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Minimizing On-Farm Grain Storage Loss: A Low-Cost, Farmer-Tested Technology

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MINIMIZING ON-FARM GRAIN STORAGE LOSS: A LOW-COST, FARMER-TESTED TECHNOLOGY

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INTRODUCTION

During our diagnostic survey on the northern highlands of Rwanda, only a handful of farmers mentioned loss of stored grains as one of their problems (FSRP, 1986; Paul et al., 1987; Franzel et al., 1985). At the time this appeared normal as the farmers were mostly subsistence farmers with little surplus production and as the area has an average annual temperature of only 18 C. Later, as I interacted more closely with the farmers, it became apparent that many of the farm families store a part of their production for a period of four to six months and some even up to a year. The farmers also face the usual storage problems such as insects, molds and rodent-related damages, and they do whatever possible to minimize losses. However, compared to their many other problems, the problem of grain storage is a relatively minor one. Farmers discussed storage problems only when asked specifically. Subsequently I received requests from many of my collaborating farmers to find them "DDT," and they were willing to pay for it. What they were referring to as DDT was in fact Malathion; the farmers use this name for any chemical used for the conservation of grains. I then contacted GRENARWA II-RECHERCHES, a USAID-funded crop storage project in Rwanda, and requested their help in this matter.

GRENARWA II researchers have been using a chemical, "pirimiphosmethyl," commonly called "ACTELLIC" (manufactured by Imperial Chemical Industries), in their commercial warehouses with good results (Clarke, personal communication). Actellic is a low-cost chemical (10 FRW, or 12 cents U.S. for 100 g of insecticide for treating 100 kg of grains) with a low toxicity (oral lethal dose for rat is 2050 mg/kg body weight). It is also known to be more effective and to provide longer protection to stored grains than Malathion. However, Actellic has not been tested at the farm level in Rwanda. It was therefore decided to launch this research with initial help and collaboration from the GRENARWA II researchers.

The objectives of this study were as follows:

1. To test and compare the effectiveness of Actellic and Malathion for on-farm grain storage;
2. To determine the farmer acceptability of Actellic; and
3. To develop appropriate recommendations for on-farm grain storage.

METHODOLOGY

In November 1986, two farmer-collaborators and the ISAR storehouse at Rwerere were chosen for demonstration and initial installation of grain storage trials. The farmers and the ISAR store-keeper were told to keep aside about 50 kg of grains of bean, sorghum or wheat that they could afford to hold for a period of at least six months. On the morning of November 11, all FSRP team members and a group of four researchers and technicians from the GRENARWA II project visited the two selected farms. The collaborating farmers were requested to invite their neighbors to witness the demonstration; consequently, there were about 40 farmer-participants on the first farm (Nduhira) and 15 on the second farm (Sebahutu).

The technicians from GRENARWA II began by asking the farmers questions pertinent to grain storage. Then they took a few grain samples from the farmer's stock and, utilizing a hand sieve, separated some insects and damaged grains, which they showed to the farmers. The participants exhibited a great deal of interest in viewing these under a magnifying lens. The demonstrations were also supplemented by colored charts and photographs.

For the installation of experiments, two portions of 20 kg each of grains were taken from the same stock; one lot was treated with 1% Actellic at the rate of 1 g/kg of grain (1:1000) while the other lot was

left untreated. For effective mixing of chemicals with the grains, one-quarter of the grain to be treated was placed in a bucket, the required quantity of insecticide was added, and the contents were then stirred thoroughly with a wooden stick and returned to the storage container. The same process was repeated until all the grain of that particular lot had been treated. The treated and untreated lots were placed in the normal storage containers of the farmers--gunny sacks for sorghum and woven baskets for beans--and stored inside the house. In the same afternoon, a training session was conducted for the ISAR technicians at the Rwerere station; this was followed by another trial installation utilizing wheat, where a third treatment of Malathion (1% Malathion, 1 g/kg of grain) was also employed.

A 1-kg sample was collected at the time of trial installation; additional samples were again collected at 3 and 6 months of storage from both treated and untreated lots. The following procedure was used to collect samples. The entire contents of a storage container were poured out to a cone on a canvas spread on the floor. With the help of a wooden plank, the cone of grain was divided into four equal parts. Three parts were put back into the container, and the remainder was again divided into four parts following the same procedure. One part was then put inside a plastic bag, and the rest was put back into the container. The samples thus collected were usually sent within a week to the GRENARWA II laboratory in Kigali for analysis.

