On-Farm Storages Participatory Evaluation and Validation of the Capability of Native Botanicals for Control of Bean Bruchids (*Acanthoscelides Obtectus* L., Coleoptera: Bruchidae) in South-Kivu Province, Eastern of Democratic Republic of Congo

T.M.B. Munyuli[1*]

Keywords: Bean bruchids management approaches- Botanicals- Participative approach- Farmers' storages- Technology dissemination & adoption- Democratic Republic of Congo

Summary

On-farm storages bean bruchids control experiments were conducted from March to August 2003 in Eastern DR Congo. Two farmers' associations were involved in the work. The effectiveness of two different approaches of bruchids management was evaluated. These two approaches were: farmers' practices and the improved approaches. Farmers' approach involve mixing plants leaves from 2 to 12 botanicals and forming layers that therefore were admixed to beans in sacks before storage. Plant leaves are applied by farmers at variable rates: 750 g to 1500 g/ 5 kg of bean grains to conserve. The improved approach involves mixing powders from several botanicals. Different doses were tested along aside the farmers' dosages: 0,100, 200 g of powders / 5 kg of bean seeds. Plant materials were admixed to bean varieties (Kirundo, Ishikazi, Lwera, Haricot soja and VCB), and thereafter stored in farmers' stores. Bean seeds were infested with bruchids before storage in farmer' stores. Members of the two associations were involved, as well as extension staff and village chiefs. Experimental designs were set up in partnership with farmers association members. The storage period was of 6 months. The farmers, who accepted to cooperate in the experiments by offering their stores for the study, were also involved in monitoring of the trials. Overall, powders bean-treated were less damaged. Results show that addition of 200 g per 5 kg of bean seeds significantly reduced infestation and losses by bruchids in farmers' storages. The number of emerged bruchids, the percentage of weight loss and the percentage of seeds damaged were of 32-122 against 126-2920 (control), 1.3-8.6% against 23.4-71.08% (control), and 1.8-29.8% against 19.9-89.9% (control) respectively. Plant powders were rated by farmers as first compared to the plant leaves in the management of bean bruchids. Additional research is required to determine the environmental and human health implications of these powders. The replication of the trials at low rate of applications of the different doses, would be interesting to investigate, since the current effective dose seems to be high and not economic or rational.

Résumé

Evaluation et validation participatives de l'efficacité d'un mélange de poudres végétales dans la lutte contre les bruches du haricot (*Acanthoscelides obtectus* L., Coleoptera: Bruchidae) dans les greniers paysans, Sud-Kivu, République Démocratique du Congo

Des essais de lutte contre les bruches du haricot en greniers ou stocks paysans ont été conduits de mars à août 2003 à l'Est de la République Démocratique du Congo. Deux associations paysannes ont participé aux essais. Deux approches de lutte contre les bruches ont été évaluées en milieu paysan: l'approche paysanne et l'approche améliorée. Dans l'approche paysanne, les feuilles fraîches de 2 à 12 plantes aux propriétés insecticides/insectifuges sont mélangées aux graines de haricot conservées dans des sacs traditionnels. Les doses croissantes de 750 g à 1500 g/ 5 kg de graines de haricot ont été appliquées lors de la conservation. Dans l'approche améliorée («l'approche scientifique»), il y a mélange des poudres végétales aux doses croissantes de 0, 100, 200 g de poudre/5 kg de graines de haricot. Les matériels végétaux (feuilles fraîches et poudres végétales) ont été mélangés lors de la conservation aux variétés de haricot suivantes: Kirundo, Ishikazi, Lwera, Haricot Soja et VCB. Les mélanges poudres végétales/ feuilles fraîches et graines de haricot ont été stockés en greniers paysans pour une période de 6 mois. Les graines de haricot étaient infestées par les bruches de haricot avant le stockage en greniers paysans. Les membres de deux associations ont offert les lieux de stockage. Les paysans chez qui les essais étaient réalisés avaient pris la responsabilité de prendre soins des essais. Des résultats de l'essai, il a été constaté que la dose de 200 g de poudre par 5 kg de graines réduisait significativement la prolifération des bruches. A cette dose, le nombre des graines trouées était très réduit. Les pertes de poids de graines en stocks étaient donc minimisées. En effet, le nombre des bruches ayant émergé, la perte de poids de graines de

[*1]Laboratory of entomology, Agricultural & Biological Research Department, National Centre for Research in Natural Sciences, CRSN-Lwiro, D.S. Bukavu, Kivu, DR Congo, Mobile: +243990572922; Email: tmunyuli@yahoo.com
Received on 02.05.06 and accepted for publication on 08.09.09.

haricot et le pourcentage des graines trouées étaient respectivement de 32-122 contre 126-2920 (témoin); 1,3-8,8% contre 23,4-71,08% (témoin) et de 1,8-29,8% contre 19,9-89,9% (témoin). Les poudres végétales étaient plus appréciées par les paysans par rapport aux feuilles des plantes. Dans le futur, d'autres essais sont nécessaires afin d'évaluer le risque pour la santé humaine lié à la manipulation des poudres végétales aux doses efficaces lors de la lutte contre les bruches. La répétition des essais avec des doses plus faibles serait intéressante à réaliser puisque la dose efficace apparaît trop élevée pour être économique ou rationnelle.

