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Farmer participatory development of a control strategy for the Variegated grasshopper with a biopesticide in the northern Mono, Benin

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Abstract

Farmers of two villages in Mono province, Benin, in collaboration with researchers of the biological control of locusts and grasshoppers program (LUBILOSA) at IITA, developed a use and marketing strategy for the biopesticide Green Muscle, an oil-based formulation of the entomopathogenic fungus *Metarhizium anisopliae var. acridum* for the control of *Zonocerus variegatus* L. Three different doses, two different sprayers and two different periods of control were tested. Farmers preferred the preventive treatment with a medium dose (20 g/ha) by ULV spinning disk sprayer. Half a day of training for a village brigade was found to sufficient to enable them to identify the egg laying areas and to apply the biopesticide. Farmers would prefer the producer to sell the biopesticide on credit, directly to the village association. The village brigade will treat the grasshoppers, and be reimbursed by the concerned farmers.

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INTRODUCTION

The variegated grasshopper (*Zonocerus variegatus*) is the only major grasshopper pest in the humid and subhumid zones of West Africa. It is most active by the end of the second rainy season and all the way through the major dry season. It especially attacks cassava in the major dry season from January to March, when this crop constitues most of the remaining green vegetation. Grasshopper attacks can be very impressive and have generated substantial donor support in the past. However, few studies have treated the economic impact of the variegated grasshopper. Crop losses have been simulated by cutting the leaves or the whole stem during the dry season. While one study found no impact at all (Baumgart 1994), another one (Page et al., 1980) found yield reductions of 36% but only when manual defoliation was carried out at monthly intervals during the dry season from November to March. This study indicates that grasshoppers only reduce cassava yields through damage at the end of the dry season, when natural leaf regeneration starts. No studies of yield loss on other crops are available.

The LUBILOSA program (Lutte Biologique contre les Locustes et Sauteriaux) has developed Green Muscle as a specific biopesticide for the control of locusts and grasshoppers. Green Muscle is an oil-based formulation containing the fungal pathogen *Metarhizium anisopliae var. acridum* (Prior et al. 1992, Bateman, 1997). After developing the technology, LUBILOSA started a third phase with more emphasis on implementation, incuding socio-economic analysis and farmer participatory research (De Groote, 1997). In 1997, LUBILOSA started a farmer participatory development of a control strategy for the variegated grasshopper, following the 4 standard stages (Werner 1993): exploring the demand, identifying different options, testing different alternatives, and assessing those alternatives.

Preliminary surveys and secondary data led to the hypothesis that demand for grasshopper control in Benin would be highest in the northern part of the Mono province. A survey in the dry season of 1990/1991 showed high variegated grasshopper densities (> 20 grasshoppers/m^2) in most of that area (Paraïso et al. 1992). A survey by the Ecologically Sustainable Cassava Plant Protection (ESCaPP) project in the countries of Nigeria, Benin, Togo and Côte d'Ivoire showed that problems with the variegated grasshopper are most important in the transition zone between rain forest and humid savanna (ESCaPP, unpublished data). For this zone in Benin, North Mono is the only region with substantial cotton production (Colnard 1995). The cotton marketing board has established a credit system to finance inputs, and cotton is the crop with the highest level of insecticide use in Benin. Application of the biopesticide developed by LUBILOSA is similar to that of cotton pesticides, and if it could be purchased through a similar distribution system, demand for the biopesticide can be expected where grasshopper densities are high and where cotton is an import crop. Both of these conditions are met in North Mono. Moreover, this zone falls in IITA's benchmark site for the derived savanna.

This potential demand for a biopesticide against grasshoppers was confirmed during an informal survey in January and February 1997 in 11 villages of North Mono. During group interviews, farmers consistently ranked the grasshoppers among three most important crop pests in their fields. Subsequently, three villages (Hontoui, Eglime and Zouzouvou) were chosen for a farmer participatory development of a grasshopper control strategy. Hontoui was chosen because of highly infested fields, Eglime and Zouzouvou were chosen because the Institut Nationale de Recherche Agronomique du Benin (INRAB) has permanently technicians based here for its research programme "Recherche Développement".