It was emphasized to all the participants that in spite of Actellic's low toxicity, care should be taken to store the chemical out of the reach of children, wash hands and all exposed body parts thoroughly with soap and water after using the chemical, wash clothes and containers that come in contact with the chemica and wash the treated grains before cooking.

A few weeks later we installed another trial (chez Kibunda) on wheat. Then one year later, in December 1987, similar trials were again installed on two additional farms (chez Rwanika and Nyilimpunga) using beans and sorghum and in the ISAR storehouse with sorghum.

ASSESSMENT OF THE PRESENT SITUATION

From the question and answer sessions and from visiting many farms over the past three years, I have learned a great deal about the farmers' practices after they bring the harvests home. The farmers realize the importance of drying grains before storing, but often this is not possible, especially for those crops harvested in season A (harvest time February - March) because of high atmospheric humidity at this time and because this is also the beginning of the long rainy season. Since about 70% of Rwanda's beans are produced in season A, the high humidity, conducive to mold growth, becomes more of a problem for the harvested dry beans. This is possibly the reason why the area farmers rarely save harvests of this season as seed for the next planting season. The crops planted in season B are harvested during the dry months of July - August, and the farmers normally save a part of this harvest for planting during the two subsequent seasons. Thus, on-farm storage of seed up to a period of 8 months is a common practice. The farmers do not feel that the changes in bean seed color or the increase in cooking time of dry beans with long periods of storage (up to 12 months) are much of a problem.

The traditional crop storage methods are intended for keeping the moisture out and providing barriers against rodents. The most common outdoor storage structures are large baskets placed on raised platforms and covered with thatched roofs. The baskets are usually coated with a cow dung-mud mixture. These structures are primarily used for storing sorghum panicles. Beans, corn and wheat are normally stored inside the house in medium-sized baskets and jute sacks. One of the reasons for storing these inside is to protect against theft. Heat and smoke generated inside the house supposedly keep humidity low and insects out, but rodents are still a problem. Small quantities of grain for seed are stored in small baskets, gourds or metal cans. Some farmers use wood ash for long-term storage of grains, especially for storing shelled sorghum.

RESULTS AND DISCUSSION

The results of the initial grain analyses as presented in Tables 1 and 2 show that the grains were of good quality. These were all from the harvest of the previous season and had been in storage for only 2 - 3 months. However, we did analyze one sample of maize and another sample of wheat that were stored for about 7 - 8 months (data not presented here) in which we found a large number of Sitophilus spp.; the percentage of damage caused by the insects was 17% and 70% for maize and wheat, respectively. This clearly demonstrates that in spite of the prevalent year-round low temperature in the region, insects can cause considerable damage to stored grains. The results also indicate that the moisture contents of certain samples were higher than those recommended for stored grains, which are 12% and 14% for sorghum and bean, respectively.

The results presented in Tables 3 and 4 show that beans stored up to a period of 7 months (experiments were installed 3 months after harvest), even without insecticide treatment, were in good condition. Sorghum samples, on the other hand, were infested with Sitophilus, and the infestations were much more serious in the non-treated lots (8 months from harvest time). In one case, more than 50% of the sorghum was lost because of insects, and Actellic treatment substantially minimized the losses. The insect population in Actellic-treated wheat was somewhat lower than that in wheat treated with Malathion (Table 3). Almost all of the insects found in the treated lots were dead, except for some of the Sitophilus larvae and Psoques, while a considerable number were alive in the non-treated lots. The samples in which a large number of insects were counted were already infested with insects prior to trial installations. Most of these were inside the grains and, therefore, were not accounted for during the first sampling. As these insects emerged from the grains, they came in contact with the insecticide and subsequently died. In addition to the insects already present in the untreated lots, there might also have been some secondary infestations. Another important reason for finding a large number of dead insects in both treated and untreated lots was the elapsed time between sample collection and analysis. Despite our best efforts to get the samples analyzed within about 10 days of collection, it was not often possible because of logistical reasons. When grain samples with live insects are left sealed in plastic bags (necessary for moisture determination) for more than three weeks, many of the insects are bound to die because of the lack of oxygen. Even the insect eggs will not hatch in the absence of oxygen. Moreover, Sitophilus spp. have a life-cycle of 4 weeks under optimum conditions (26 C and 14% moisture content); therefore, some will die naturally.