Introduction

In the Democratic Republic of Congo as in other countries of Eastern, Central and Southern Africa, bean (*Phaseolus vulgaris* L.) is an important food and cash crop and the most important food legume (6, 12, 13). In these Sub-Sahara African countries, beans cover more than 22% and 10% of communities' daily needs of proteins and energy respectively (6, 7). In eastern of DRC (Kivu provinces particularly), beans are a primary source of vegetable protein and an essential supplement to roots and tuber-based diets (7, 10). Beans are mostly grown by 90% of smallholder farmers in Kivu provinces. Yields vary considerably in different agro-ecological zones of the provinces: from 500 to 4000 kg/ha. Farmers grow both bush and climbing beans as sole or in intercropping with sorghum, maize, bananas and cassava. Climbing beans are more present in high altitude than in low and medium altitude areas (5, 6, 8, 10). It is a common practice in that region to conserve bean grains after harvesting, waiting for moments of good prices at local and regional markets. Therefore, beans are stored for a period of three to nine months in traditional stores.

However, bean storage over long periods, especially at small-scale subsistence farming levels in Kivu (D. R. Congo), is limited due to bruchid infestation that results in heavy losses about 35-95% (6, 8, 10). To avoid excessive losses, most farmers are forced to sell off surplus grain immediately after harvest, and this; unfortunately, often coincides with the time when prices are lowest. This scenario reduces motivation to increase production as well as to store for longer periods and hence contributes to develop the vicious cycle of low dietary intake of cheap proteins of high biological value.

Conditions are usually inadequate at farmer level to prevent or reduce insect attacks during storages. In earlier works, bean bruchids (*Acanthosclelides obtectus*, Coleoptera: Bruchidae) were identified as main pest of beans in storage (9). Generally, in Kivu provinces, bruchid infestations start in field and continue in storage (Munyuli, personal observation). There is still a paucity of information on appropriate field and storage management methods of bruchids at small-scale farmers' level in eastern and central Africa.
Available bruchids management methods in storages include use of vegetable oil, hermetic storage, solarisation, sunning, sieving regimes and contact insecticides and fumigants.

Across Sub-Sahara Africa bean growing regions, there are increasing efforts to develop cheaper and sustainable insecticide-based local techniques for protecting seeds in small traditional farm stores (Dr K. Ampofo, personal communication). Some of these methods (sunning, ash,…) were evaluated by scientists for their effectiveness in controlling bean bruchids (17, 21). The use of plant products is popular in Kivu provinces. Small-scale farmers in Kivu usually mix stored foodstuffs with different kinds of plant products to protect them against bruchid damages.

A modest survey of ethnobotanical materials used traditionally for stored products protection in Kivu, was conducted by Munyuli (9), with the objective of evaluating their active constituents.
A checklist of botanicals used by farmers for the control of bean bruchids was thereafter established (9, 10). The performance of effective botanicals was also earlier tested in the laboratory (10). Findings from these laboratory trials showed that the mixture of several (around 12) botanicals (insecticide and repellents plant species) during the formulation of doses is effective rather than using powders from one or three plant species (11). The repellency of that powder can be maintained in stores for more than 6 months unlikely for powder from a single plant species. The performance of a single plant species do not go over than 3 months in store: generally, bruchid attacks are observed from the first month of storage. Farmers in Kivu provinces are mostly interested in storing their beans as seeds in order to meet needs and wants of seeds in further cropping campaigns. During cropping campaigns, there is a growing willingness of all bean producers to buy seeds of good quality from their neighbors. Farmers are also interested in delaying sales, waiting for the improvement of the market (8). To be efficient, these activities require that bean be stored for at least 6 months. The mixture of several plant species during powders manufacturing, appears meeting farmers' needs.

There was a need to validate and disseminate promising technologies under farmer field and storage

conditions for the benefit of smallholders who store beans to improve their income.

Before recommending effective doses (mixture of several plant powders) for a large use by farmers, with high expectation of adoption, it was judged necessary to evaluate them with participation of strong and influent farmers' groups. The participatory research approach in the technology evaluation involved also village leaderships.

Therefore, the present research work was designed to investigate with farmers' participation, the potential of powders made from mixture of several plant species, as protectants, antifeedants and repellents against bean bruchids in farmers' stores.

In this study, an attempt was made to evaluate two different pest management approaches proven effective in reducing damage by bruchids during earlier laboratory studies and from farmers' reports. The study focused on determining efficacies of selected doses against bruchids assuming that plant based insecticides can be an alternative method to the heavy use of classical insecticides, and that they can increase the biodegradability of insecticide treatment and develop a better respect for the environment (14, 20).

Material and methods

Study area

The study was carried out in one of the main bean growing areas of Kivu provinces (28-29° E, 11-12° S) from March to August 2003. The climate of Kivu area is tropical humid, type AW3 (3). This climate has 2 main seasons: the rainy season (September- May) followed by the dry season (July-August). The rainfall pattern is bimodal, and receives an annual average rainfall, which varies between 1500 and 2100 mm with average temperatures of 19° C and a relative humidity of 76% (3). The tropical humid climate of the study area is temperate owing to its high altitude which varies between 800 and 3200 m. Subalpine meadow cover all the region and an abundant vegetation grows on the volcanic and ferrisols (3).

