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EFFORTS TO IMPROVE THE POTENTIAL OF *MUCUNA* AS A FOOD AND FEED CROP: BACKGROUND TO THE WORKSHOP

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SUMMARY

Mucuna pruriens performs well as a green manure/cover crop (GMCC) but has been poorly adopted because it lacks – or is perceived to lack – uses as a food and feed. The latter perception has persisted despite its extensive utilization as a feed in the early 20th century and its consumption as a minor food crop in numerous countries in Africa and Asia. This paper briefly reviews research on the crop during the past 100 years and recounts the experiences of the 1980s and 1990s that inspired the current efforts to increase its utilization as a food and feed. The importance improving *Mucuna*'s potential as a food and feed was identified in a number of fora during the 1990s, including the GMCC Exploration Project of the Rockefeller Foundation. An April 2000 workshop "*Mucuna* as a Food and Feed: Current Uses and the Way Forward" led to the development of the project "Increasing *Mucuna*'s Potential as a Food and Feed" to which this workshop is marking an end.

INTRODUCTION

At least for many of us who have worked on it, *Mucuna pruriens* is an intriguing crop. It grows extremely well – like a weed - in a wide variety of conditions, often producing high biomass (up to 10-12 t DM ha^{-1}) and high seed yields like almost no other legume. It consequently performs very well as a green manure/cover crop (GMCC) but has been poorly adopted because it lacks – or is perceived to lack – uses as a food and feed. The latter perception has persisted despite its extensive utilization as a feed in the early 20th century and its consumption as a minor food crop in numerous countries in Africa and Asia.

Despite its potential, contemporary coordinated efforts to improve its utilization as a food and feed crop initiated only three years ago. These efforts emerged from research and development experiences with *Mucuna* as a GMCC in the 1980s and 1990s, while keeping in mind and actively learning from the previous, older experiences with the crop. This paper gives a brief overview of the history of *Mucuna* utilization as well as factors that drive the current research interest in increasing its food and feed utilization. The efforts of the past three years will be recounted, focusing on the activities of the project "Increasing *Mucuna*'s Potential as a Food and Feed Crop." Finally, this workshop and its objectives are described.

HISTORICAL OVERVIEW OF EFFORTS ON *MUCUNA*

Research and utilization of *Mucuna* before 1980

There are several overview articles on the history of *Mucuna*. Buckles' (1995) pioneering work has been followed by others (Carsky *et al*., 1998, 2001; Eilittä *et al*., 2002a; Eilittä and Sollenberger, 2002). Figure 1 gives a brief history on the research efforts on *Mucuna* from the year 1900 to the present time.

Mucuna's use as a food, feed and cover crop had been reported from several tropical locations prior to the 1890s, but cultivation greatly increased in the 1890s after it was introduced first to the Floridian, then to other southern USA farmers. *Mucuna* was grown for both soil fertility maintenance and feed for both monogastrics (i.e., pigs) and ruminants. The farmer utilization was accompanied by a substantial amount of research both in agronomy and in animal sciences until the 1940s-1950s, when its cultivation quickly decreased and almost completely terminated. From the USA, *Mucuna* was reintroduced to the tropics in the early part of the 20th century, and extensive cultivation (and quite a bit of research) took place in southern Africa, and in locations in Central America. Seemingly, *Mucuna*'s utilization as a minor food crop continued during the first half of the 20th century in Africa and Asia, but neither in the USA nor in Central America was it used as a food. Interestingly, however, it came to be used as a coffee substitute in Central America.

A number of factors seem to have caused a quick decline and an almost discontinuation in cultivation

and research on the crop in the 1940-1950s. Inorganic fertilizer suddenly became more affordable (decreasing the need for *Mucuna* as a cover crop), soybean cultivation increased (diminishing *Mucuna*'s importance as a feed), and the agriculture in the USA underwent a large structural change from smaller farms where crop and livestock production were integrated to extremely specialized farms focusing on either crops or livestock.