EXPLORING DEMAND FOR NEW TECHNOLOGIES OF GRASSHOPPER CONTROL

Methodology

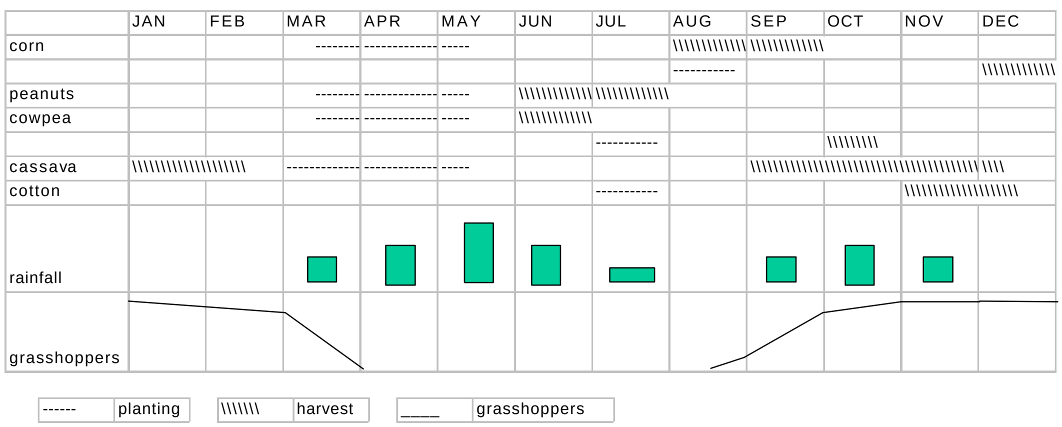
After a literature review and the study of secondary data, an interdisciplinary team, consisting of IITA scientists and officers of the Benin Plant Protection Service (PPS), performed a two day Participatory Rural Appraisal (PRA) in Hontoui in March 1997. The purpose was to understand the social organization of the village, the agricultural system, and the pest problems encountered by farmers. Several PRA tools were used (see Pretty 1995 for an overview) such as drawing a village map with a group of farmers, walking a village transect, conducting individual interviews as well as separate group interviews with younger men, older men and women, and ranking the most important crops and pests. The results were presented and discussed during a final general assembly of the village.

In Eglimé and Zouzouvou, general information was already available from the participatory research project conducted by the Institut National de Recherche Agronomique du Bénin (INRAB). One day of individual and group interviews per village was sufficient to obtain an overview of the agricultural system, crop pests and plant protection technologies.

Results

The climate in the Mono is subhumid with two rainy seasons. The agricultural calendar, as established by the villagers, is represented in Figure 1. In the first season (March-July), mainly maize, cowpea and peanuts are grown. In the second, short rainy season (September to November), cotton is the main crop, often planted between the corn rows. Most farmers only have one field at a time, and in this field oil palms are planted mixed in with the crops. When, after some years, the soil is depleted, the field is left in fallow except for the palm trees. The farmer moves on to an old palm orchard, cut the trees and clears the ground to start a new field.

Figure 1. The agricultural calendar in the Mono province.



The six most important crops for the farmers of Hontoui are presented in Table 1. Maize and cassava are the most important subsistence food crops, although a substantial part is sold. Cowpea and groundnuts are more important as cash crops than as food crops, while oilpalm is equally used for both purposes. Cotton is a pure cash crop.

Table 1. Evaluation by the farmers of Hontoui of the 6 most importance crops, as subsistence and cash crops.

Crop	subsistence crop	cash crop
Maize	++	+
Groundnut	+	++
Cowpea	+	++
Cassava	++	+
Cotton		+++
Oilpalm	++	++

+ less important, ++ important, +++ very important

In all three villages, the variegated grasshopper was mentioned as one of the three most important pests (first place in Hontoui and on the third place in Eglimé and Zouzouvou, see Table 2). Other pests, mentioned in at least two villages, were aphids, rodents, caterpillars and the larger grain borer,

Table 2. Farmers ranking of the 4 most important field pests, by village

Ranking in order of importance	Hontoui	Eglimé	Zouzouvou
1	grasshoppers	rats and aphids	snails
2	crickets		aphids
3	partridges	grasshoppers	grasshoppers
4	rats	caterpillars	stemborers of maize

In the group discussions, villagers remarked that although they have known the grasshoppers all their lives, only over the last 5 years had they become a major problem. They described the typical cycle of the grasshopper over the year, emerging at the end of the first rainy season to reach a peak at the end of the second rainy season or the beginning of the dry season. The grasshoppers decrease slowly in numbers over the dry season to disappear quickly at the beginning of the rainy season (Figure 1). Contrary to a study in Nigeria where farmers understood the egg laying behavior and the cycle of the grasshoppers (Page and Richards, 1977), farmers of the Mono know very little about their biology. They assume grasshoppers reproduce through eggs, although they have never seen them, and consider the larvae and the adults as two different species. They do observe a high mortality at the end of the main rainy season, which they attribute to the rainfall. Farmers don't have any efficient control methods.