Selection of farmers' associations

We used lists of farmers' groups available in the study area. The lists were obtained from the UPDEBU ("Union pour la promotion et le développementt du Bushi). Farmers' associations to work with were selected on criteria of having long experience in the management of bean bruchids using natural products including plants. Selection of farmers' associations was also based on the ability to take care of scientific trials, willingness to work in partnership with research and extension staffs from planning, implementation and evaluation of the activities. Farmers' experience on the matter was appreciated through a fair organized in conjunction with the national agricultural advisory service. During the fair, five farmers' associations presented their best technologies and were thereafter selected. These included: ADEA-CIRHEJA (Action pour le développement de l'élevage et l'agriculture), COLUMAPHAR (Comite de lutte contre les Maladies par la Pharmacopée), BUNYIBUNYI (Association des mamans de Kadjucu), JAK (Jeunesse Agricole de Katana), BRAK (Brigade Agricole de Katana). Two (ADEA and JAK) of those retained during the fair were randomly selected.

Two days were spent with members of each of the two groups. During the meeting, agreements for collaboration were discussed and determined.

Management and evaluation of the storage experiments

In partnership with ADEA and JAK farmers' associations, two bruchids management methods were evaluated using a randomized complete block design of five replicates (five replicates per treatment). The two methods tested were: farmers' method and the "scientific method" or improved approach.

Farmers' method is the method used by many farmers including members of JAK and ADEA. It consists of admixing bean grains during the storage with a mixture of fresh plant leaves/parts from 2 to 8 plant species. During storage, in traditional baskets or sacks, beans are stored between several layers made from these fresh plant leaves. The number of botanicals to use varies from an area to another and from a season to another, depending on their availability in the nature. Several plant leaves and fruits are mixed but often *Cuppressus lusitanica* L. (Cuppressaceae), *Eucalyptus sp* (Myrtaceae), *Tetradenia riparia* L. (Lamiaceae), *Maesa lanceolata* Forsk. (Myrsinaceae), *Nicotiana tabacum* L. (Solanaceae), *Chincona ledgeriana* L. (Rubiaceae), *Tephrosia vogelii* Hook. (Fabaceae), *Capsicum fruitensis* L. (Solanaceae), *Vernonia amygdalina* Del. (Asteraceae), *Tithonia diversifolia* L. (Asteraceae), *Momordica foetida* L. (Cucurbitaceae) and *Ricinus communis* L. (Euphorbiaceae). Before forming layers, plant materials are collected separately from each plant species and then mixed later. A sack of 100 kg is therefore filled with around five layers. The quantity (dose) of fresh leaves per layer varies from a farmer to another one. In addition to that, there is a paucity of information in the plant materials combination to formulate effective and economic dose.

During the trial, the following doses were tested: 0.75 kg and 1.5 kg of mixed fresh leaves from the above 12 plant species per 5 kg of bean grains. The "scientific method" is an improved version of the farmers' one. This technology was developed and evaluated under

laboratory conditions. It consists of mixing powders of repellent and insecticide plants. Plants are chosen among those used regularly by farmers. Plants considered as effective by farmers are collected from the nature, dried and powdered separately. Powders from different plant species are mixed at equal proportion (10) during the formulation of the doses. Under laboratory conditions, 20-40 g plant powders/ kg of bean seeds was found to be effective doses (8, 10). In this experiment, 3 doses were evaluated alongside farmers' ones: 0, 0.1, 0.2 kg powders / 5 kg of bean seeds.

The trial was conceived and set up in collaboration with members of the two farmers' groups. With ADEA, two bean varieties were used: Majambere (*VCB*) and Katabonimbwa (*Kirundo*). In partnership with JAK, five popular and marketable bean varieties were used: M'Lwera (*Mafutala*), *Kirundo*, Haricot Soja (*G2333*), *Ishikazi* (local variety) and *Namakala*.
Five to ten kg of bean seeds was admixed with fresh leaves or with plant powders. The products (beans + plant materials) were stored in sacks (common storage envelops) and kept in storerooms of the farmers' associations. These sacks were kept in a dry, cool and lighted place. Sacks used were bought by farmers. Before storing, bean seeds bought from farmers, were put in a fridge (refrigerator at 4 °C) for 4 days to minimize late infestation dues to young stages of bruchids from the fields.

Members of the two associations were required to take care of trials and protecting them against any disturbance from children, rats…

Bruchids (*Acathoscelides obtectus* L.) were artificially released in all the treatments at the rate of 20 (for JAK) and 50 (ADEA) unsexed adult bruchids. At each association, the rate of bruchids infestation depended on their availability in the area. The storage period was of 6 months, and immediately after that time, the experiments were evaluated.

At the evaluation, extension staff, village chiefs as well as the association members (men and women) were invited. Farmers were requested to give own opinion or perception on the performance of each method or dose in conserving/protecting bean seeds against bruchid attacks during 6 months of storage.

During the evaluation, three parameters were appreciated: the number of emerged bruchids, the percentage of seeds damaged and the percentage of weight loss.
Weight loss was evaluated using Shulten (1, 4, 19) equation, as follows:

% Weight loss (Y):

$$Y = \frac{(Wu.Nd)-(Wd.Nu)}{Wu\,(Nd+Nu)}$$

Where:

Wu= weight of undamaged seeds;
Wd= weight of damaged seeds (perforated grains);
Nu= number of undamaged seeds;
Nd= number of damaged seeds.