While interest in *Mucuna* declined between the 1950-1970s, a few researchers continued to investigate its properties from the perspectives of agronomy and food and feed sciences.

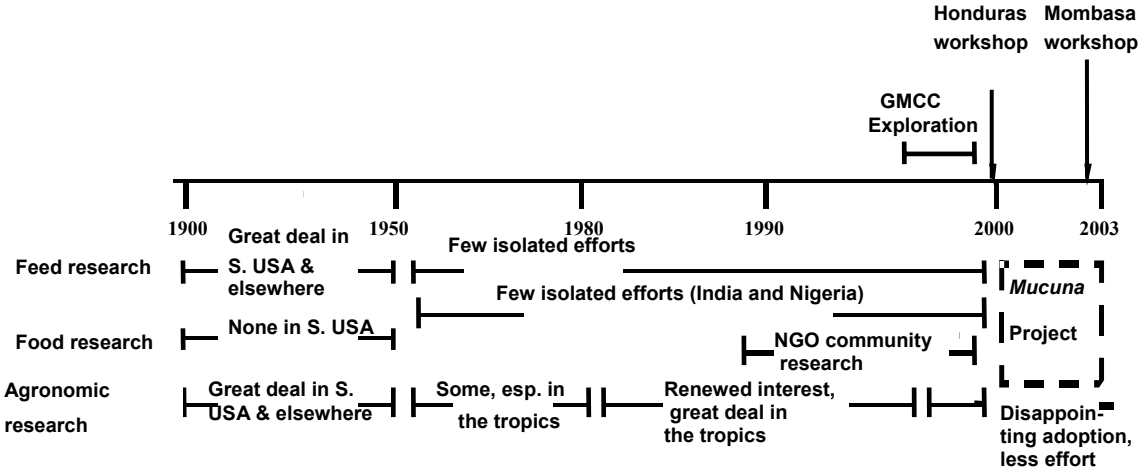

Figure 1. A rough timeline on research in *Mucuna* during the past century.

Efforts on *Mucuna* in the 1980s and 1990s

In the 1980s, there was a renewed interested in *Mucuna*. Due to the quickly decreasing soil fertility in many developing countries, research and extension efforts on GMCC were initiated. Of the GMCC for tropical regions, *Mucuna* has been the most researched (Buckles, 1995). It grows well in diverse environments, usually producing the highest biomass among green manure/cover crops tested (Lathwell, 1990; Lobo Burle *et al*., 1992; Carsky *et al*., 1998, 2001). Very positive impacts on main crop yield (Lathwell, 1990; Lobo Burle *et al*., 1992; Carsky *et al*., 1998, 2001; Buckles *et al*., 1998a, 1998b) and on weed incidence, even the most noxious ones such as *Imperata cylindrica* (Chikoye and Ekeleme, 2000; Versteeg *et al*., 1998), have been observed. Not surprisingly, high hopes for future utilization resulted from the positive research results and, in effect, *Mucuna* came to be viewed as a potential "miracle crop" to alleviate decreasing soil fertility in tropical regions. A number of organizations, both large and small, used various extension approaches to introduce the crop to smallholder farmers (Arteaga *et al*., 1997; Buckles, 1995; Versteeg and Koudokpon, 1993; Bunch, 2002). Spontaneous adoption of *Mucuna*, particularly in the Atlantic Honduras (Triomphe, 1996), seemed to further provide evidence of its high potential as a GMCC.

Farmers were initially extremely impressed by *Mucuna*'s vegetative growth and seed production, even in relatively infertile soils. In subsequent years, however, little adoption was typically seen. Many of the organizations that promoted it became disillusioned and gradually terminated their efforts.