The results of grain analysis 6 - 7 months from the commencement of the trials, or 9 - 10 months from the harvest dates, have been presented in Tables 5 and 6. Most of the sorghum samples collected at this time had a musty odor; this was especially true for those of Nduhira farm (Table 5). The high grain moisture content all through the storage period and a temperature range of 20 - 25 C are ideal for mold development. Even if the grains are dried to an acceptable moisture content before storage, they will absorb moisture with time because of high relative humidity (about 80%) in the area unless, of course, they are stored in moisture-proof containers. Molds will cause grain deterioration and impart a foul odor and thus will lower grain quality. High humidity is also ideal for the survival of stored grain insect Psoques (Psocoptera).

As shown in Tables 5 and 6, the insect population in untreated samples was much larger than that of the treated samples. Untreated sorghum samples from the Nduhira farm had 143 Sitophilus spp., and almost two-thirds of these were alive, while the Actellic-treated samples had only 12, and two of these were alive (Table 5). A similar trend was observed for the wheat samples stored at the ISAR storehouse (Table 5) and the sorghum samples obtained from the Nyilimpunga farm (Table 6). The results obtained with wheat clearly show that Actellic provided better Sitophilus control than Malathion. We were unable to count the number of Psoques (Table 5) in the samples because of their microscopic size and rapid movement. Neither Actellic nor Malathion was found effective against Psoques. Although Malathion is still a good insecticide for controlling pests in stored grain, it is known to lose its effectiveness in poor storage conditions or if applied on grains with relatively high moisture content, and insect resistance to Malathion is now quite widespread (Hindmarsh et al., 1978).

The results presented in Tables 3, 4, 5 and 6 show a clear relationship between the number of insects present in a sample and the percentage damage thereof. This is only to be expected; the importance of insect control in grain storage, even in the Buberuka Highlands area, cannot be overemphasized.

SUMMARY AND CONCLUSIONS

This study clearly shows that insects could become a real problem for storing grains even in the high altitude, colder regions of Rwanda. Insect infestation varies greatly from one farm to another because of differing farm conditions and management practices. Infestation could begin in the field even before harvest; then improper storage conditions could help to multiply the number of insects, or unsanitary conditions could bring secondary infestation. The area extension workers and farmers should be made aware of this potential problem (the FSRP team based in Rwerere should be able to help).

The traditional crop varieties are known to possess certain resistance against stored grain pests, and these might have been selected by the farmers for their ability to withstand a period of storage and still be viable (Hindmarsh et al., 1978). With the constant introduction of new, improved varieties that might lack natural resistance to insect pests, storage of grains of these varieties may pose a much greater problem. Agricultural researchers and policy makers in the country should be aware of this potential problem.

The insecticide Actellic appears to provide an excellent control of the principal stored grain pests. It is a relatively safe, very low-cost pesticide; it costs only 10 FRW to treat 100 kg of grains, the greatest quantity stored by any subsistence-level farmer in a year. It is available in Rwanda in dust formulations and has a long shelf-life. The procedure of mixing Actellic with grains prior to storage is the same as mixing ash with grains, a method used by the area farmers for a long time. We are overwhelmed with requests from our farmer-collaborators to bring them this compound. Perhaps the agents of MINAGRI could offer this compound for sale in small packets of 50 g each through local cooperatives and CERAIs (Paul and Grosz, 1987).

Besides insects, moisture and rodents offer a real challenge to grain storage. Low-cost techniques are already available to combat these problems; the Project GRENARWA II - RECHERCHES has developed semi-hermetic containers for on-farm storage of grains. The effectiveness and the acceptability of these storage containers by the farmers should be evaluated.

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Table 1. Analysis of grain samples removed at the time of trial installation (1st sampling), 1986.

Crop/Farm	Weight, volumetric	Moisture %	Impurities %	Insect[1] Sp. & No.	% Damage
Bean/ND[2]	860 g	15.3	0.40	0	0
Bean/SB	856 g	13.0	0.33	0	0
Bean/IS		11.6	0.10	0	0
Wheat/KB	685 g	16.1	0.03	S (42)	2.5
Wheat/IS		13.9	0.21	0	0.6
Sorghum/ND	793 g	14.6	0.50	S (many)	0.8

[1]No. of Insects/kg of grain; S = Sitophilus.
[2]ND = Nduhira; SB = Sebahutu; IS = ISAR; KB = Kibunda.