Data analysis
All data were subjected to analysis of variance (ANOVA), after checking the validity of the assumptions underlying this test. For skewed data distribution, raw data were transformed and adjusted to approximate the normal distribution. Percentage of seeds damaged and percentage of weight loss data were subjected to arcsin√x transformation. The number of emerged bean bruchids data was also subjected to natural logarithmic [Xt= ln(x + 1)]. Where the F-statistics indicated significant effects, means were separated using Fisher's protected least significant difference (LSD) test at 5% probability level. All analyses were conducted with the Genstat computer package programme (Genstat 5 release 3.2 PC/Windows 95).

Results

For both ADEA and JAK associations, ANOVA revealed significant ($P< 0.05$) effects for bruchids management practices (methods), doses and bean varieties used. However, regarding the percentage of weight loss, with JAK farmers' association, ANOVA did not reveal significant ($P> 0.005$) effects of treatments (doses, methods).

The proliferation of bruchids in farmers' stores was significantly influenced by the management practices applied. The "scientific method' was effective in controlling bean bruchids at the rate of 0.2 kg powders/5 kg of bean seeds. In fact, with the improved method, the population of emerged bruchids, was of 122-106 (dose 3), (Table 1) and 10-32 (dose 3), (Table 4) against 746-2920 (control), (Table 1) and 126-438 (control), (Table 4), for ADEA and JAK associations respectively.
With the "scientific method", the dose of 0.2 kg powders/5 kg of bean seeds significantly ($P< 0.05$) reduced bruchids attacks and weight losses in farmers' stores. At that dose, the percentage of weight loss was of 0.19-3.54 % (Table 2), 1.3-8.6% (Table 5) against 23.4-71.08% (control), (Table 2) and 27.6-58% (control), (Table 5). The percentage of seeds damaged (perforated) by bruchids was of 1-1.8 (Table 3) and

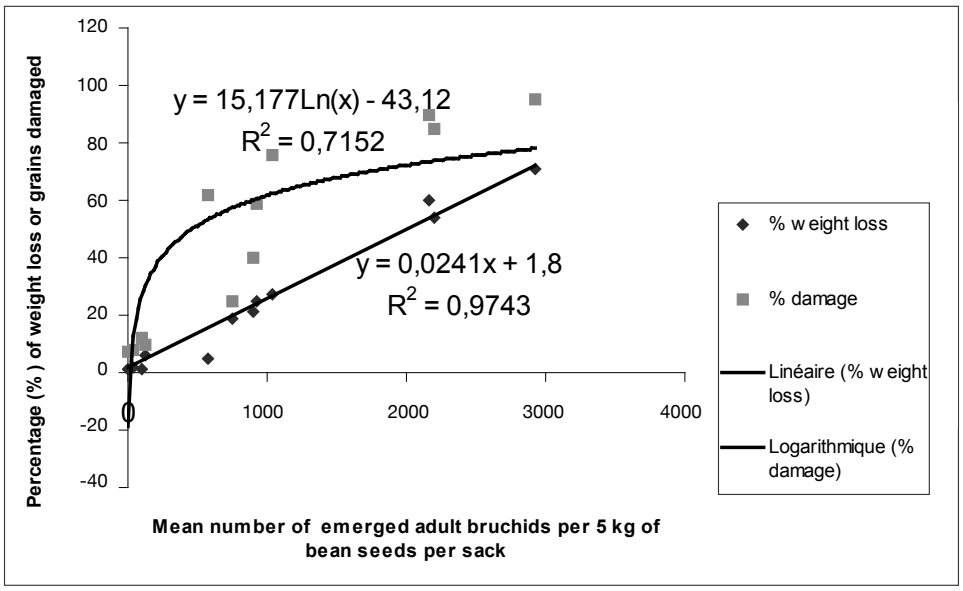

Figure 1: Relationship between the emergence of bean bruchids, damage level of bean grains and losses in farmers' storages, in Kivu, DRCongo March-August 2003.

Table 1
Effect of different methods of protecting bean grains with plant materials, in farmers' storages, on the mean number of emerged bean bruchids *(Acanthoscelides obtectus* L*.)* in Kivu, D R Congo (March- August, 2003)
A: ADEA farmers 'association

Methods of bean bruchids management	Doses tested	Bean varieties		Mean
		VCB	Kirundo	
Farmers' method (mixture of plant leaves from 3 to 8 botanicals): kg of fresh leaves / 5 kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	2160.0 b	900.00 a	1530.0
	Dose 2 (0.75 kg/5 kg beangrains)	2200.0 b	1040.0 a	1620.0
	Dose 3 (1.5 kg/5 kg bean grains)	9280.0 c	570.00 b	4925.0
"Scientific method" or improved method (mixture of plant powders from 12 botanical species): kg of powders / 5 kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	2920.0 a	746.00 a	1833.0
	Dose 2 (0.1 kg/5 kg bean grains)	106.00 d	122.00 c	114.00
	Dose 3 (0.2 kg/ 5 kg bean grains)	5.000 d	37.000 c	21.000
	Mean	1387	569	
	CV (%)	28.1	22.1	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%)= coefficient of variation (%).

