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FARMER EVALUATION OF INTEGRATED PEST MANAGEMENT ON-FARM RESEARCH

By

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FARMER EVALUATION
OF INTEGRATED PEST MANAGEMENT
ON-FARM RESEARCH

IPM CRSP MALI SITE

March 4 - 16, 1996

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Abstract. IPM CRSP Mali site researchers, in conjunction with extension agents from the Protection de Végétaux (PV) and the Opération Haute Vallée du Niger (OHVN), conducted a participatory appraisal of 1995 on-farm integrated pest management (IPM) research. The evaluation was carried out March 4 -16, 1996, with 36 farmers at research sites in 4 villages in the Mourdiah and Sirakorola zones. Thirteen questions evaluated the pertinence of the trials; farmer comprehension of their objectives; the effectiveness and compatibility of the technology; the technology testing process; farmers' propensity for adoption; and diffusion and communication of the technology. The pest priorities identified in the 1994 participatory assessment, blister beetles (*Psalydolytta* spp. and *Melabris* spp.) and parasitic weed striga (*Striga hermonthica*), were confirmed by farmer ranking of pest severity, but the relative severity of these two pests was reversed in this evaluation, with striga on sorghum ranked higher than blister beetles or striga on millet. A range of other pests was also indicated by farmers, but no other single pest exceeded 12% of the responses given. Farmer collaborators displayed a moderately good understanding of trial objectives (1.5 on a scale from 1 = well understood to 3 = not understood), with understanding highest for light trap monitoring and the striga management trials. No significant difference was found between field interviewer evaluations of farmer responses and post-hoc researcher evaluation of farmer responses, indicating that the pooling of individual assessments by members of an interdisciplinary team is a reliable method. Farmers found integrated striga management, neem control of blister beetles, and striga resistant sorghum varieties, as all moderately effective in controlling the respective pest focused on by the trial (1.6, 1.9, and 2.0, respectively, on a scale of 1 = very effective to 3 = not effective). For striga management, farmers ranked their own practices lowest in yield but also lowest in labor requirements; conversely, they considered the combination of all striga management practices together to be the most productive but also the most labor demanding. Organic matter was seen as being less labor demanding and more effective in contributing to yield, compared to late weeding. Farmers had more difficulty with the technology of the striga management trial than with the use of neem in that trial, because of labor demands for alternate row seeding and the second late weeding. Farmers desired methods that reduced labor needs for seeding, including wider spacing, less thinning, and mechanical seeding. Farmers were interested in adopting light traps and neem use into their production system, and in learning how to produce neem extract. Some farmers were interested in adopting striga management practices, but not necessarily all together. The number of other farmers who visited trials was highly variable, ranging from 0 to greater than 20, with higher numbers having visited the neem trials, striga-resistant sorghum trials, and light trap monitoring (8-9 farmers) than the integrated striga management trials (5 farmers). Comments by other farmers visiting the integrated striga management trials focused almost entirely on the technologies tested. Their comments covered 11 aspects of the technology, but the closely related aspects of seeding, thinning, plant density, and method of association collectively involved 59% of the responses. Farmers visiting the neem and striga-resistant sorghum variety trials commented about equally on the technologies and on trial implementation issues. Farmer awareness of trials other than their own was highest for the light traps, and lowest for the neem and striga-resistant sorghum variety trials. Approximately half of the farmers either were unaware of the nature of other trials in the village, or had no awareness at all that there were trials besides their own trial type. The significance of these results is discussed in terms of a model of participatory technology development that combines the process model of technology generation and the diffusion model of technology adoption.

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I. INTRODUCTION

Crop production in the Sahelian/savannah Zone in Mali is limited by low and unreliable rainfall. It is made more difficult by a complex of insect, disease, and weed pests. Malian farmers prefer chemical pesticides as a pest management strategy (Koenig, 1993, cited in International Ag-Sieve), but the use of pesticides on subsistence cereal and legume grain crops has been low (Caldwell et al., 1994a). Factors that have curtailed their use are the removal of price subsidies, low average farm incomes, and restricted market access. Thus, there is an opportunity to develop appropriate pest management alternatives before farmers become highly dependent on pesticides, to improve the sustainability and viability of agricultural production for Malian cereal and legume grain farmers.

Participatory integrated pest management includes farmers in each stage of technology research and development. Local farmer knowledge can make important contributions to the development of improved agricultural technologies (Chambers et al., 1985; Warren, 1991; Nelson, 1994). Participatory evaluations of agricultural trials are conducted in order to access and incorporate farmer knowledge into the re-design of agricultural technologies. The process of subjecting technology development to farmer evaluation will help increase the probability of technology adoption and dissemination.

A series of integrated pest management trials was implemented with farmers during the 1995 crop season at research sites in 4 villages in the Mourdiah and Sirakorola zones of north central Mali. These trials were based on farmers' crop and pest management priorities identified in an initial Participatory Assessment (PA) conducted July 1994 (Caldwell et al, 1994b). The objectives of this report are: (1) to apply evaluation criteria perceived to be important for IPM technology with farmers in Mali; (2) to present findings from the assessment of the 1995 trials using these criteria and discuss their implications for subsequent IPM on-farm research; (3) to develop a model for technology development that combines farmer participation and evaluation of IPM on-farm research.

II. THEORETICAL APPROACH

Participatory research seeks to learn from local farmers. Along with scientific knowledge, local farmer knowledge is now recognized as a legitimate form of knowledge (Kloppenburg, 1991). Participatory evaluation of research is conducted with farmers in order to assess and understand their decision-making criteria regarding the characteristics and potential of technology (Ashby, 1990). Farmers and scientists use various criteria to evaluate technologies. Sometimes the criteria themselves are different, and other times each may prioritize the same criteria differently. Identifying and understanding these differences is a way to merge local farmer knowledge with scientific knowledge.

Establishing the criteria and priorities used by farmers to evaluate technology can contribute to the design and re-design of field trials, and to the development of technologies that are more likely to fit in with farmer circumstances. Technologies which are pre-adapted in this manner are more likely to be adopted in the long-run.