Table 2. Analysis of grain samples removed at the time of trial installation (1st sampling), 1987.

Crop/Farm	Weight volumetric	Moisture %	Impurities %	Insect[1] Sp. & No.	% Damage
Bean/RW[2]	578 g	18.3	0	0	0
Sorghum/NY	586 g	15.4	0.6	S (14)	0.3
Sorghum/IS	736 g	14.2	0.2	P (2)	0.3

[1]S = Sitophilus; P = Psoques; the number in parentheses indicates the number of insects/kg of grain.
[2]RW = Rwanika; NY = Nyilimpunga; IS = ISAR.

Table 3. Analysis of grain samples 3 months after the trial installation date (2nd sampling), 1986.

Crops/Farms		% Moisture	Insects Species	Insects Numbers		% Damage
Bean/SB[1]	(T)[2]	15.7	0	0		0
Bean/SB	(NT)	17.5	0	0		0
Sorghum/ND	(T)	15.3	S	10	(0)[3]	1.5
Sorghum/ND	(NT)	15.6	S	50	(0)	4.5
Wheat/IS	(T)	14.5	S	5	(0)	0.3
Wheat/IS	(NT)	15.2	S	22	(20)	1.0
Wheat/IS	(TM)	14.9	S	12	(0)	1.0

[1]SB = Sebahutu; ND = Nduhira; IS = ISAR.
[2]T = Treated with Actellic; NT = Non-treated; TM = Treated with Malathion.
[3]Number in parentheses indicates the number of live insects.

Table 4. Analysis of grain samples 4 months after trial installation (2nd sampling), 1987.

Crops/Farms		% Moisture	Insects Species	Insects Numbers		% Damage
Bean/RW[1]	(T)[2]	18.1	S[3]	5	(0)[4]	0
Bean/RW	(NT)	17.7	0	0		0
Sorg/NY	(T)	13.9	S	173	(0)	0.8
			P	8	(8)	
Sorg/NY	(NT)	14.0	S	566	(?)	53.0
Sorg/IS	(T)	14.5	S	8	(0)	0.3
Sorg/IS	(NT)	14.7	S	14	(0)	0.3

[1]RW = Rwanika; NY = Nyilimpunga; IS = ISAR.
[2]T = Treated with Actellic; NT = Non-treated.
[3]S = Sitophilus; P = Psoques.
[4]The number in parentheses indicates the number of live insects.

Table 5. Results of the analysis of grain samples 7 months after the trial installation date (3rd sampling), 1986.

Crops/Farms		% Moisture	Insects: Species	Insects: Numbers		% Damage
Sorg/ND[1]	(T)[2]	15.1	S[3] P	12 ?	(2)[4] (all)	1.0
Sorg/ND	(NT)	15.4	S P	143 ?	(93) (all)	7.2
Wheat/IS	(T)	14.9	S	7	(0)	0.3
Wheat/IS	(NT)	15.1	S P	91 ?	(16) (all)	3.3
Wheat/IS	(TM)	14.9	S P	37 ?	(8) (all)	1.3

[1]ND = Nduhire; IS = ISAR.
[2]T = Treated with Actellic; NT = Non-treated; TM = Treated with Malathion.
[3]S = Sitophilus; P = Psoques.
[4]The numbers in parentheses are the number of live insects. Could not count the number of Psoques because of their microscopic size and rapid movement.

Table 6. Results of the analysis of grain samples collected 6 months after the trial installation date (3rd sampling), 1987.

Crops/Farms		% Moisture	Insects: Species	Insects: Numbers		% Damage
Bean/RW[1]	(T)[2]	18.2	0[3]	0[4]		0
Bean/RW	(NT)	18.2	0	0		0
Sorg/NY	(T)	15.9	S	196	(5)	1.4
Sorg/NY	(NT)	12.1	S	657	(14)	61.0
Sorg/IS	(T)	14.1	S	6	(0)	0.3
Sorg/IS	(NT)	14.6	S	10	(0)	0.4

[1]RW = Rwanika; NY = Nyilimpunga; IS = ISAR.
[2]T = Treated with Actellic; NT = Non-treated.
[3]S = Sitophilus.
[4]The numbers in parentheses are the number of live insects.