Table 2
Effect of different methods of protecting bean grains with plant materials, in farmers' storages, on percentage of weight loss of bean seeds in farmers ' storages, in Kivu, D R Congo (March- August, 2003)
A: ADEA farmers ' association

Methods of bean bruchids management	Doses tested	Bean varieties		Mean
		VCB	Kirundo	
Farmers' method (mixture of plant leaves from 3 to 8 botanicals): kg of fresh leaves / 5 kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	69.340 a	39.40 a	54.37
	Dose 2(0.75 kg/5 kg bean grains)	59.200 b	36.10 a	47.65
	Dose 3 (1.5 kg/5 kg bean grains)	38.200 c	16.28 b	27.24
"Scientific method" or improved method (mixture of plant powders from 12 botanical species): kg of powders / 5 kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	71.080 a	23.40 b	47.24
	Dose 2 (0.1 kg/5 kg bean grains)	9.060 d	5.840 c	7.450
	Dose 3 (0.2 kg/ 5 kg bean grains)	0.190 e	3.540 c	1.865
	Mean	41.18	20.76	
	CV (%)	18.6	19.2	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%)= coefficient of variation (%).

4.42-29.8% (Table 6) against 19.9-89.9% (control), (Table 3) and 57.4-66.20 % (control), (Table 6) for ADEA and JAK associations respectively.

There was a strong correlation between the emergence of bruchids and the percentage of weight loss (Figure 1).

Table 3
Effect of various practices of protecting bean grains with plant materials, in farmers' storages, on percentage of damaged (perforated) bean seeds by bruchids, in Kivu, D R Congo (March- August, 2003)
A: ADEA farmers 'association

Bruchids management practices	Doses tested	Bean varieties		Mean
		VCB	Kirundo	
Farmers'practices (mixture of plant leaves from 3 to 8 botanicals): kg of fresh leaves / 5 kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	85.2 a	36.2 b	60.7
	Dose 2 (0.75 kg/5 kg bean grains)	42.8 b	72.4 b	57.6
	Dose 3 (1.5 kg/5 kg bean grains)	53.4 b	40.4 b	46.9
Improved practices (mixture of plant powders from 12 botanical species): kg of powders / 5 kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	89.9 a	19.9 c	54.9
	Dose 2 (0.1 kg/5 kg bean grains)	6.80 c	5.20 d	6.00
	Dose 3 (0.2 kg/ 5 kg bean grains)	1.00 c	1.80 d	1.40
	Mean	46.5	29.3	
	CV (%)	23.5	22.5	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%)= coefficient of variation (%).

Table 4
Effect of various management practices of bean bruchids with plant materials, in farmers' storages, on the mean number of emerged bean bruchids *(Acanthoscelides obtectus* L*.)*, in Kivu, D R Congo (March- August, 2003)
B: JAK farmers 'association

Bruchids management practices	Doses tested	Bean varieties					Mean
		M'Mafutala (M'Lwera)	Kirundo	Ishikazi	Haricot Soja	Namakala	
Farmers'practices (mixture of plant leaves from 3 to 8 botanicals): kg of fresh leaves / 5 kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	139.4 0b	200.0 c	256.0 a	134.80 b	233.00 a	192.64
	Dose 2 (0.75 kg/5 kg bean grains)	181.40 a	434.0 a	200.0 b	101.00 b	216.00 a	353.28
	Dose 3 (1.5 kg/5 kg bean grains)	104.00 b	160.0 d	180.0 b	47.200 c	105.00 b	119.24
Improved practices (mixture of plant powders from 12 botanical species): kg of powders / 5 kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	126.00 b	298.0 b	158.0 b	438 .00 a	106.40 b	250.48
	Dose 2 (0.1 kg/5 kg bean grains)	91.00 b	150.0 d	149.0bc	35.000 c	101.00 b	105.20
	Dose 3 (0.2 kg/ 5 kg bean grains)	30.600 c	102.0 e	10.40 d	32.800 c	27.400 c	40.640
	Mean	112.1	224.0	159.4	131.50	131.4	
	CV (%)	19.1	18.0	18.7	17.8	19.4	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%)= coefficient of variation (%).

Table 5
Effects of various management practices of bean bruchids with plant materials, in farmers' storages, on the percentage of weight loss of bean grains, in Kivu, D R Congo (March- August, 2003)

B : JAK farmers 'association

Bruchids management practices	Doses tested	Bean varieties					Mean
		M'Mafutala (M'Lwera)	Kirundo	Ishikazi	Haricot Soja	Namakala	
Farmers' practices (mixture of plant leaves from 3 to 8 botanicals): Kg of fresh leaves / 5 kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	59.60 a	39.40 a	22.80 a	47.000 a	28.600 a	39.48
	Dose 2 (0.75 kg/5 kg bean grains)	51.40 a	23.40 a	29.00 a	25.200 b	19.000 a	29.60
	Dose 3 (1.5 kg/5 kg bean grains)	31.00 a	20.40 a	16.00 a	16.600 b	18.400 a	20.48
Improved practices (mixture of plant powders from 12 botanical species): Kg of powders / 5 kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	29.00 a	39.20 a	30.00 a	58.00 a	27.600 a	36.76
	Dose 2 (0.1 kg/5 kg bean grains)	7.000 b	10.40 b	9.100 a	29.20 b	8.0000 b	12.74
	Dose3 (0.2 kg/ 5 kg bean grains)	8.600 b	7.60 b	1.300 b	14.00 b	2.6000 b	6.820
	Mean	31.10	23.40	18.00	31.70	17.40	
	CV (%)	51.00	57.00	52.00	51.00	49.00	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%)= coefficient of variation (%).

