to soak overnight.

**2. Second day**

Throw the water away. Wash the seeds in clean water. Remove loose seed coats and put the seeds in a pot with fresh ample water. Heat this new water, plus decoated beans, until it boils and keep it thoroughly boiling for at least 20 min. Leave the pot on the dying fire, with the grains soaking in the hot water until it has cooled to room temperature. Throw the water away. Wash the grains again and leave them once more in a pot of fresh ample water to soak overnight.

**3. Third day**

Throw the water away. Wash the soaked grains again and dry them in the sun. When the grains are completely dry (usually after 23 d), winnow them from the remaining seed-coat particles and grind the cleaned seeds to flour.

Using the village mill to crack the seeds, we obtained net *Mucuna* flour yields of about 50% of the dry weight of the *Mucuna* grains.

**Note:** Use old clothes during the work with the *Mucuna* seeds, as we found that soaked seeds and splashes of soaking water left brown-black stains on tissues, which we were unable to clean afterwards.

This procedure dramatically decreased the L-Dopa content to 0.32–0.42%, well below the 1% threshold. Furthermore, *pâte* prepared with one-third *Mucuna* flour had an even lower L-Dopa content (0.08–0.10%) (Table 1). Boiling the seeds for more than 20 min did not improve the results. However, to complete the preparation of the dish, 40–45 min of heating is required in addition to boiling; hence, heating time totals at least 1 h. Incorporation of detoxified flour in daily *pâte* would thus require more heating time for food preparation, which would require more fuelwood. This would be a gender issue, as the burden of collecting extra fuelwood would fall mainly to women. Nevertheless, the use of *Mucuna* flour would free up a significant amount of maize, which may be sold easily to provide more money for the household.

**Table 1. Content of L-Dopa in detoxified flour from two *Mucuna* varieties (*Mucuna pruriens* var. *cochinchinensis* and *M. pruriens* var. *utilis*) and in a *pâte* consisting of this flour and maize flour.**

Flour from *M. pruriens* var. *cochinchinensis* had a significantly lower L-Dopa content than that from *M. pruriens* var. *utilis* ( $P < 0.05$ ), but the significance of the difference disappeared in the final *pâte* values. All in all, properly treated *Mucuna* seeds can be consumed in significant quantities. However, toxicologists recommend several additional tests for toxic proteins, carcinogenic and mutagenic components, and semichronic, allergic, or immunological effects, especially after long-term consumption (Alink, personal communication, 1996<sup>(3)</sup>).

*Mucuna* grains may also be incorporated in feed as an additional protein source for farm animals, a practice that was rather extensively used in the southern United States for steers and pigs at the beginning of this century (Tracy and Coe 1918). In Benin, tests are under way with goats and pigs, but results are still unavailable.

Profitable use of *Mucuna* grains may eliminate an important barrier to *Mucuna* adoption. Moreover, reasonable grain yields can be obtained with less effort, smaller investments, and a lower risk of failure than are associated with traditional second-season crops such as maize, groundnut, and cowpea. Relay-cropped *Mucuna* needs no additional land preparation, sowing, or weeding and is unaffected by drought during August and September. The major risk is the destruction of the aboveground biomass by bush fires during the dry season, so some extra effort is required to protect the field, such as installing proper fire breaks.

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<sup>2</sup>R. Myhrman, Director, World Hunger Resource Center, Judson College, Elgin, IL, USA, personal communication, 1996.

<sup>3</sup>G. Alink, Wageningen Agricultural University, 1996).