Farmers make decisions whether to adopt or reject new technologies based on a process of learning about new technology. The diffusion model of technology adoption (Rogers, 1983) describes a sequence of stages leading to the adoption decision (figure 1). In this model, technology is provided to farmers by research and extension. This model assumes that researchers have identified a real problem, and that the first step is to assess if farmers are also aware of the problem. The model also assumes that the technology offered to farmers is appropriate for the problem, and assesses how well farmers comprehend the technology and how positive a perception they have of it, as conditions for a favorable adoption decision.

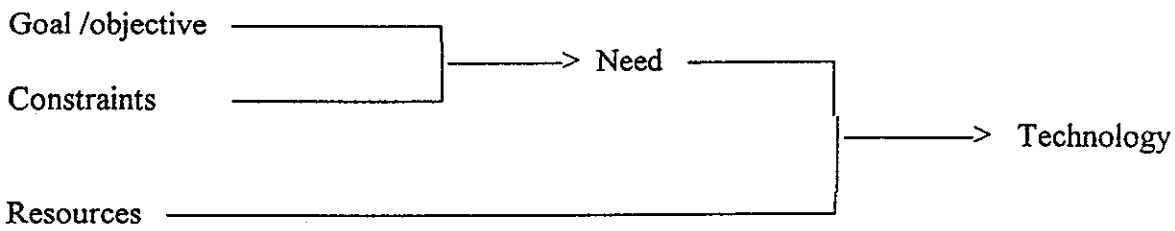
Figure 1: Stages of farmer learning in technology adoption decisions

Problem Awareness	Comprehension of technology	Perception of Technology	Adoption Decision

In participatory research, farmers are actively involved in the generation of the technology for which they ultimately make adoption decisions. Participatory technology generation can be described using a process model (Franzel, 1983; Frankenberger et al., 1987). The process model (figure 2) starts with farmer goals and objectives and asks, what constraints are preventing farmers from achieving their goals and objectives. These constraints may be due to the natural environment, resource limitations on or off the farm, or the socio-economic environment. The gap between unrealized farmer goals and objectives and the identification of constraints in turn indicates a need for the easing and, if possible, removal of those constraints. This model thus assumes that farmers

are aware of their needs. To address a farmer need, the model then asks, what resources are available, or could be brought to bear, on the constraints. Farmers already combine existing resources in their current management strategies; the task of technology development is to find new ways to combine existing resources and bring in new resources, to create new technology that overcomes the constraints, responds to the need, and enables farmers to achieve their goals and objectives.

Figure 2. A process model of technology generation



The process model and the diffusion model can be linked in a model of participatory technology development. In this combined model, technology generation and adoption follow a sequence of needs identification, technology development, and technology adoption and diffusion. Needs assessment is farmer-based. Technology development includes both a hardware component of materials and a software component of information on how to use the materials going into the technology (Rogers, 1983). Adoption and diffusion involve both use of the technology by collaborators in the technology development, and information exchange among collaborators and other potential users, leading to spread of the technology beyond the initial users who participate in its development.

In farmer evaluation of technology that is developed in a participatory manner, not only the technology itself, but also the process of technology development and the propensity for adoption and diffusion, are all evaluated. Five steps, each with associated criteria, are involved:

1. Pertinence

   The pertinence of the technology is assessed in terms of farmer constraints and needs, and measured by the success of the technology in meeting farmer needs. This provides a baseline to determine if the technology development process was properly targeted.

2. Comprehension

Farmer and researcher comprehensions of the technology are compared, based on the postulate that the more participatory the technology development is, the greater should be the correspondence between farmer and researcher comprehensions of the technology. Since in participatory research, technology design is based on participatory assessment of farmer needs, close correspondence also indicates that researcher understanding of farmer needs was accurate.

3. Technology effectiveness, compatibility, and complexity

Effectiveness is an outcome measure that refers to the clarity of benefits or the magnitude of results. A technology that would dramatically eliminate a priority pest, visibly raise yields, or lower costs of production would have greater effectiveness. Compatibility and complexity criteria are assessed both in terms of hardware and software components of the technology. Compatibility refers to the degree of difference of new technology from established technology, and may involve either hardware, software, or both. If a new technology requires less change, then it will be more positively evaluated. Labor is an important criterion that affects perceptions of compatibility in sub-Saharan Africa (Blackie, 1990; Cleaver, 1993). Technologies that reduce the demand for labor are often perceived favorably. Complexity is primarily a software criterion and refers to the degree of difficulty in using a new technology. Technologies that are more complex and. less understood will be considered more risky and thus less likely to be adopted.

4. Technology testing process

Parallel with technology itself, the technology testing process also has "hardware" and "software" aspects: on the "hardware" side, materials that are not part of the technology itself, but are used to carry out testing; on the "software" side, the manner of implementation and monitoring of the testing.

5. Adoption propensity, communication, and diffusion

The collaborators themselves involved in the technology development provide an initial assessment of propensity to adopt. Communication refers to the extent by which the technology and the testing process are being discussed among farmers. If communication is occurring, then more farmers will have input into the technology testing process, and a higher rate of final adoption and diffusion of technologies can be expected. Assessment by other farmers provides an indication of wider propensity to adopt and the potential for diffusion of the technology.

III. MATERIALS AND METHODS

Questions were developed through exchange of drafts between U.S.-based and Mali-based scientists in winter 1995-96. Some questions drew from the experience of Malian researchers in evaluating on-farm trials conducted by IER's farming systems team that has operated in the same region since 1987. The questions were used in a semi-structured interview format. Interviews were conducted with those farmers who participated in trials during the 1995 growing season. IER field agents based in the two zones arranged the interviews with farmers. The interviews were conducted by six researchers from IER and U.S. collaborating institutions and two field-based members, each from a local extension service operating in one of the respective zones [Protection de Végétaux (PV) in the Mourdiah zone and Opération Haute Vallée du Niger (OHVN) in the Sirakorola zone]. The team going to a given zone divided itself into sub-teams of 2-3 persons, and each sub-team conducted interviews with a sub-set of the collaborating farmers. All farmers were interviewed individually by the sub-teams. Most topic areas used a combination of quantitative, closed questions and qualitative, open questions. Of the 13 questions whose responses are reported here, five sought quantitative responses from farmers for analysis on a predetermined scale. One question had interviewers rate farmer qualitative responses using a closed scale; these ratings were also compared with post-hoc ratings given during analysis of the qualitative responses. Seven questions sought qualitative responses through open-ended questions and were analyzed by content analysis techniques.