The main reasons for the low sustained interest in *Mucuna* are its low utilization as a food and feed and, consequently, its lack of marketability for the beans (Arteaga *et al*., 1997; Carsky *et al*., 1998; Eilittä *et al*., 2003a, 2003b). Some organizations attempted to introduce it as a food crop, often after adaptive research efforts (Bunch, 2002; Price, 2002; World Neigbours *et al*., 1991; Derpsch and Florentin, 1992). Initially, limited markets were created as various organizations bought *Mucuna* seed from the farmers for further extension efforts (Douthwaite *et al*., 2002; Honlonkou *et al*., 1999; Eilittä *et al*., 2003a, 2003b). This induced quick increases in areas cultivated with *Mucuna* while the markets lasted, but its cultivation almost stopped when these temporary markets failed.

By the mid-to-late 1990s, efforts to promote *Mucuna* had mostly waned, which implied that there were insurmountable problems that prevented its utilization as a GMCC. Most organizations and institutions diverted the bulk of their efforts to other species, often grain legumes. While *Mucuna* remained on the agenda of agronomic research, it assumed a much

lesser role, and often only that of a "test species" for potential, maximum soil fertility impact.

Taking stock of experiences with green manure/ cover crops

By the late 1990s, experiences with green manure/cover crops had accumulated worldwide. Clearly, there seemed to be some potential. Green manure/cover crops seemed to be a technology well suited to the smallholder farmer in that these crops required few sources of external inputs (often only seed in the first year of use), their use reinforced synergies within mixed cropping systems – such as intercropping – and, importantly, they addressed the problem of declining soil fertility that is quickly worsening in many smallholder farms. While diverse experiences were available, little exchange of experiences and synthesis of information had been done.

Increasing experience led to attempts to synthesize information with a view to improving future research and development efforts. Regional syntheses were undertaken in West Africa, where a workshop was held (Buckles *et al*., 1998a), in Mexico, where an inter-institutional assessment of these crops' potential was conducted (Arteaga *et al*., 1997), and – in the form of overview articles – in Central America (Flores *et al*., 1997) and southern Brazil (do Prado Wildner *et al*., 2003). A global workshop was also held in Santa Catarina, Brazil, in April 1997.

Another global effort was the Green Manure/Cover Crop Exploration Project of the Rockefeller Foundation-Mexico (1998-1999), a direct precedent to the work described here. This project, bringing together both researchers and development specialists, documented and synthesized experiences of tropical and subtropical smallholder farmers with GMCC systems (Eilittä *et al*., 2003c). Across the diverse regions, it became clear to the GMCC Exploration that lack of multiple uses was one of the most important bottlenecks to the adoption of GMCC. Improved utilization as a food and feed became particularly important in conditions of extreme poverty and land scarcity. This important issue had also been identified in the other fora described above.

The GMCC Exploration project recognized *Mucuna*'s potential and the investments of effort and funds that had been directed towards it. Given the good knowledge base in agronomy of *Mucuna*, it was judged that relatively small funds could lead to large payoffs if they were directed solely to the primary problem in its adoption: limited use as a food and feed. As a first step, the GMCC Exploration proposed that a workshop on *Mucuna*'s multiple uses should be held.

April 2000 workshop in Honduras

This interdisciplinary, small workshop held in April 22-26, 2000, in Tegucigalpa, Honduras brought together scientists with field-level development experience on *Mucuna* with a group of others from diverse disciplines, ranging from toxicology, industrial processing, and plant breeding to food and animal sciences (Flores *et al*., 2002). The workshop was organized by three institutions that had, over the years, worked greatly with *Mucuna*: International Center for Information on Cover Crops (CIDICCO; based in Tegucigalpa, Honduras), Clearinghouse for Cover Crops Information and Seed Exchange in Africa (CIEPCA; at IITA, the International Institute of Tropical Agriculture, Cotonou, Benin), and Judson College (Illinois, USA).

