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Economic importance of farm-level bruchid control in stored dry beans and cowpeas in Uganda

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Abstract

The damage bruchids cause to beans and cowpeas as major vegetable sources of protein is of considerable significance as protein shortage is acute in the diets of many Ugandans. Use of post-harvest techniques that would allow beans and cowpeas to be stored free of bruchids would reduce loss of these sources of protein, enhance their shelf life, improve food quality and seed viability and ultimately increase rural incomes and food security. This research explored financial consequences of effects of alternative farm-level bruchid control measures in stored dry beans and cowpeas in Iganga and Kumi districts of Uganda during the 1997-1999 period using partial budgeting and dominance analysis techniques. Results showed that actellic, wood ashes, solar heat and leaf powders of tobacco and tephrosia were economically viable post-harvest protectants of dry beans and /or cowpeas for at least 3 months in farm storage. Tobacco was the most profitable treatment on beans and tephrosia was the most profitable treatment on cowpeas. Additional economic benefits were realised either as a result of higher returns from increased marketable and sowable surplus or the low cost of grain protection. The analysis scheme outlined in this study that links partial budget and dominance evaluation techniques is a useful tool for future determination of the best post-harvest interventions to control bruchids.

Key words: Botanicals, bruchids, credits and debits, marginal rates of return, net benefit curve, post-harvest grain losses, grain legumes, Uganda

Introduction

A tragic, but all too common plight, of the small-scale farmer in Uganda is the irreversible seed and grain damage by weevils, which constitutes economic losses in nutritive value (vegetable protein) shortage in the Ugandan diet. The damaged product could also become a health hazard. Moreover, food grains that have been damaged by bruchids and weevils are undesirable in the market place causing surplus losses to both the producer and the consumer. In the case of seed grain, germination potential can be highly impaired (Taylor, 1972). As a consequence, inability to store beans and cowpeas safely forces small-scale farmers to sell off excess grain beyond their domestic requirements at harvest time at glut produce prices. Later traders sell needed grain back to farmers at high prices, increasing the farmers' debt burden.

Unfortunately, few data exist as to the actual quantitative and qualitative losses of beans and cowpeas in farm storage. Post-harvest losses caused by bruchids are difficult to quantity in Uganda because the semi-subsistence farmers do not keep relevant records. There is also a wide variety of storage methods in use. Given undefined periods over which grains are kept and the random trading practices used, the grain quantities in storage are continually changing. An earlier study in Uganda which collected data from actual sample farms showed that in some specific situations post-harvest grain legume losses exceeded 30 percent (Hall, 1970). In another farm storage survey in the central and western regions losses of beans attributed to insects in farmers' stores were estimated at 22.9 percent (Byaruhanga, 1971).

This study was conducted during the 1997-99 period in Iganga and Kumi districts under farmer-managed storage conditions. The economics component of the study explored financial consequences of effects of tested treatments on grain legume quantity and seed viability in storage with the following objectives: (a) to determine differences in post-harvest loss of quantity as a result of alternative treatments applied to control grain legume bruchid infestation, (b) to evaluate extra debits and credits involved in the proposed post-harvest bruchid control measures, and (c) to identify economically viable bean and cowpea bruchids management interventions to reduce loss of stored grain legumes on the farm.

Methodology

Two aspects of bean and cowpea bruchids management strategies were distinguished in this study: the product and process innovations and the economic terms on which the innovations have to be based. Evaluation from the product and process perspective involved ten farmers in Iganga district and six farmers in Kumi district. Seven treatments of dry large seeded beans (*Phaseolus vulgaris* L.) in Iganga district included leaf powders of three botanicals namely *Lantana camara* L., *Nicotiana tabacum* L. (tobacco) and *Tagetes minuta* L. (Mexican marigold); a solar dryer treatment; a wood ash treatment; a chemical treatment (actellic dust 1% a.i) and a control (no-treatment). Eight treatments of dry cowpea seeds (*Vigna unguiculata* L.Walp) in Kumi district included leaf powders of three botanicals namely *Tephrosia vogelli*, *Tagetes minuta* and tobacco and also a wood ash treatment, a solar dryer treatment, an actellic dust treatment, a vegetable oil treatment and a control.

The leaf powders of botanicals were processed from harvested leaves that were shade-dried. Leaves were used because of easy availability and shade-drying was to avoid rapid volatilisation of inherent active ingredients. The use of the powder form was to increase active surface area. The leaf powder was applied to grain at the rate of 2% w/w. Wood ash was obtained from the participating farmers' kilns irrespective of the tree species used. The application rate of wood ash was also 2% w/w. Solarisation of grains involved sun drying in a low cost dryer made of a shallow (1x3x0.3 m) pit lined with a black plastic sheet and the grain covered with a clear plastic sheet. Sun drying was done on a dry sunny day for two hours once a month. In the vegetable oil treatment dry cowpea grains were coated with an edible vegetable oil at the rate of 5 ml per kg of grain. In the chemical treatment, actellic dust 1% a.i was applied at the rate of 0.5 gm per kg of grain. Control treatments included grain which did not receive any form of treatment prior to or during experimental storage.