IV. RESULTS

A. PERTINENCE

The participatory assessment conducted in 1994 established priority crops and problems on each specific crop. However, the incidence of pests is subject to annual and seasonal fluctuations and thus perceptions of priority pests can change. Farmers were asked "if the pest focused on by the trial was a problem during the growing season." They were asked to rank the pest as a severe problem (scored as 1); a moderate problem (scored as 2); or not a problem (scored as 3).

Table 1: Severity[z] of the pest during the past growing season

Pest	Trial type	Mean	Standard deviation
Blister Beetle	Neem	1.9	0.5
Striga (millet)	Integrated management	1.9	0.7
Striga (sorghum)	Resistant varieties	1.2	0.4
Flying insects	Light trap monitoring	1.7	0.5
Ground insects	Pitfall trap monitoring	2.0	0.0

z Severity: 1 = severe; 2 = moderate; 3 = not a problem.

Results shown in Table 1 indicate that the severity of the parasitic weed striga (*Striga hermonthica*) on sorghum was ranked higher than either striga on millet or blister beetles [*Psalydolytta* spp. and *Melabris* spp.(Coleoptera:Cantharidae)]. Blister beetles were of intermediate severity this year with several of the research sites reporting very low counts of blister beetles. Farmers considered the nocturnal flying pests focused on by the light trap monitoring to be somewhat more severe than the ground insects focused on by the pitfall trap monitoring.

Another aspect of pertinence is whether pests other than those that were focused upon during the previous growing season were important. Another question asked farmers to list pest priorities that were not addressed in their trials. Table 2 lists the pests and the proportion of total responses that the number of times each pest was mentioned represented. Each farmer could give up to 3 additional pests; a total of 51 responses were given by 36 farmers.

Table 2: Priority pests not addressed by trials

Pests	Proportion of total responses (%)
Insects	
lepidopteran larvae (raghuva)	12
grasshoppers	12
millipedes	8
stem borer	8
blister beetles	5
pachnoda	4
termites	2
total insects	51
Diseases	
mildew on millet	12
smut	4
total diseases	16
Birds	10
No others indicated	24

Although a variety of additional pests were mentioned, there was no systematic mentioning of a new pests species. Mildew on millet [*Sclerospora graminicola* (Sacc) Schröet], raghuva (*Heliocheilis albipunctella*), and grasshoppers were the most frequently given, but each represented only 12% of the total responses. Insect pests were more important than disease or bird pests, but these were divided among 7 types of insects. One fourth of the responses did not indicate other pests.

Considered together, the responses to both questions indicate that striga and blister beetles are considered to be important, if not priority, pest constraints. The choice of priorities for the trials is pertinent to farmer needs. We would expect that farmers would have good motivation to explore the application of appropriate new control technologies for these pests, because of the importance of these problems to farmers, and the consequent awareness farmers have of these problems.

B. COMPREHENSION

This question asked each farmer to provide their interpretation of trial objective(s). The purpose of this question was to assess farmer knowledge and understanding of field trials. This was an open-ended question in which farmers' responses were recorded by the interviewer. A total of 36 collaborators were interviewed. A second part of this question requested interviewers to evaluate the farmers' knowledge of objectives on a 3-point scale, where 1 indicated that the objectives were well understood; 2, that the objectives were partially understood; and 3, that the objectives were not understood. In the course of the analysis of the farmers's responses, a post-hoc evaluation of the farmers' understanding was also done by the authors of this working paper.

Table 3 shows that overall, farmer collaborators displayed a moderately good understanding of trial objectives (mean = 1.5). Farmers understood best the objectives of the light trap monitoring and the striga trials, followed by the neem trial. The objectives of the pitfall traps were least understood. For both light and pitfall traps, farmers occasionally confused insect control with identification and monitoring objectives. This reflects the fact the farmers' principle objective is pest control, not monitoring, which is what the traps were designed to do. Striga trial collaborators occasionally mentioned insect control in addition to striga control as an additional objective of these trials. This may indicate that farmers are aware of the overall objectives of the research program in the village but that they do not understand that each trial focuses on a specific problem. This also suggests, however, that a trial which combined practices for management of multiple pests might be easily understood by farmers.

Table 3: Interviewer and post-hoc evaluation of farmer-collaborator understanding of trial and monitoring objectives

Trial type	Farmer comprehension[z]		
	Interviewer evaluation	Post-hoc evaluation	t-test
Neem	1.7	1.7	
Striga	1.5	1.6	
Light traps	1.2	1.5	
Pitfall traps	2.0	1.9	
Total	1.5	1.6	NS

z Comprehension: 1 = well understood; 2 = partially understood; 3 = not understood.

A t-test of mean differences was used to assess the hypothesis that field interviewer evaluations of farmer responses were different from the post-hoc evaluation of farmer responses. No significant difference was found. This result indicates that the collective assessment provided by the pooling of individual assessments by different members of an interdisciplinary team of diverse interviewers is as consistent as a single assessment made a person who reviews all responses together.

The moderate level of farmer comprehension of trial objectives suggests that the level of farmer participation in the trials was also moderate. If the field agents and researchers carried out the trials with little interaction and discussion with farmers about the objectives of the trials and the cause and effect relationships of their results, then we would expect that the level of farmer comprehension of objectives would have been low. Conversely, if there had been very active farmer participation, then we would expect that the level of farmer comprehension would have also been high. Among the trial types, farmer comprehension was highest for light trap monitoring. This might be explained by the continuous farmer participation in lighting and extinguishing the light trap kerosene lamp. Each morning farmers could see how many insects had been collected compared with the previous evening when they had light the lamp. Farmer comprehension of the objectives of the pitfall trap monitoring was conversely low, which can be explained by the fact that only the agents serviced these traps.