All crops are attacked by the grasshopper, and farmers estimate that yield reduction can go up to 90% in cowpea and 33% in maize and cotton. Other impacts are the decrease in cassava tuber quality, the destruction of cassava cuttings, and the replanting of lost cuttings in the first rainy season.

In their fields, farmers commonly use two different sprayers: a cheap flit gun (external air-shear nozzle sprayer) imported from China and a spinning-disk sprayer (ULVA Plus, Micron L, UK). As there was an infested field in Hontoui, the farmers agreed to a demonstration treatment of that field with Green Muscle so that they could evaluate its efficacy.

IDENTIFICATION OF OPTIONS

Methodology

The identification of different options was based on literature review, analysis of secondary information and interviews with experts (Werner, 1993) and resulted in a list of potentially efficient grasshopper control methods. Different technologies are available (mechanical, chemical and biological), and can be used in different strategies (including timing, application methods, and organization). The criteria to choose which methods are most appropriate to the farmers resources were obtained from farmer panels in the three villages Eglimé, Hontoui and Zouzouvou.

Control technologies: mechanical, chemical and biological

The two major efficient methods to control the variegated grasshopper are the manual destruction of egg pods and the spraying of the first three instars with insecticides (Chiffau & Mestre 1990). The first control strategy was tested on the village level in southern Nigeria (Page & Richards 1977). In a communal action, farmers search for the sites where the grasshoppers lay their eggs and dig them out to destroy them. This method was found to be efficient because the Nigerian farmers have a good knowledge of grasshopper biology. Since the

Mono farmers showed little knowledge about grasshopper biology, the use of this technology is only possible with an efficient extension service. Unfortunately, the Beninese extension service is experiencing a severe lack of operational funds.

Most farmers in the north of Mono province use already use chemical insecticides, mostly on cotton but also on other crops (Olichon 1998). During the interviews they mentioned, however, that chemical insecticides do not kill the grasshopper and that they have only a repellent effect. Farmers in Eglime observed that insecticides in the past used to be more efficient against grasshoppers. Nevertheless, some farmers still spray chemical insecticides on the more susceptible first instars of the grasshopper, to their satisfaction.

An alternative to the chemical insecticide is the biological insecticide, developed by the LUBILOSA program. This biopesticide consists of an oil-based formulation of the conidia of *Metarhizium anisopliae var. acridum*, strain I91-609. Its efficacy against fifth instars and adults of the variegated grasshopper was shown in field trials), reducing grasshopper populations by about 90% after 15 days (Dourou-Kpindou & al. 1995). Ecotoxicological studies have indicated that it would be unlikely to have a negative impact on any non-target organisms.

Use strategies: timing, sprayers, and organization

Both chemical and biological insecticides can be targeted at the different stages of the grasshoppers. The variegated grasshopper typically gregarizes (concentrates) for egg-laying, so the first instars are concentrated in relatively small areas. Therefore, preventive spraying of these instars is limited to small surfaces only. Preventive spraying also has disadvantages. Grasshoppers often hatch in the fallow, where they are harder to find. They do not move very far, so treating fallow might be unnecessary, and they hatch over a period of several months, so several treatments are needed. Moreover, it is much easier to establish the threshold (the density at which when grasshopper control becomes cost efficient) for older instars and adults. On the other hand, older grasshoppers are more mobile and harder to control.

Different types of sprayers can be used, for chemical as well as for biological pesticides. The most common sprayers in the Mono are battery driven spinning-disk sprayers (type ULVA plus) and external air-shear nozzle sprayers. Spinning-disk sprayers are promoted by the cotton marketing board, and preferred by most farmers. Most of these sprayers are owned by the cotton producers association (groupement villageois or GV). The GV has access to credit for inputs and sprayers, based on a guaranty on the cotton harvest, on which the cotton marketing board has a marketing monopoly. External air-shear nozzle sprayers are very simple and cheap, but require more labor. Both sprayers can be used for ultra low volume (ULV) formulations and for EC (emulsifiable concentrate) formulations. Tests of the distribution of droplet sizes of the fint gun at CABI Bioscience, formerly the International Institute of Biological Control (IIBC), showed that it produces more droplets smaller than 50 µm, which can easily rise by convection in hot weather and get lost in the wind.