The grains were obtained from participating farmers' new season harvests at about 15-16% moisture content and were divided into one-kilogram working samples by the coning and quartering method (NRI, 1995). From each farmer, 7 kg of beans or 8 kg of cowpeas were obtained for the treatments. Treated and untreated grains were placed in muslin-cotton bags, stored on raised platforms to avoid moisture and arranged in a completely randomised pattern in the farmers' houses. Samples of each treatment were drawn monthly during the 3-month storage period to determine damage levels following the converted percentage damage method (NRI, 1995). Bruchid damaged grains were defined as those with distinct insect emergence holes. The effect of each treatment method on grain quantity and quality was then determined and compared with control trials.

Economic evaluation methods included partial budgeting and dominance analysis. Data on differences in bean and cowpea quantities, seed viability, input quantities and associated prices, grain farmgate and retail prices at harvest and 3 months later were collected. Seed viability was determined using blotter method (Neergard, 1979). Partial budgeting involved comparing the sum of added income (AI) and reduced costs (RC) equals credits with the sum of added costs (AC) and reduced income (RI) which is debits. Credits minus debits were the estimates of the differences in net cash benefits (NCB) as specified below:

NCB = (AI + RC) - (AC + RI) .... (1)

Dominance analysis was done by listing post-harvest bruchid control measures in the order of their increasing debits and matching them with their respective net cash benefits. The bruchid management methods with net cash benefits less than those of options with lower debits were dropped as dominated options (Mubanderi *et al.*, 1999). The remaining options which were not dominated were used to plot a net benefit curve along which farmers can expect to gain cash income as they shift between economically viable options. Marginal rates of return (MRR) gained by shifting along the net benefit curve were computed using the following formula:

MRR = (MB/MC) x 100 .... (2)

Where: MB = Marginal benefit or change in net benefits and MC = Marginal cost or change in debits.

According to Bereket and Asefu-Adjaye (1999), the marginal rates of return are the rates at which net benefits change as the investment changes.

Results and Discussion

From a biophysical perspective, the effectiveness of the different treatments applied to control bean bruchid infestation varied considerably. Bean damage levels built up depending on the type of treatment applied and storage duration. After 3 months of storage, solar heat, tobacco leaf powder and actellic dust provided effective disinfestation, registering bruchid bean injuries of 0.35%, 1.85% and 2.47%, respectively. Seed viability generally decreased as bruchid infestation increased. Solar heated beans were, however, least viable (50% germination) whilst beans admixed with actellic dust and tobacco leaf powder were most viable with 90.22% and 88% germination, respectively. Generally, the effectiveness of botanicals declined with protracted storage duration.

On cowpeas, bruchid damage levels and seed viability also varied according to the type of treatment applied and prolonged storage duration. The best treatments that reduced bruchid damage levels included mixing cowpeas with tephrosia and solarisation which registered 2.8% and 8.8% bruchid injury levels, respectively. Unlike the case of beans, solarisation did not impair cowpea seed viability. The most viable seeds were those mixed with tephrosia leaf-powder ashes and solar heated which had germination levels of 76%, 88% and 94%, respectively. According to CIAT (1986), the efficacy of wood ashes is dependent on mechanical filling of the spaces between the grains prohibiting bruchids from infestation. In the case of cowpeas, the efficacies of botanicals also declined with prolonged duration.

Results from partial budget analysis (Table 1) showed that, on average, tobacco leaf powder, if adopted by the farmer, can give an added net cash benefit of USD 1.27 per 100 kg of beans in storage. This comes from mainly grain loss reduction and improvement in seed viability. Another promising technology for bean bruchid control was actellic (1% a.i) dust which, on average, gave incremental net cash benefit of USD 1.23 per 100 kg of beans. It has to be noted that the additional procurement cost in the latter case was three times as high compared to the cost incurred in using tobacco leaf powder. The results also indicated that, on average, solarisation with an added net cash benefit of USD-4.31 per 100 kg of beans, was a viable option for bruchid control in the study area. The marginal revenue derived from the use of this technology was not enough to compensate for the additional cost of solarisation due to high rates of loss of seed viability and procurement cost of pit construction and plastics. Partial budgeting also indicated that farmers would be able to realise an additional net cash