Table 6
Effects of various management practices of bean bruchids with plant materials, in farmers' storages, *on the mean percentage of bean grains damaged(perforated) by bruchids* , in Kivu, D R Congo (March- August, 2003)

B : JAK farmers 'association

Bruchids management practices	Doses tested	Bean varieties					Mean
		M'Mafutala (M'Lwera)	Kirundo	Ishikazi	Haricot Soja	Namakala	
Farmers' practices (mixture of plant leaves from 3 to 8 botanicals): Kg of fresh leaves / 5 Kg of bean grains	Dose 1 (0 kg /5 kg bean grains)	58.000 a	75.80 b	60.40 a	50.800 b	49.40 a	58.880
	Dose 2 (0.75 kg/5 kg bean grains)	61.800 a	50.40 c	58.00 a	31.800 c	39.60 b	48.320
	Dose 3 (1.5 kg/5 kg bean grains)	59.400 a	39.60 d	9.000 c	17.120 e	37.60 b	32.544
Improved practices (mixture of plant powders from 12 botanical species): Kg of powders / 5 Kg of bean seeds	Dose 1 (0 kg/5 kg bean grains)	57.400 a	82.20 a	57.40 a	66.200 a	40.20 a	60.680
	Dose 2 (0.1 kg/5 kg bean grains)	31.400 b	49.80 c	35.40 d	27.80 d	36.60 b	36.200
	Dose 3 (0.2 kg/ 5 kg bean grains)	4.4200 c	29.80 c	4.640 d	6.2400 f	20.06 c	13.032
	Mean	45.4	54.00	37.470	33.330	38.230	
	CV (%)	9.30	9.00	7.90	9.20	8.80	

Within columns, means followed by the same letters are not significantly different at 5% probability levels as determined with Fisher's protected least significant difference (LSD) test for means separation. CV (%) = coefficient of variation (%).

Discussion

There was a great variation in bean varieties regarding the degree of susceptibility to bruchids attacks. High attacks of bean varieties by bruchids depended on approaches and type of doses applied. Local varieties were more resistant than improved, elite, commercial and marketable ones. Also, the degree of humidity of bean varieties before storage could have been of high importance in term of susceptibility to bruchids attacks. Therefore the local varieties *Ishikazi* and *Namakala* were less attacked by bruchids. However, *Kirundo*, although being a recent introduced variety had similar trend to *Ishikazi* in terms of degree of susceptibility to bruchid attacks. Such behavior was less understood. However, the variety belongs to a group of varieties currently being released under the "bean biofortification project "of the national legume crops program based at Mulungu agricultural research station in the Kivu provinces. These varieties are said to be rich in proteins, iron, zinc, etc. There is a vaste campaign to release these varieties especially in areas severely affected with children and adult malnutrition in the Kivu provinces (M. Nkonko, personal communication). Among the targeted areas, include Kabare North, Kalehe South territories of South Kivu provinces. In these areas, more than 5000 children are admitted yearly in nutritional centers (Dr Bahizire, Director of Pediatric hospital of CRSN-Lwiro, personal communication). Therefore, scientific communities are mobilizing their efforts in a multi-sectorial approach to reduce of the frequency of child mortality due to chronic malnutrition. Malnutrition is becoming endemic in the region for several cultural and nutritional reasons. Therefore, farmers are being encouraged to adopt some agricultural technologies such as such as orange flesh genotypes and beans varieties rich in proteins, vitamins and minerals already available regional research centers within DRC.

There was a high to moderated level of bruchids emergence across farmers' storages.
The difference in emerged bruchid populations between the two farmers' associations may be due to the difference in numbers of non-sexed bruchids initially released in all treatments. Farmers' stores used were not prior disinfested. It is therefore possible that other bruchids may redundant in ADEA stores.

Reading from the figure 1, it is clear that the high level of seeds damaged does not necessary implies high level of weight loss. However, the proliferation of bruchids in stores implies high numbers of grains damaged. Minimizing weight losses in storages will require that effective measures are taken to reduce or control population density of bruchids.

Over all, powders-treated beans were least attacked and, this was demonstrated by reduced emergent adult bruchid numbers, low damage level and low weight loss percentage. Fresh leaves were the least effective against bean bruchids even when applied at high rate. This was demonstrated by the highest number of adult bruchids that emerged.

The emergence patterns of *A. obtectus* from bean varieties varied between the different treatments applied. Results from the current study say that dose of 0.2 kg powders/5 kg was effective in controlling bean bruchids in all storages. The performance of that dose was earlier observed during laboratory studies by Munyuli (10).
Farmers' method of controlling bruchids in stores reduced fairly the proliferation of insects in stores, only at the dose of 1.5 kg of fresh plant leaves/ 5 kg of bean seeds. This means that farmers are obliged to collect a huge quantity of plant leaves for the conservation of around 100 kg of bean seeds. Such activities require also more labor, sacks and space in the store. That dose seems to be not sustainable for small-scale farmers' level since it involves depleting natural resources (botanicals) in the villages in a single cropping season.
The performance of plant powders in reducing bruchid damages was rated first to fresh plant leaves by farmers during the participatory evaluation of the trails. The efficacies of all other doses tested were better than the control and had reduced adult emergent numbers and seed damage but not at a significant level.