Three types of preliminary efforts were done prior to the workshop:

1. A thorough review of available literature was conducted to take stock of the state of knowledge (Eilittä *et al*., 2002a). This review spanned the time period from late 19th century to today as well as the fields from medicine and toxicology to animal and food sciences and anthropology.

2. Disciplines that had not been involved with research on *Mucuna* as a food and feed crop to date but whose contribution seemed crucial to resolving bottlenecks associated with its use were identified, and individuals from these fields were asked to prepare papers on how their disciplinary perspective could address the problem of *Mucuna*'s limited multiple uses (Temple and Huyck, 2002; Balaban and Teixeira, 2002; Szabo and Tebbett, 2002).

3. A detailed review of historical experience with *Mucuna* in the early 20th century USA and elsewhere was also initiated (Eilittä and Sollenberger, 2002). In fact, a great deal of both journal articles, book chapters, and extension leaflets are available on *Mucuna*'s use as a feed from this time period. This review highlighted experiences in the three states in southern USA where its adoption was greatest: Georgia, Alabama, and Florida.

The reviews identified limited knowledge of harmful compounds in *Mucuna* as an important bottleneck. Three categories of compounds are found in *Mucuna*:

- A well-known, unusual anti-nutritional factor (i.e., L-dopa).

- Common anti-nutritional factors in beans on which relatively much information is available for *Mucuna* (e.g., trypsin, lectins).

- Little known, unusual anti-nutritional factors (e.g., serotonin, bufotenin).

It was also clear that relatively little was known regarding the impact of processing on harmful compounds.

The workshop both assessed the state of knowledge on *Mucuna* in a detailed way and brought it forward on a number of fronts. The following is a brief overview of the discussions and findings of the workshop.

- At field level, farmer enthusiasm generated by *Mucuna*'s good yield was confirmed by a number of participants, who also discussed its traditional utilization as a food crop in various countries (Gilbert, 2002; Diallo *et al*., 2002; Price, 2002; Ukachukwu *et al*., 2002).

- A detailed review of the nutritional value of *Mucuna* beans revealed its high potential: its protein content, amino acid profile, and content of common anti-nutritional factors resemble those of common food legumes, posing no obstacles to its future development (Bressani, 2002).

- Although a number of toxic alkaloids have been identified in the beans, they seem to be present in sufficiently low quantities so as not to prevent its use as a food and feed crop. However, no exact quantification of these compounds had been done and this was identified as a crucial research issue (Szabo and Tebbett, 2002).

- A basic understanding of the ways to effectively extract L-Dopa from *Mucuna* had been developed, which was mainly due to the long-standing efforts of Judson College (Myhrman, 2002). However, further work was proposed to clarify the principles behind various methods of extraction of L-dopa in the *Mucuna* beans (Balaban and Teixeira, 2002).

- *Mucuna* has shown promise as a feed crop for ruminants, both in recent, albeit scarce, research projects (Burgos *et al*., 2002) and in its historic utilization (Maasdorp *et al*., 2002; Eilittä and Sollenberger, 2002).

- As a feed for non-ruminants, *Mucuna* is far less suitable (Del Carmen *et al*., 2002; Carew *et al*., 2002; Flores *et al*., 2002), although at low levels, it can be incorporated in poultry feeds (Del Carmen *et al*., 2002).

- A limited number of studies indicate that both genetic and environmental factors may control L-Dopa production (Lorenzetti *et al*., 1998; St-Laurent *et al*., 2002); however, information available on the topic is insufficient. Any future genetic improvement program in *Mucuna* should take into consideration also ecological factors which are likely to affect its performance in a cropping system (St-Laurent *et al*., 2002; Temple and Huyck, 2002).

After the workshop, a research agenda was developed and a project proposal was submitted for funding by CIEPCA-IITA to the Rockefeller Foundation. This research project constituted the second step in the efforts to improve *Mucuna*'s utilization as a food and feed.