C. EFFECTIVENESS

The first question in this category asked farmers to evaluate the success of the trial component in addressing the problem. The scale used to rank success was: 1, very effective; 2, partially effective; 3, not effective at all. Table 4 shows that farmers found integrated striga management, striga resistant sorghum varieties, and neem control of blister beetles as all moderately effective in controlling the focal pest. Although integrated striga management had the highest mean effectiveness (1.6), differences in effectiveness among the three trials were not significant (table 4).

Table 4. Farmer evaluation of the success of the trial

Trial type	Success of the trial[z] (mean ±std)
Neem	1.9 ± 0.3
Integrated striga management	1.6 ± 0.5
Striga-resistant sorghum	2.0 ± 0.0
Significance	NS

z Success: 1= very effective; 2 = partially effective; 3 = not effective.

Another question assessed perceptions of effectiveness in terms of yield improvement against compatibility as indicated by labor requirements. Farmers were asked to rank the integrated striga management trial treatments in increasing order of both yield and labor requirements. This trial was based on the common farmer practice of growing cowpea in association with millet. Treatment 1 utilized farmer's varieties and the farmer practice of mixing cowpea and millet seed together when seeding in rows. Treatments 2-5 utilized alternate rows of a striga resistant cowpea and the farmer millet variety, with differences involving weeding and organic matter application: treatment 2, striga resistant cowpea and alternate association without other practices; treatment 3, striga resistant cowpea, alternate row association, and late weeding; treatment 4, striga resistant cowpea, alternate row association, and organic matter application; treatment 5, striga resistant cowpea, alternate row association, late weeding, and organic matter. For yield, a rank of 1 indicated the most productive treatment and a rank of 5 the least productive; for labor, a rank of 1 indicated the treatment requiring the most labor and a rank of 5 the treatment requiring the least labor. Farmers were not always able to rank all the treatments; in some cases, they were only able to rank the highest and lowest treatments, for example. Hence, the number of responses was not equal for all treatments for the two criteria.

Farmers' considered that their own practices were more compatible in terms of labor requirements, but that the introduced practices were more effective in increasing yields (table 5). Specifically, farmers ranked the control treatment (their own practices) lowest in terms of yield but also lowest in terms of labor requirements. On the other hand, farmers perceived that the combination of all striga management practices together was the most productive, but at the same time also the most labor demanding. However, comparison of the results for treatments 3 and 4 shows that organic matter was seen as being less labor demanding while more effective in contributing to yield, compared to late weeding.

Table 5: Farmer ranking of yield and labor requirements of integrated striga management trial treatments

Techniques and measures	Treatment[z]				
	1	2	3	4	5
Seeding method	M	A	A	A	A
Cowpea variety	F	I	I	I	I
Late weeding	N	N	Y	N	Y
Organic matter	N	N	N	Y	Y
Yield[y]					
Mean	4.4	4.0	2.6	2.0	1.5
SD	1.0	1.1	0.8	1.3	1.0
N	8	5	5	8	9
Labor[x]					
Mean	4.3	3.3	1.8	2.4	1.3
SD	1.3	1.1	0.8	2.4	0.6
N	8	6	8	8	10

z M = mixed, A = alternate rows;
F = farmer variety, I = introduced striga-resistant variety;
N = no; Y = yes.
y 1 = most productive; 5 = least productive.
x 1 = most labor demanding; 5 = least labor demanding.

A follow-up open-ended question regarding effectiveness asked farmers what other control methods they would like to use against the targeted pest (blister beetles or striga). This question was interpreted as an indirect indication that the trial was effective if the farmers did not have other methods they would like to try.

For striga control, four farmers expressed interest in organic manure applications, even though organic manure was applied in two treatments in the striga trial. Six expressed interest in the manual uprooting of striga, but with several caveats. One farmer said he wanted to try this only if time permitted. Another said he would like do this but by the time he would be able to, the striga would have already done its damage. A third farmer asked for assistance to obtain a mechanical means to uproot striga.

For blister beetle control, several indigenous controls were suggested: use of burning tires, pounding striga and neem into a powder and mixing it with the seed, burying kola nuts in the field, and extracting the blister beetle abdomen and applying this to the crop. One farmer asked for chemical control products to be provided free as they had been (according to him) in the past. Six farmers said that they did not have any other ideas (besides what was being tried in the trial).

D. Technology Compatibility and the Technology Testing Process

One question in this category asked farmers to give up to three difficulties that they had with the trial, in order of severity of the problem (scale: 1 = most severe, 2 = second in severity, 3 = third in severity). A second question asked farmers what changes they would like to see in the way future trials would be conducted. Although not explicitly stated, this question followed the preceding question, hence the implication was that changes related to the problems cited in the previous question for the same type of trial. Responses to these questions provided information both about the compatibility of the technologies tested, and about the testing process. For both questions, the greatest difference in responses was between the neem trial and the integrated striga management trial.

1. Difficulties

Neem trial. Six neem trial respondents gave a total of 12 responses. Five (83%) of the farmers indicated that stakes were a problem (average ranking 1.2). Stakes made up 42% of the total responses given. This is a problem not associated with the IPM technologies tested, but with the need to mark off treatments and crop cut squares. All but one of the other problems cited involved general production constraints, rather than the IPM technologies tested. Only one farmer (17%) cited a difficulty related to the IPM technology tested in the trial, removal of leaves at the base of the plant (table 6).

Integrated striga management trial. Twenty farmers in the integrated striga management trial gave a total of 35 responses. In contrast with the neem trial, most of the problems were related to the IPM technologies that were tested in the trial. Alternate row seeding and the second late weeding were both seen as conflicting with farmer labor use. Thirteen (65%) of the farmers cited seeding as a difficulty (average ranking 1.3). Weeding was a problem for a greater number of farmers than thinning (50% vs. 25%), and weeding was a more severe difficulty (average ranking 1.4 vs. 1.8). Only 15% of the farmers gave non-technology-related difficulties (water, plowing; stakes). Two (10%) of the farmers had no difficulties with the trial (table 6).

Striga-resistant sorghum variety trials. Five farmers in this trial gave a total of 10 responses. No farmers cited problems associated with the varieties themselves. Seeding and weeding were the main problems cited, given as general constraints. All farmers cited weeding as a problem, but the average ranking of seeding difficulty was higher (1.3) for the farmers (80%) who cited it as a problem (table 6) .