The performance of plant materials in controlling cowpea and bean bruchids, has been reported in Eastern, Central and Southern Africa, by several authors (1, 18). Similar findings to ours were reported by Silim Nahdy in Uganda while controlling cowpea bruchids (*Callobruchus maculatus)* with plant materials of several botanicals (*Tephrosia vogelii, Capsicum fruitensis, Chenopodium sp., Piper guinensis, Eichhoria crassipes*…). Powders made from various botanicals are reported to be effective in other parts of Sub-Sahara Africa (5, 16, 20).

Earlier work by Agona *et al.,* (2) showed that when used as an admixture, tobacco powder extended the storage duration of stored beans to more than 4 months with insignificant bruchid damage. Ofuya (15) used tobacco powder as admixture against *Callobruchus maculatus* and reduced egg laying and hatchability by the pest on cowpeas.

Powders made by mixing several botanicals (around twelve) do extending the storage duration of stored bean for more than 6 months with insignificant bruchid damage, while single plant powder can offer

a maximum of 4 months only. Despite the fact that powders from mixture of several dried parts of many botanical species are more effective than those from a single plant application, there is however, a paucity of information on the toxicological levels of botanical admixtures on stored grains, and environment and human health; and this may restrict usage of plant powders. Since phytochemicals are organics in nature, they are assumed to be easily biodegradable, and thus their field/storage application (manipulation) may greatly be reduced than manipulating synthetic insecticides that pollute the environment with many health risks to human being and living organisms.

The relatively poor performance of farmers' formulations (doses) may be attributed to insufficient dosage rates both in quantity and quality. Fresh leaves contain more moisture than dried ones. The pressure and action of chemicals compound of plant against bruchids as antifedants or repellents, are not limited with fresh leaves.

This study presents strong empirical evidence that plant powders can delay development and spread of bruchids within storages. During the evaluation of this trial, where scientists and farmers shared experience, members of the two associations were required to appreciate the difference in approaches experimented and determine the effective dose per approach. All farmers admitted that their method of managing bean bruchids during the conservation in stores was poorly designed.

Farmers requested training on the formulation of the effective dose from the "scientific method". Training was organized for them. Members of other associations were invited and associated to the events. On-storage demonstrations, field days, shows, exchange visits/ discussion were organized to strengthen the "farmers-learning-from other farmers" system as one of the tools to support communities development in Kivu provinces of DRC. During the training, many other farmers (non-bean growers) from several villages were also associated. Concerning the issue of sustainable bean bruchids management in Kivu provinces of eastern DRC, it seems to be important to asses the spread rates of technologies adoption. There is also a need to conduct socio-economic impact studies of the technology disseminated among bean growers.

Acknowledgment

We thank Mr Bisusa, coordinator of ADEA, Mr R. Bashige, coordinator of JAK, extension staffs and village chiefs for their cooperation in this study. All associations' members who participated in the trials are also acknowledged. We are grateful to CIAT/ PABRA-ECABREN for funding this study. Finally, we also thank the laboratory technicians Bwema (CRSN-Lwiro) and Koleramungu (INERA-Mulungu) for their technical assistance during data collection. We also thank M. Nkonko, National bean research program coordinator based at INERA-Mulungu research station, for providing useful information about bean varieties cultivated by farmers in eastern D R Congo.