"INCREASING *MUCUNA*'S POTENTIAL AS A FOOD AND FEED CROP"

In November 2000, the Rockefeller Foundation awarded a grant for CIEPCA-IITA to lead a collaborative research effort – Increasing *Mucuna*'s Potential as a Food and Feed Crop" -aimed at resolving some important bottlenecks associated with the utilization of *Mucuna* as a feed and food crop.[1]

The project was inter-institutional, involving 18 activities conducted by researchers working in Africa (Benin, Nigeria, Malawi, Kenya, Zimbabwe), India, and the Americas (Guatemala, Honduras, USA, and Columbia). The project investigators were based in diverse institutions, i.e., national universities and research systems, NGOs, and international institutions.

Research activities and outputs

Most of investigators initiated their projects by January-March 2001 and finalized their work by March 2002. Five major issues, originally identified in the workshop, were the outputs of the research project:

- Processing Methods for Food and Feed from *Mucuna* Beans
- Characterization and Improvement of *Mucuna* Germplasm
- The Use of *Mucuna* in Diets for Non-Ruminants
- The Use of *Mucuna* in the Diets for Ruminants

[1] This was later supplemented with an additional grant to conduct a second year of a genotype by environment trial on *Mucuna*'s L-dopa production.

- Impact of *Mucuna*'s Secondary Compounds on Human Health

In each output, there were two to four activities (Table 1). Most activities were individual, but a collaborative project, the genotype-by-environment trial, was undertaken by five (2000-2001) to nine (2001-2002) researchers involved in the project.

Approach and mode of work

The project attempted to create mechanisms that would increase the payoffs from the research activities through constant exchange of information and through help given by the coordinators. For example, an informal bulletin, *Mucuna News*, was initiated to share information on progress of research projects, new publications, and analytical methods. Throughout the course of the project, there was a good deal of communication among the researchers, partly to attempt to resolve certain bottlenecks in research on *Mucuna*, such as methods of L-Dopa analysis, and partly to comment on research proposals or to discuss emerging results. Finally, the coordinators provided research direction and attempted to assist the researchers with various problems they faced in their work.

The project consciously continued to reach out to become a "project on *Mucuna*" rather than "The *Mucuna* Project."[2] Involvement of all those working on *Mucuna* – whether within or outside of the project -- was encouraged. Consequently, *Mucuna News* had a wide recipient list, from development workers to researchers, both within and outside of the project.

Most workshop activities were terminated in the first months of the year 2002. It became clear that a second workshop would be required to review the progress of the previous two years. This workshop, the focus of these proceedings, constituted the third step in the efforts to improve *Mucuna*'s utilization as a food and feed.

MOMBASA WORKSHOP, SEPTEMBER 2002

This workshop, held in Mombasa, Kenya, September 23-26, 2002, marked the end of the project discussed above. It was hosted by the Legume Research Network Project of the Kenya Agricultural Research Institute (KARI) and organized by KARI and CIEPCA, with funding from the Rockefeller Foundation and Sasakawa-Global 2000. It brought together researchers and development workers to present their work and to discuss the implications of their work for future efforts. A number of researchers outside the project were invited to participate to ensure that progress on *Mucuna* research would be reviewed more generally, not just within the project. Altogether, 35 individuals participated, and 31 papers were presented.

The workshop had ambitious objectives that ranged from development to research to evaluating and assessing effective mechanisms for work. Regarding an agenda for future research and development work, the specific objectives of the workshop included:

- To conduct a general review of the findings of the project activities and other relevant recent research and development projects:
    - New knowledge generated
    - Implications of such knowledge for future development efforts.

- To define the most promising development options for *Mucuna*'s food and/or feed utilization and determine where those options may be suitable.

- To define the least promising lines of work which should not be pursued.

Regarding mechanisms for future work, the specific objectives were:

- To evaluate the need for further research on food and feed utilization of *Mucuna*, and to develop a well-defined research agenda.

- To consider potential arrangements for future efforts on *Mucuna*'s food and feed utilization.