Monitoring. For the light traps, five farmers in three villages gave 11 responses. Difficulties associated with the light trap varied from village to village, but all involved conflicts with other farmer activities. Lighting the trap each day was the most constraining activity (80% of the farmers). Obtaining stakes was the only problem cited by the farmers who had pitfall traps (data not shown).

Table 6. Number of farmers (n) and mean ranking (X) of difficulties in establishment and implementation of IPM trials

Problem	Trial type					
	Neem		Integrated striga mgt.		Striga-resistant sorghum	
	n	X	n	X	n	X
Technology-related						
Leaf removal	1	1.0				
Seeding			13	1.3		
Spacing			1	1.0		
Thinning			5	1.8		
Weeding			10	1.4		
Organic matter			1	3.0		
Testing process						
Stakes	5	1.2	1	2.0		
General constraints						
Water			1	1.0		
Plowing			1	2.0	1	2.0
Seeding	1	3.0			4	1.3
Weeding	1	2.0			5	1.6
Harvest	2	2.5				
Threshing	1	3.0				
No problems	1	1.0	2	1.0		
All responses	12	1.7	35	2.5	10	1.6

2. Changes desired

Neem farmers. Changes desired by neem farmers (five farmers responded to this question) mostly involved the testing process (67% of responses), with a reduction in the number of plots being the most frequently cited desired change. None of the changes given involved the IPM technology itself (table 7).

Striga management farmers. Most of the changes desired by the 10 integrated striga management farmers who suggested changes in the trials involved seeding (29% of their responses) and spacing (36% of their responses). These farmers desired methods that reduced labor needs for seeding, including wider spacing, less thinning, and mechanical seeding. This suggests that the alternate row system as implemented was seen as these farmers as being too labor demanding. One third of the 15 trial farmers had no suggestions for changes in the trials (table 7).

Striga-resistant sorghum. Half of the six responses given by the five farmers in the striga-resistant sorghum trial at Koroma indicated a desire for larger parcel or trial field size. Another 33% of the responses indicated a desire to change to varieties other than 'Malisor' varieties used in the trial (data not shown). The improved varieties may not be acceptable to farmers for taste reasons. The results of the palatability trial may clarify this.

Monitoring activities. A majority (60%) of light trap farmers had no suggestions for change. The remainder (40%) thought that the light trap was an insect capture method and made suggestions in that regard (data not shown).

Table 7. Trial changes desired by collaborating farmers

Problem	Trial type	
	Neem	Integrated striga mgt.
Technology-related		
Seeding method		1
Increase spacing		3
Respect spacing		1
Retain traditional thinning		1
Testing process		
Provide stakes	1	1
Reduce number of plots	2	
Increase area		1
Use a mechanical seeder		3
General constraints		
New varieties	1	1
Seed treatment	1	
Weed control		2
Don't know, no changes		3
No response	1	2
Total responses	6	19

E. ADOPTION PROPENSITY

Farmers were asked to assess indirectly their adoption propensity based on their overall evaluation of the trials and their interest in continuing as trial collaborators. Although it is much too soon after only one growing season to expect that farmers will adopt trial technologies, we were interested to see if farmers were forming positive or negative impressions of the trial technologies. Farmers were asked which trial practices they were planning on adopting and the possibilities of inserting them into their production system.

Those farmers who had used light traps were all interested in adopting them into their production system. However, they liked the light traps because, as one farmer stated, "the insects die". Thus, many of the farmers perceive light traps as an effective control device, rather than as the monitoring tool it was used for. Reservations regarding the light traps expressed by several farmers concerned the cost and availability of supplies needed to operate the traps.

All participating farmers were very interested in using the neem technology. Most farmers also expressed an interest in "learning how to produce the neem extract".

The results for this question regarding the striga trials were more complex, paralleling the greater complexity of the trials themselves. Seven farmers expressed interest in adopting organic manure. However, follow-up studies are needed to determine the availability of manure, its economic cost, and the amount of labor required for its application. Seven farmers expressed interest in adopting the improved seeding method which combined the new variety of cowpea planted at a higher density in the alternate row arrangement, and thinning of millet. The perception was that the increased cowpea density increased overall production and that the millet thinning both reduced plant competition and conserved moisture. Six farmers expressed interest in adopting all the components together: new cowpea variety with higher density in alternate rows, millet thinning, the additional late weeding, and the use of organic manure. However, six farmers also expressed concerns about labor needs for these practices. One farmer stated that, "thinning increases yield but I don't have the labor". Another expressed the opinion that the new practices are "possible on a small area but on a large area the workers would get tired".

F. Communication and Diffusion

For the trials to have broader impact, the technologies being tested need to be widely discussed and diffused in the villages. To assess this, farmers were asked how many other farmers had visited the trial and what was discussed with those visiting farmers.

The number of other farmers who visited trials was highly variable, ranging from 0 to greater than 20. Higher numbers (8-9 farmers) visited the neem trials, striga-resistant sorghum trials, and light trap monitoring than the integrated striga management trials (5 farmers) (table 8).

Table 8. Number of farmers who visited trials

Trial type	Village					
	Dontiéri-bougou	Koroma	Doua-bougou	Koïra	Overall	N
Neem	8.7 ± 5.5	0, many			8.7 ± 5.5	5
Integrated striga mgt.	8.3 ± 8.1		2 ± 2.6	5.6 ± 3.8	5.1 ± 5.8	18
Striga-rest. sorghum		8.3 ± 8.8			8.3 ± 8.8	5
Light traps	Many	10, many	5	10	8.3 ± 2.9	6

Farmers visiting the neem trials commented about equally on insect control and damage (57% of 7 responses on ideas discussed) and implementation issues (43% of 7 responses on ideas discussed) (Table 9).

Comments by other farmers visiting the integrated striga management trials focused almost entirely on the IPM technologies tested (86% of 21 responses on ideas discussed), but there was great diversity in their comments (11 aspects, with multiple responses on only 4 aspects). The largest number of responses involved the alternate row seeding method (28% of these responses). This was also the only issue commented on by one or more farmers across all the three villages that had this trial. Moreover, when closely related aspects of number of times of seeding, thinning, plant density, and method of association are combined with seeding method, these aspects together predominate, involving 56% of these responses (Table 10).