Given the migratory nature of most locust and grasshopper species, their control is not usually organized by the farmer, but on a higher level. In the Sahel, the PPS of many countries have organized village brigades to spray infested areas. In the past, they received training from the PPS, as well as free pesticides and equipment. Unfortunately, the structure and the functioning of these village brigades was mainly driven by the needs of the PPS, not of the farmers (De Groot 1995). They depend heavily on external support for subsidized pesticides, which donors are increasingly hesitant to provide.

The variegated grasshopper is not as mobile as Sahelian grasshoppers, so its control can be handled at the village level, or even by groups of farmers with adjacent fields. Treatment on an individual farm, however, seems difficult since many farmers have their fields spread over many kilometers. Therefore, some institution needs to be created with responsibility for the training of the farmers in grasshopper and the commercialization of the insecticide. For a sustainable solution, however, the mistakes of the Sahelian village brigades need to be avoided. A participatory approach was therefore favoured, aiming for a self-financed solution.

TESTING AND ASSESSING ALTERNATIVES

Methodology

After defining and studying the options, the use of the biopesticide (*Metarhizium anisopliae var. acridum*) was maintained as preferred technology. Different use strategies now needed to be tested. In the three research villages, farmers were asked to form a village brigade of 8 people to coordinate the grasshopper control activities. They each received a half day training. Only in Hontoui and Zouzouvou had serious grasshopper outbreaks in 1997, so work focussed on these villages. Both timing and sprayers were tested.

The preventive treatment of first instars was tested in October and November 1997, the period when most grasshopper hatch. The infested areas were sprayed by the village brigades, with the technical assistance of LUBILOSA. A formulation of 50 g of conidia powder ($5x10^{10}$ spores/gram) in a solution of 600 ml peanut oil and 1400 ml kerosene was used on a total of 19 sites, 10 of which with spinning disk sprayers, and the rest with flit guns. The members of the brigades were not paid for their work. The first 3 sites sprayed in each village were visited 10 and 21 days after the treatment by IITA scientists and the village brigades, and the brigade members were interviewed about the perceived efficicacy of the treatments.

The curative treatment of older instars and adults was executed by both village brigades in January 1998 in cotton fields, all in plots of 1 ha. Three replicate blocks were laid out, two near Zouzouvou and one near Hontoui, each block with six treatment plots and one control plot. Two different doses were used (2 g/ha, 20 g/ha and 50 g/ha), two different sprayers (spinning disk and flit gun), and the effect of technical assistance of LUBILOSA during the application. Details of the treatments are presented in Table 3.

Table 3. The different treatments of older instars and adults

treatment	dose	sprayer	technical assistance
1	2g/ha	spinning disk	yes
2	20g/ha	spinning disk	yes
3	20g/ha	spinning disk	no
4	50g/ha	spinning disk	yes
5	50g/ha	spinning disk	no
6	50g/ha	flit gun	no
7	0 (control)	no treatment	no

Quantitative data about the efficiency of the treatments have been collected and will be published in another paper. A summary of those data is presented in Table 3, to allow for a comparison with farmers' assessment. All blocks were visited blocks 12 and 21 days after treatment for an evaluation of the efficacy of the treatments. The members of the brigades received a meal as compensation for their work. The brigades were interviewed after visits and treatments.

Finally, a meeting between the brigades and researchers was organized in Hontoui in March 1998 and in Zouzouvou in August 1998, to discuss the institutional aspects of the grasshopper biological control as well as the organization of the marketing and distribution of the biopesticide.

Farmers' evaluation of the sprayers

Immediately after treatment, farmers had a clear preference for the spinning disk sprayer since it requires less labor. They did indicate, however, that low doses are easier to apply with the flit gun. Spraying one liter with this sprayer is such hard work that farmers often reduce the dose, while with spinning disk sprayer they have a tendency to increase the dose. Generally, farmers only use external air-shear nozzle sprayer when they do not own a spinning disk sprayer and when they do not belong to the GV, or when the GV doesn't have enough spinning disk sprayers, or when they don't have the cash to buy the necessary batteries.

For the curative treatments, farmers found the spinning disk more efficient as they found more cadavers in the plots sprayed with spinning disk. This could, however, not be confirmed by the quantitative data collected. The spinning disk sprayer was also preferred because it requires less labor.

Farmers evaluation of the treatments

Ten days after the preventive treatment, the farmers found some cadavers of the variegated grasshopper larvae, but did not observe a substantial decrease of population density. After 21 days, they found a lot of cadavers. They noticed a considerable reduction of grasshopper density, although they still observed many live larvae. Being informed that these larvae had hatched after the treatment, some farmers suggested that they would spray again two weeks after the first treatment.