Table 1. Partial budget analysis of effects of farm-level bruchid control measures 3 months after treatment of stored dry beans and cowpeas in Iganga and Kumi districts 1997-99

Differentials in USD/100 kg.	Beans (Iganga)							Cowpeas (Kumi)							
	Control	Tagetes	Tobacco	Lantana	Ashes	Solarisation	Actellic	Control	Tagetes	Tobacco	Tephrosia	Oil	Ashes	Solarisation	Actellic
1. Credits															
Mean loss reduction in grain[a]	-	0.15	0.42	0.13	0.22	1.57	1.42	-	0.94	0.51	3.79	1.07	2.03	3.19	0.53
Mean Improvement in Viable seed[b]	-	0.81	1.26	0.77	0.59	0.02	1.52	-	0.05	C.11	3.75	0.50	1.28	2.76	0.47
Sub totals	0	0.96	2.68	0.90	0.81	1.57	2.94	0	0.99	0.62	7.54	1.57	3.31	5.95	1.00
2. Debits															
Mean loss of bruchid damaged grain[a]	-	0.31	0.71	0.37	0.45	0.78	0.71	-	0.47	0.25	1.90	0.30	1.01	0.33	0.75
Mean loss of unviable seeds[b]	0.66	0.08	0.63	0.08	0.06	2.52	0.76	1.45	0.11	0.50	1.88	-	0.64	0.67	1.16
Mean procurement costs[c]	-	0.03	0.07	0.04	-	2.58	0.24	-	0.01	0.05	1.19	0.61	-	2.58	0.24
Sub totals	0.66	0.42	1.41	0.49	0.51	5.88	1.71	1.45	0.59	0.80	4.97	0.91	1.65	3.58	2.15
3. Added net cash Benefit (1-2)	-0.66	0.54	1.27	0.41	0.30	-4.31	1.23	-1.45	0.40	-0.18	2.57	0.66	1.66	2.37	-1.15

NOTES:
/a 1USD = UShs 1550 (1998); farmgate average price per kg at harvest: beans = 0.3, cowpeas = 0.25, average non glut price per kg, 3 months later for beans = 0.4, cowpeas = 0.3
/b Seed grain retail prices per kg at harvest, beans 0.9, cowpeas 0.7. Seed grain buy-back prices per kg from traders 3 months later bean 1.0, cowpeas 0.8
/c Input procurement prices per unit: Vegetable oil 1.2/l, clear and dark plastic 1.0/m Acetlic; (1% a.i) 4.8/kg. The cost of producing leaf powder of botanicals was estimated at 10% based on grain injury levels.

benefit of USD 2.57 per 100 kg of cowpeas, if they could adopt the tephrosia leaf powder technology due to mainly high rates of grain loss reduction and improvement in seed viability. Unlike in the case of beans, solarisation also, once adopted to control cowpea bruchids, can give an additional net cash benefit of USD 2.37 per 100 kg of grain stored. But the corresponding additional cost of using this technology was USD 3.58 per 100 kg of cowpeas which was incurred in constructing the pit and paying for the plastics.

The various bruchid management strategies were arranged in increasing order of debits and matched with their respective net cash benefits as presented in (Table 2). In the pattern of increasing debits and increasing net cash benefits, tobacco leaf powder followed by actellic (1% a.i) dust dominates all other bean bruchid control options because each of these two options has higher net cash benefits but generally less debits than the dominated control measures. Similarly in the case of cowpeas, use of ashes, solar heat or tephrosia leaf powder dominates the rest of the tested cowpea bruchid control measures. When dominating bruchid control options were ploted against a pattern of increasing net cash benefits, a net benefit curve was obtained (Figure 1). On the basis of the net cash benefit curve, marginal rates of return (MRR) were computed (Table 3) to indicate changes in net cash benefits from one treatment to another along the net benefit curve.

Results from MRR analysis showed that a one USD investment in shifting from the cheap and locally available tobacco leaf powder to use of actellic in bean bruchid control could result in a 15 percent reduction in returns. In the case of cowpeas, for a farmer using ashes and would like to shift to use of solar heat to control bruchids, a 27 percent increase in returns would be realised. And, a 13 percent

Table 2. Dominance analysis of bruchid control measures (USD per 100 kg of grain).

Treatment	Debits	Net cash benefit
Control (beans)	0	-0.66
Control (cowpeas)	0	-1.45
Tobacco (cowpeas)	0.62	-0.18
Ashes (beans)	0.81	0.30
Lantana (beans)	0.90	0.41
Tagetes (beans)	0.96	0.54
Tagetes (cowpeas)	0.99	0.40
Actellic (cowpeas)	1.00	-1.15
Solarisation (beans)	1.57	-4.31
Oil (peas)	1.57	0.66
Tobacco (beans)	2.68	1.27
Acetellic (beans)	2.94	1.23
Ashes (cowpeas)	3.31	1.66
Solarisation (cowpeas)	5.95	2.37
Tephrosia (cowpeas)	7.54	2.57

Table 3. Marginal rates of return (%) for adoption of alternative bruchid control measures.