Table 9. Ideas exchanged among farmers on neem trials

Idea	Village			
	Dontiéri-bougou	Koroma	Doua-bougou	Overall
Technology-related				
Blister beetle control	2	1		3
Insect damage	1			1
Testing process				
Staking	1			1
Choice of field		1		1
Plot layout		1		1
No ideas exchanged	1		1	2
No visits		1		1

Table 10. Ideas exchanged among farmers on integrated striga management trials

Idea	Village			
	Dontiér-bougou	Doua-bougou	Koïra	Overall
Technology-related	10	3	5	18
Trial objectives		1		1
Comparison with rest of farmer's field		1		1
Seeding methods	2	1	2	5
No. of seedings	1			1
Thinning	1		1	2
Density	1			1
Method of association			1	1
Fertilization	1			1
No. of weedings	1			1
Varieties used	1		1	2
Impossibility on a large scale	2			2
Other			3	3
Cowpea pests			1	1
Lack of water			1	1
Stand			1	1
No ideas exchanged	1	1		2
No visits		1		2

Comments by other farmers on the striga-resistant sorghum variety trials were equally divided between comments on the new varieties and comments on implementation methods (small area, plot layout). Comments by other farmers visiting the light and pitfall traps focused most on the methods

of insect capture (50% of responses given), followed by implementation issues (lighting and extinguishing, 38% of responses given) (data not shown).

Farmers were asked if they were aware of other trials and monitoring activities conducted in the village. More farmers were aware of the light traps than the trials (table 11), perhaps because the light traps are so visible at night in the village. One farmer stated that the light traps "permit us to identify the pests and after identification one can find control measures against these pests." Another farmer indicating a commonly held impression that the light traps were effective control devices stated, "I like the light traps because they capture lots of insects during the night". An almost equal number of farmers were aware of the integrated striga trial, perhaps because of the obvious difference from farmer practice of the alternating row system. The neem and striga-resistant sorghum variety trials were not well known by non-collaborating farmers. Prior to neem application, a millet field to receive neem would not look any different from a millet field not to receive neem, except possibly for the presence of stakes delineating areas to be treated. If a non-collaborator did not observe neem application or talk with the collaborating farmer, unless there was a dramatic difference in insect damage, even after treatment the non-collaborating farmer would probably not recognize that a field of millet on which neem had been applied was different from another millet field that had not received neem application. Approximately half of the farmers were either aware simply that there were other trials in general, but without awareness specifically of what those trials involved, or were not aware at all of trials other than their own trial type.

Table 11. Awareness of other trials

Responses	%
Aware of light traps	28
Aware of integrated striga trial	24
Aware of striga resistant sorghum varieties	4
Aware of neem trial	0
Aware of other trials in general	24
Not aware of other trials	20

V. CONCLUSIONS

Applying the combined model of participatory technology development to the farmer evaluation of these IPM field trials in Mali requires an assessment of each of the evaluative criteria established in the model. The model starts with pertinence and comprehension as criteria for assessing selection of the problems focused on by the trials. It then uses effectiveness, compatibility, and complexity as criteria to assess the technology itself and the technology testing process. Finally, it uses adoption propensity, communication among farmers, and diffusion to assess the broader relevance of the technology as well as the degree of involvement and awareness of farmers of the overall participatory research effort beyond the specific trial they are carrying out. These criteria thus model a technology generation research process, and their application can suggest alterations or continuance of trials in subsequent research.

Viewed in their totality, the results presented above indicate that the trials are pertinent, but that there are important differences in farmer assessment of their effectiveness and compatibility. The results also show that there is need for increased farmer participation to improve comprehension, communication, and diffusion, to increase the effectiveness and long-term farmer ownership of the research process. These results lead to nine implications for subsequent research.

First, the results confirm the pertinence of the selection of priority pests made in the 1994 PA, blister beetles and striga, but indicate that the relative ranking of these pests and their relative importance on the two main cereal crops are different. In the 1994 PA, blister beetles on early millet were the highest pest-crop priority combination in three of the four villages (Caldwell et al., 1994b). In contrast, in these results based on the 1995 season, striga on sorghum is ranked as the most severe problem. Striga on millet may be perceived as a less important problem because, paradoxically, millet is generally considered the farmers' most important crop; millet may be more likely to planted nearer to the villages than sorghum, receive more intense surveillance and care, and benefit from the majority of organic matter returned back into the system. Participatory mapping of crops on farmers' fields and their rotations during the past three years, together with a follow-up study on organic matter use, could help verify this interpretation of the reason for farmers' perception of striga on sorghum as being a more severe constraint.

Blister beetle infestations were low at all sites this year. Another coleopteran species that has recently entered Mali from Niger, *Rhinyptia infuscata* (Coleoptera:Scarabaèidae), was reported in higher numbers this year. Insect populations can fluctuate from year to year based on annual variation in rainfall and other environmental factors. The PA results probably provided a better indication of farmers' average assessment of relative pest severity based on a qualitative, informal integration in their minds of observations over many years. At the same time, it is important to monitor insect population change, not only to document yearly variation, but also to capture potential longer-term shifts in relative distributions of species. Hence, we believe that neither the change in farmer ranking of relative priorities in this evaluation nor the 1995 insect population data argue for discontinuance of the research focus on blister beetles. Rather, counts of this new species and assessment of the effectiveness of neem against it should be included in the data collected in the trials

of neem application on early and late millet.

The importance that farmers gave to flying insects may indicate that the light traps, designed to monitor nocturnal movement of pests, also served to expose farmers to other pest species, and that farmers saw the collection of insect species by the traps as indicative of their problematic status and the light traps as a means to control these species. PV has used light traps as a control technique in their extension program, and we recommend that their experience be assessed by the IMP CRSP research team.

Second, collaborators displayed only a moderately good understanding of trial objectives. Given the results on pertinence presented above, that the trials are addressing farmer priorities, this finding indicates that there is room for improving the participation of farmers in trial implementation. We recommend that the field agents and IER researchers increase their interaction with farmers, by insuring that farmers are involved in each key step of technology application, and discussing with them what the technology will do before each step. For example, if the farmer goes to the field with the agent when the date to apply neem based on percentage flowering is nearing, they can both discuss together the importance of preventing insect buildup before grain formation. The agent can pose questions to guide the farmer to make the actual decision to apply. In this way, farmer understanding of the objectives and methods used during trial implementation could be increased.