- To discuss and evaluate the process of the *Mucuna* project as a mechanism for conducting research.

- To identify and resolve particular obstacles to more effective research on *Mucuna* as a food and feed crop, particularly in a developing country context.

This volume of "Tropical and Subtropical Agroecosystems" includes the papers presented in the Mombasa workshop. As mentioned, most of the papers describe research results conducted within the project "Increasing Mucuna's Potential as a Food and Feed Crop," but a number of projects have been done independently by individuals who became known to the project.

[2] Researchers participating in or collaborating with the project often referred to the group as "*Mucuna* community." And by the time they met at Mombasa they were calling themselves the "*Mucuna* family."

Table 1. Outputs and activities of the project "Increasing *Mucuna*'s Potential as a Food and Feed Crop."

Output	Activity
I. Processing Methods for Food and Feed from *Mucuna* Beans	1. Solvent Extraction Studies For Removing L-Dopa From *Mucuna* Bean
	2. Worldwide Survey of Ways to Utilize *Mucuna*
	3. Protein Quality and Residual L-dopa and Trypsin Inhibitor Activity in *Mucuna* Beans Processed by Atmospheric and Pressure Cooking, Germination and Fermentation
	4. Seed Characteristics, and Nutrient and Antinutrient Composition of 12 *Mucuna* Accessions from Nigeria
	5. Evaluation of Processing Methods of *Mucuna* for food to enhance its adoption for soil fertility improvement in Kenya
	6. Processing of Velvet Bean (*Mucuna pruriens* var. utilis) by Fermentation
II. Characterization and Improvement of *Mucuna* Germplasm	1. Trial to Assess the Contribution of Environment and Genotype on *Mucuna*'s L-dopa Production
	2. Assessment of Genetic Diversity and Initial Genetic Map for *Mucuna* sp.
	3. *Mucuna pruriens* var. utilis Germplasm Seed Material Collection and Screening for Antinutrients in Kerala and Tamil Nadu, South India
	4. A Meeting to Conduct a Field-level Assessment of *Mucuna* Accessions Grown During 2000 in Alabama
III. The Use of *Mucuna* in Diets for Non-Ruminants (Chickens)	1. Effect of Processing, Additives, and Vitamin B6 Supplementation of *Mucuna cochinchinensis* on Broilers
	2. The Effects of Heated Velvet Beans (*Mucuna pruriens*) on Blood Chemistry and Organ Size in Growing Chickens
	3. Studies of the Effect of Heated, Water Extracted and Extruded Velvet Beans (*Mucuna pruriens*) and of Methionine and Lysine Supplementation in Diets for Broilers
IV. The Use of *Mucuna* in the Diets for Ruminants (Goats and Sheep)	1. Impact of *Mucuna pruriens* Seed on the Growth of West African Dwarf Goats in Southern Republic of Benin
	2. Nutritive Evaluation of Velvet Beans as Feed Ingredient for Small Ruminants in Zimbabwe
	3. The Effect of L-Dopa in Velvet Bean Forage on the Performance of Lactating Cows
V. Impact of *Mucuna*'s Secondary Compounds on Human Health	1. Assessment of the Levels of Alkaloids in Different Parts of *Mucuna* Plant
	2. Mutagenic Characterization of *Mucuna*

As is evident in the pages ahead, the workshop made good progress towards achieving these objectives. A wide range of research results were presented and assessed for both their development and research significance. Promising lines of future work were identified in the papers presented and in the discussions and working group presentations, which are reflected in the final chapter of this volume.

The enthusiasm for the potential of *Mucuna* was evident in the workshop discussions and deliberations. In fact, the participants are determined to continue working together on the theme, and efforts are underway to explore funding and mechanisms for such work. The exact nature of the next stage in the efforts on *Mucuna* is still unclear, but it is evident that such efforts can already involve both development and research aspects.

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