Twelve days after the curative treatment, the farmers of Zouzouvou observed a high mortality in all the treatments except treatment 1 (dose of 2g/ha) and treatment 6 (flit gun sprayer). In those treatments, they found very few cadavers, so they considered them inefficient. Farmers of Hontoui, after 12 days, appreciated the efficiency of the flit gun nozzle sprayer treatment and found treatment 4 (dose of 50g/ha, Flit gun with technical support) inefficient. This was probably due to different temperature and wind conditions during the treatments. As Table 4 shows, farmers' observations coincided with the scientific observations of insect mortality. The second visit, 21 days after curative treatment, confirmed their comments of the first. They preferred the lower dose (20 g/ha) since only a small difference between 20 and 50 g/ha could be observed, and the cost for 20 g would be lower.

Table 4. Cumulative grasshopper mortality (%) 10 days and 20 days after treatment with biopesticide (50 g/ha), by sprayer and by treatment.

Villages	sprayer	preventive treatment		curative treatment	
		10 days	20 days	10 days	20 days
Zouzouvou, site 1	control	0	0	4	7
	ULV	94	100	85	100
	flit gun	100	100	0	8
Zouzouvou site 2	control	0	0	4	4
	ULV	70	88	58	92
	flit gun	69	86	12	38
Hontoui	control	4	4	8	8
	ULV	80	86	0*	32
	flit gun	69	81	32	68
Average	control	1	1	5	6
	ULV	81	91	48	75
	flit gun	79	89	15	38

* No wind during treatment

Strategies proposed by the village brigades

The members of the brigade of Hontoui prefer to spray the first instars. They feel that all farmers should participate in the search for the sites where the grasshopper is hatching. These sites can then be sprayed by the members of the brigade or by the farmers themselves. All farmers with fields adjacent to the site should pay for the biopesticide. The members of the village brigade would receive a certificate after receiving their training, and be officially recognized as representative and sole vendor for the biopesticide producer in the village. Earning a profit on biopesticide sales would offer the brigade an incentive to organize grasshopper control in the village and to train other farmers. The biopesticide needs to be sold in small quantities corresponding to the small areas to be sprayed, and simple manual should be provided. The biopesticide should be sold at a low price on credit.

The members of the brigade of Zouzouvou also prefer to spray the first instars, but propose another strategy. As most of the grasshoppers hatch at the border of the fields, every farmer needs to supervise his own fields. Those who observe grasshoppers in their field should pay for the biopesticide and remunerate the brigade, which will treat the site. The biopesticide needs to be sold on credit to the GV, who stores it and sells it on to the farmers.

DISCUSSION AND CONCLUSIONS

Half a day of training is sufficient for farmers to have a good understanding of grasshopper biology and to find the sites where the grasshoppers hatch. Farmers of both villages found spraying of the first instars more efficient. In Hontoui, a village which shows a stronger social structure and more solidarity, villagers prefer that the search for grasshoppers be organized on the village level, and that the cost of grasshopper control be divided over all farmers concerned. In Zouzouvou, the villagers prefer that grasshopper control is organized on the farm level. A partial explanation is that many fields are far away from the village center, among fields of farmers from other villages.

Farmers prefer the spinning disk sprayer; they would only use the external air-shear nozzle sprayer if no spinning disk sprayer is available or if they do not have money for batteries. The GVs usually lack sufficient sprayers, so many farmers only have access to the spinning disk sprayers when it is hot or when there is no wind, unfavorable conditions for their use. Quantitative data of the trials showed that the efficicacy of the treatments is more influenced by weather conditions than any other parameter. The lowest dose of 2 g/ha proved to be inefficient in all three replications. The high variability of the replication explains also the farmers contradictory evaluation of the efficiency of the external air-shear nozzle sprayer in the two villages.

Cash is a major constraint for most farmers in the Mono, so a credit system is highly desirable to make biopesticides available to most farmers. The brigades in both villages prefer to establish a direct relationship with the biopesticide producer, to avoid the extra cost associated with intermediaries such as distributors or extension agents.

So far, the results of the research have been positive: the farmers are interested, the technology is efficient and seems affordable. Ultimately, the adoption rate will show if there is a demand for the technology. To estimate the market in this area, the biopesticide will be offered on credit in a random sample of villages. The results will indicate if commercial production is feasible.

Women did not yet participate in the village brigades. A special survey indicated that they are also interested in biological control of grasshoppers, but that they would prefer a separate structure. The participatory research will therefore be repeated for women's groups in 1999.

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