Literature

1. Anonymous, 2002, Rapport d'activité de la commission d'évaluation des pertes dans les denrées stockées crées à l'issue du Congrès de Marseille sur la protection des cultures tropicales. Agronomie tropicale, 24, 872-878.
2. Agona J.A., Owera-Odom F., Kyamanwya S., Silim Nahdy M. & Willson H.R., 2001, Field management of bruchids on beans using selected phytochemicals, insecticides and entomopathogen. African Crop Science Conference Proceedings, 5**,** 153-157.
3. Bagalwa M., Munyuli Bin M. & Mweze Z., 1999, Activité insecticides de quelques plantes médicinales du Kivu, contre le *Cosmopolites sordidus* (Coleoptera: Curculionidae), ravageur principal du bananier à Iko, Sud-Kivu. R.D. Congo. Recherches Africaines, 4, 45-52.
4. Dent D., 2000, Insect Pest Management. CABI Bioscience, UK, 410 pp.
5. Donald L.M.C., Guy R.H. & Speirs R.D., 1970, Preliminary evaluation of new candidates' materials as toxicants, repellents and attractants against stored product insects. Marketing Research. Rep. 882. Agric. Research Service, USD Dept of agriculture, Wasginton, DC.
6. Munyuli B.M. & Balezi N., 2001a, Utilisation des poudrages des plantes médicinales à propriétés insecticides dans la protection des semences et denrées alimentaires stockées (haricot, mais & sorgho) contre les coléoptères ravageurs des stocks, au Kivu, RDCongo. African Crop Science conference proceedings, 5**,** 293-303.
7. Munyuli T.M.B. & Balezi N., 2001b, Tuteurage du haricot volubile (*Phaseolus vulgaris* L.) par le mais (*Zea mays* L.) dans une association culturale de haricot- mais- manioc à Katana, Sud-Kivu, République Démocratique du Congo. African Crop Science Conference Proceedings**,** 5**,** 985-990.
8. Munyuli T.M.B., 2001a, Farmer's perception of bean pest problems in Kivu area, Democratic Republic of Congo. African Crop Science Conference Proceedings*,* 5**,** 705-713.
9. Munyuli T.M.B., 2002, Local inhabitants'control strategies of crop pests in eastern Democratic Republic of Congo, by exploiting the local plant diversity species. Delpinoa Italy, 44**,** 65-74.
10. Munyuli T.M.B., 2003, Effet de différentes poudres végétales sur l'infestation des semences de légumineuses et de céréales au cours de la conservation au Kivu, République Démocratique du Congo. Cahiers Agricultures France, **12**, 1, 23-31.
11. Munyuli T.M.B., Balezi N. & Musakamba M., 2005, L'utilisation des poudrages de plantes médicinales dans la lutte contre les bruches du haricot au Kivu. PABRA Millennium Workshop. Novotel Mount Meru, Arusha, Tanzania. 28 May–1st June 2001. PABRA (Pan Africa Bean Research Alliance)/ECABREN (Eastern and Central Africa Bean Research Network)/ SABRN (Southern Africa Bean Research Network), Pp: 292-300.
12. Munyuli T.M.B., Luther G.C. & Kyamanywa S., 2007, Effects of cowpea cropping systems and insecticides on arthropod predators in Uganda and Democratic Republic of the Congo. International Journal of Crop Protection*,* 26, 114-126.
13. Munyuli T.M.B., Luther G.C. & Kyamanywa S., 2008, Effects of groundnut genotypes, cropping systems and insecticides on the abundance of native arthropod predators from Uganda and Democratic Republic of the Congo. Bulletin of Insectology, **67**, 1, 11-19.
14. Munyuli T.M.B., Kyamanywa S. & Luther G.C., 2008, Capability of *Forficula auricularia* L. (Dermaptera: Forficulidae) to prey on *Aphis craccivora* K. (Homoptera: Aphididae) in eastern and central Africa. Agronomie Africaine, **20**, 1, 57-66.
15. Ofuya T.I., 1986, Use of wood as, dry chill pepper fruits and onion scale leaves for reducing *Callobruchus maculates* (F) damage in cowpea seeds

during storage. Journal of Agricultural Science, 107, 467-468.

16. Sara J.B., 2002, Plants as insecticides for the protection of stored cowpea: back to basis. *In*: Cornel Adler, Shlomo Navarro, Matthias, Scholler and Lise Stenard-Hansen, (editors), integrated protection of stored products. IOBC Bulletin, **25**, 3**,** 165-169.
17. Chinwada P. & Giga D.P., 1997, Traditional seed protectants for the control of bean bruchids. Tropical Science, 37, 80-84.
18. Silim Nahdy M., 1999, Biopesticides: their potential in controlling storage pests. *In*: Silim Nahdy & Agona Ambrose, (editors). Proceedings of the first regional conference on stored product insect pests: their status, coping strategies and control in Eastern, Central and Southern Africa. Kampala, Uganda, 29 November-1st December 1999. ISPM-EU/NARO: p. 38-61.
19. Sindabona J.M. & Kayitare J., 1987, Contribution à l'étude de la résistance variétale du haricot aux bruches (*Acanthoscelides obtectus* et *Zabrotes subfasciatus*). Séminaire sur les maladies et les ravageurs des principales cultures vivrières d'Afrique Centrale. IRAZ/ISABU/CTA/ AGCD, Belgique. Pp: 409-420.
20. Tapondjou A.L., Adler C., Bouda H. & Reichmuth C., 2002, Ability of products derived from the leaves of *Clausena anisota* to protect stored legumes from attack by *Collobruchus maculates* and *C. chinense* (Coleoptera: Bruchidae). *In*: Cornel Adler, Shlomo Navarro, Matthias, Scholler and Lise Stenard-Hansen (editors), integrated protection of stored products. IOBC Bulletin, **25**, 3**,** 153-164.
21. Van Huis A., 1991, Biological methods of bruchid control in the tropics: a review. Insect Science and its Application, 12**,** 87-102.

T.M.B. Munyuli, Congolese (DR Congo), PhD Candidate, Senior Researcher from the National Centre for Research in Natural Sciences, CRSN-Lwiro, D.S. Bukavu, Kivu, Democratic Republic of Congo.

Erratum

Dans l'article intitulé, «Détermination du niveau de contamination de l'ochratoxine A(OTA) dans les fèves de cacao à l'exportation » de Messieurs A. Dembele, A. Coulibaly, S.K. Traoré, K. Mamadou, N. Silue & A. Abba, Vol. 27,1, 2009, p.30, le curriculum vitae de Monsieur Mamadou Koné comportait une erreur d'identité. Il mentionnait « K. Mamadou, Ivoirien, DEA en chimie minérale à l'Université P.M. Curie (Paris 6e) , Maître-assistant à l'Université d'Abobo-Adjamé.

Veuillez excuser cette erreur et lire le curriculum vitae repris ci-dessous

« Mamadou Koné, Ivoirien, Doctorat de l'Université Pierre et Marie Curie (Paris 6e) en Chimie minérale, Professeur, Maître de conférences, Laboratoire des Sciences de l'Environnement UFR-SGE, Université d'Abobo-Adjamé, Côte d'Ivoire.