Third, farmer evaluation of effectiveness was also only moderate. This may be due to several causes. In the case of neem, the fact that blister beetle pressure was low meant that dramatic reductions could not have been expected in any case. It may also be that farmers are reluctant to consider a technology highly effective based only on one year's experience with it. Farmers may be mentally projecting the performance of the technology observed in one season across their accumulated experience with insect pest pressure, and making a more conservative judgment.

Farmers who participated in the neem trials were very interested in continuing with this practice and most expressed an interest in learning the method for neem extraction. However, recognition and visitation by collaborators in other trials to the neem trials did not occur. The low visibility of these trials needs to be corrected. We suggest that neem extract preparation be done at the village level. Additionally, trials could be marked with a sign in Bambara (taking advantage of *alphabétisation*, the Malian adult literacy program active in the villages) that would indicate the type of trial taking place. Finally, when village level field agents are sampling and taking counts, the involvement of other villagers in this process might diffuse the technique of sampling and aid in pest identification.

Fourth, there was an important difference in farmer evaluation of technology compatibility between the neem and striga management trials. Farmers did not cite labor problems associated with neem application. This likely reflects absence of other conflicting labor needs at the time of neem application as the crop nears maturity, and most weeding at earlier stages of crop growth has been done.

In contrast, compatibility was an issue with the increased labor associated with late weeding and organic matter application in the striga management trial. Farmers traditionally stagger planting dates from field to field, because of the uncertainty of which date will benefit from the best rainfall distribution. The late weeding can thus conflict with a more critical early weeding of a later planting that the farmer may judge to have a better chance of giving a higher yield under the actual rainfall of the year in question. Also, organic matter application comes at the time of field preparation, another critical period, when farmers are trying to be prepared for the uncertain start of rains.

The farmer comparison of the compatibility criterion of labor requirements with the effectiveness criterion of yield in the integrated striga management trial thus reveals a classic contradiction between labor use and productivity found in many primarily subsistence oriented farming systems in sub-Saharan Africa. Despite demonstration of enhanced productivity, new technology that requires additional labor is often not adopted because the subsistence goal can be met using traditional production practices that are less labor intensive. Boserup (1965) and Ruthenberg (1980) have argued that adoption of production-enhancing technologies that increase labor demands will only occur when at least one of two conditions are met. The first condition is that there is a perception by farmers that production is in precipitous decline because of over-exploitation of soil resources. Boserup maintains that over-exploitation occurs when population density requires intensification of the use of land resources to meet subsistence requirements, due to loss of adequate fallow years and land use consequently exceeding the regenerative capacity of the soil. The second condition is that markets appear that offer a cash return over and above subsistence needs.

Malian agriculture is a transition agriculture, moving in the direction of the fulfillment of these conditions. The above results are thus very relevant to this transition and lead to suggestions for further research to better understand how the transition is now occurring. Land has until recently not been a major constraint, but shortages of better land are beginning to appear in some places. Farmers' perceptions of the availability of productive land for their subsistence cereal crops thus could be the focus of participatory discussions during and after the season. Grain markets have only been liberalized in recent years, and road infrastructure in Mali to provide access to such markets is not very good. Assessment of market access and farmers' perceptions of returns from markets could help in assessing the likelihood that there might be sufficient potential financial incentives to justify the additional labor of the integrated striga technology. This assessment can also help better reveal farmer goals and objectives, the driving force of the technology generation model, to make it more effective for agricultural change under transition.

Fifth, another conflict appears in the integrated striga trial that has implications for the technology testing process. This is the conflict between the interest of farmers in partial adoption and the demonstrated synergistic effects of a combination of practices. Researchers have often brought combinations of practices to farmers as a package, precisely because of the positive, synergistic effect on yield of such combinations. However, farmers have often chosen to adopt incrementally, either because of labor constraints associated with some of the practices, or because of risk associated with multiple simultaneous changes.

In this case, the data suggest that late weeding is both the most problematic and the least effective of the practices in the combination. Treatment 3, which combined all the practices except late weeding, was considered by the farmers to be almost as effective as the complete set of practices, treatment 5. The alternate row system alone was perceived as having little yield advantage over the farmer control, but when combined with organic matter, the yield ranking moved to second place. The two row systems (mixed seeding vs. alternate rows) could be compared with and without organic matter, and labor monitored carefully to assess whether there is enough synergistic gain to justify the increased labor associated with the alternate row system in combination with organic matter use.

Sixth, results also revealed a logistical problem in the technology testing process, in the supplying and using of stakes to mark treatments and sampling areas in trial fields. This is a recurring problem in on-farm trials in Mali. Field agents and farmers are both busy with trial establishment at the time the stakes are needed. If the field agents could prepare stakes during the off-season and store them, this could be a way to resolve this problem. With more explanation to farmers of why stakes are needed, farmers could also be better motivated to help the agents in the off-season. Perhaps the stake preparation process could be turned into a group activity, with music and traditional tea, and in the process informal discussion about the trials carried out.

The problem of supplying and using stakes to mark fields may also be related to the cultural phenomenon of bias against "picky work". The Bambara adjective for this is *ka misen* and the word in French is *mesquine*. An explanation for this phenomenon may be that farmers in Sahelian Africa have traditionally practiced an extensive agriculture. With low population pressure farmers have not had to intensify production practices with more detailed work. Examples of more detailed work inherent in the intensification process are row planting, marking of field boundaries, precise application of inputs, and pest identification and knowledge. Thus, when we propose to introduce new production practices that entail more detailed work, cultural resistance is encountered. This reflects a lag between changing demographic conditions and farmer modes of production.

Seventh, the results on propensity for adoption paralleled the results for compatibility, with a higher propensity to adopt the neem technology. This propensity could be acted upon by giving farmers control over the technology. Currently, none of the villages have a neem press, since the research team only has access to one neem press. We recommend that the team explore with non-governmental organizations the possibility of their collaborating to make presses available to villages and to develop an educational program in neem collection and oil extraction.