Treatment USD/100 kg	Debits (MC)	Marginal Cost USD/100 kg	Net benefit benefit	Marginal (MB)	MRR = (MB/MC) 100
Tobacco (Beans)	2.68		1.27		
Actellic (Beans)	2.94	0.26	1.23	-0.04	-15.4
Ashes (cowpeas)	3.31	-	1.66	-	-
Solarisation (cowpeas)	5.95	2.64	2.37	0.71	26.9
Tephrosia (cowpeas)	7.54	1.59	2.57	0.20	12.6

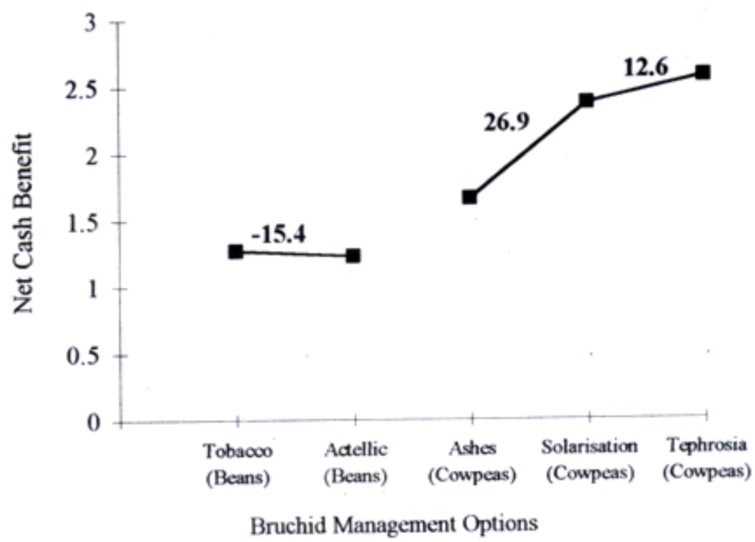

Figure 1. Grain bruchid control net cash benefit curve for adopting various management options.

increase in returns would be obtained by a farmer shifting from solarisation to use of tephrosia leaf powder in the control of cowpea bruchids in storage.

Conclusion

Economic losses attributed to bruchids in stored dry beans and cowpeas are substantial in Uganda where well-built storage facilities are not usually available at farm-level. While it is often possible for crops in the field to recover after an insect attack has been controlled, it is impossible for stored dry beans and cowpeas to recuperate after bruchid damage. Thus, a farmer participatory approach in the use of techniques that would allow beans and cowpeas to be kept in storage free of bruchids would clearly provide economic benefits to both bean and cowpea growers and consumers.

This research has demonstrated that wood ashes, solar heat and leaf powders of tobacco and tephrosia can be economically viable post-harvest protectants of dry and/or cowpeas for at least 3 months in farm storage despite the short-life repelling action of botanicals and the largely physical beneficial action of wood ashes. Since solar heat treatment has a negative effect on bean germination, this bruchid control method should be limited to cowpeas and to beans for food consumption only. The use of approved contact chemical pesticides such as actellic (1% a.i.) would be profitable for dry bean storage but the recommended dosage rates must strictly be adhered to and the food grains need to be washed thoroughly to remove the chemical from the seed coat. The consumer would probably prefer a safer protectant.

The additional economic benefits obtained from the tested bruchid control measures were realised mainly as either a result of higher returns from increased marketable and or sowable surplus or lower cost of grain protection. This revelation strongly suggest that post-harvest protectants must be evaluated from both a biophysical and an economic perspective. For example, solarisation of beans was viewed favourably from a biophysical perspective but this option was not found economically viable due to high rates of loss of seed viability and procurement cost of pit construction and plastics. Conversely, use of wood ashes to profitable cowpeas in storage did not apppear to be very efficacious from a biophysical view point but this protectant was preferred in an economic context because wood ashes are spare by-products from the farmer's kiln which would otherwise go to waste.

Given the opportunity to choose from the tested improved postharvest technologies farmers are expected to make rational decisions according to their real local agro-ecological and socio-economic situations. A farmer will try out the solution to the bruchid problem that does not involve too much risk taking in the social -economic context and that seems to be economically feasible.

The analysis scheme outlined in this study, that takes into consideration the actual cash costs and benefits involved in technological investments and ranks the improved technologies according to marginal rates of return, seems to be a rational way small-scale farmers would try out and adopt any technology, not to mention post-harvest technology.

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