Eighth, the results on communication and diffusion of information about the trials indicate a need to strengthen the social characteristic of technology generation. Indigenous knowledge is shared socially, and on-farm participatory technology can be more effective if it builds on this characteristic. Only half of the farmer-collaborators were aware of the nature of the other trials on-going in their villages. We recommend that additional activities be built into the research program to increase opportunities for farmer-to-farmer sharing of knowledge about and input into the planning and implementation of the trials. Collaborating and non-collaborating farmers can be linked by planning pre-trial discussions and by field days conducted during the growing season. Additionally, an idea

suggested by several farmers is that they be given the opportunity to visit other villages carrying out same trials, to observe the trials and discuss them with the farmers in those villages. Such efforts can contribute to more farmer-initiated and farmer-led research. In essence, having first demonstrated a participatory research process with individual collaborators, through a planned socialization of that process, researchers can facilitate farmers taking over more of the process in the future.

Finally, ninth, this evaluation should be seen as the beginning of an on-going evaluation and research process. By maintaining a reasonably consistent instrument over the course of the research in the coming years, a long-term data base for evaluation of research impact can be established. At the same time, the instrument can be improved through increased precision of the questions. The conceptualization and measurement of variables needs to be better standardized. Varying scales and measurements impedes the use of more robust statistical procedures. Several questions were eliminated or modified because farmers were unable to ascertain differences or interpret gradations implicit in some of the scaled responses. For example, this evaluation revealed that ranking of multiple treatments is best understood by farmers if they proceed through a process of elimination, starting either with the best or the worst treatments, and then selecting the next best or next worst. Intermediate treatments are thus revealed as those that remain after elimination. We also found a need to make clearer the difference between the evaluation of severity of different pests on the same crop versus evaluation of the severity of the same pest on different crops. The problem is not that these evaluative comparisons are too complex for farmers, but that researchers need to learn how to express these distinctions in comparisons in language understandable by farmers. This in turn stimulates farmers to make more explicit the criteria that they have until now used more implicitly.

The evaluation process also can be improved. Greater participation by research scientists in this exercise would be one suggestion. Research scientists have much to learn from farmers, and this learning can help them modify field trials to meet farmers' needs better. The use of interviewer pairs should be retained. This facilitates separation of questioning by one person and recording of responses by another. Conducting another evaluation in group settings might be a useful mechanism for diffusing trial technologies if done during the growing season in the field.

Overall, this first farmer evaluation of on-farm IPM research was deemed a success by farmers, researcher scientists, and field agents. Farmers were more than willing to participate, spending an average of 45 minutes each answering questions. Research scientists recognized that they learned from farmers and gained a better appreciation of farmer circumstances and pest management problems at the research sites. Field agents were pleased to receive recognition for their many months of hard labor.

In essence, in participatory evaluation of on-farm IPM research, the research team is serving as facilitators for more organized farmer self-assessment. In this way, participatory research can become not only research to generate new IPM technology, but research to develop a farmer-led technology generation process. At the end of this research, if farmers are left with such a process and independent capacity to apply it to their pest management needs, they will have tools they will need for sustainable integrated pest management under future changing environmental and socio-economic conditions of transition agriculture.

VI. REFERENCES CITED

Ashby, J.A., (1990), "Small Farmers' Participation in the Design of Technologies." In: M. Altieri and S. Hecht (eds.), Agroecology and Small Farm Development. CRC Press, Boca Raton, Florida.

Blackie, M.J., (1990), "Maize, Food Self Sufficiency and Policy in East and Southern Africa." Food Policy, October.

Boserup, E., (1965), The Conditions of Agricultural Growth. Aldine Publishing Company, Chicago.

Caldwell, J.S., C.R. Richards, and D.B. Taylor, (1994a), Planning for IPM CRSP Implementation. Trip Report Ma-1. IPM CRSP, Blacksburg, Virginia.

Caldwell, J.S., M. Erbaugh, F. Dunkel, R. Balakrishnan, S. Kyamanywa, and D.B. Taylor, (1994b), Participatory IPM Assessment for the OHVN Zone of Mali. Trip Report Ma-2. IPM CRSP, Blacksburg, Virginia.

Chambers, R., A. Pacey, and L. Thrupp, (1989), Farmer First: Farmer Innovation and Agricultural Research. Intermediate Technology Publications, London.

Cleaver, K.M., (1993), "A Strategy to Develop Agriculture in Sub-Saharan Africa and a Focus for the World Bank." World Bank Technical Paper: No. 203, The World Bank, Washington, D.C.

Frankenberger, T. (technical ed., 2nd ed.); S. Franzel, M. O'Dell, M. O'Dell (technical editors, 1st ed.); L. Walecka (coordinating editor), (1987). Diagnosis in Farming Systems Research and Extension. FSR/E Training Units Vol. I (2nd. ed). Farming Systems Support Project (FSSP), University of Florida, Gainesville, Florida.

Franzel, S., (1983). Process Model. Gambia FSSP Workshop, Banjul, The Gambia (mimeo).

Kloppenburg, J., (1991). "Social Theory and the De/Reconstruction of Agricultural Science: Local Knowledge for an Alternative Agriculture." Rural Sociology, Winter 56 (4):519-548.

Koenig, D., (1993), "Chemicals in Context: Why Farmers in Mali Prefer Pesticides", International Ag-Sieve, excerpted from (unpublished paper) "Understanding Farmer Responses to Pest Management Initiatives: An Illustration from Mali." Vol 5(6), Natural Resource Institute, Kent, United Kingdom.

Nelson, K., (1994), "Participation, Empowerment, and Farmer Evaluation: A Comparative Analysis of IPM Technology Generation in Nicaragua." Agriculture and Human Values 11(2-3): 105-125.

Rogers, E., (1983), Diffusion of Innovations. Free Press, New York.

Ruthenberg, H., (1980), Farming Systems in the Tropics. Clarendon Press, Oxford.

Warren, M., (1991). "Using Indigenous Knowledge in Agricultural Development." World Bank Discussion Papers:127. The World Bank, Washington, D.C.