Participative farmer testing of low input technologies*

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On-farm testing, involving effective farmer participation, is an essential tool in developing improved technologies that address issues faced by farmers. But such testing is often hampered by practical problems. For example, some practices that need to be included for comparative purposes—and for maintaining scientific rigor—simply hold no immediate attraction for participating farmers. Discussed here are some ways to overcome this obstacle, based on experiences in testing four low-external input technologies with farmers in Mono province, Benin; the tests aimed to arrest or reverse declining soil fertility. The authors stress that addressing a real issue the farmers face is vital to ensure their wholehearted participation in on-farm research.

Introduction

Participative experimentation of technologies by farmers was initiated in early 1986 in Mono province, Benin, within the framework of a project called "Recherche appliquée en milieu réel" (RAMR). This project is carried out jointly by the Beninois Institute of Agronomic Research, with technical assistance from the Royal Tropical Institute (KIT) in Amsterdam, the Netherlands, and the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria. On-farm experimentation has aimed at the development of a methodology for both increasing farmer participation and enhancing interdisciplinary collaboration. Another objective has been to develop feasible technologies that can effectively be spread by extension agencies, with a good potential for a high degree of farmer adoption.

The RAMR project is active in regions typical of three major ecological zones of southern Benin. This paper deals with experiences on the Adja plateau, representing one such zone. The traditional system of restoring soil fertility here is based on a 12–15 year planted fallow of a dense (800–1800 trees ha^{-1}) oil palm grove, which is economically attractive because of the palm wine output when the fallow is cleared. This palm wine is further distilled into marketable liquor. Due to mounting demographic pressure, the system is no longer viable and decline in soil fertility is a major concern for farmers (Kang et al. 1991).

Historical background

Experimentation on soil fertility, 1986–89: an exploratory phase

In 1986 and 1987, on-farm varietal trials were originally started with fertilizer applications. The trials indicated significant fertilizer responses in maize fields, although in about half of the fields, the application produced less extra maize than is needed (750 kg ha^{-1}) to reach a benefit/cost ratio of two (Versteeg and Huijsman 1991). Very large variability was found among farmers' fields and a considerable number of them produced poorly (Fig. 1).

At the same time, the team installed some researcher-controlled demonstrations of novel technologies, such as alley cropping, cover crops, and live mulch. These demonstration fields were very important for on-farm participative experimentation later on.

In 1987, two pioneer farmers volunteered to plant 4-m spaced *Leucaena leucocephala* hedgerows on rather infertile plots. The hedgerows showed a very slow development, but nevertheless reached a reasonable establishment after about $2^1/_2$ years. The experience of these pioneer farmers, who were partly interested in the production of fodder for goats, also proved useful in later discussions with the farmers.

In 1988, on-farm trials were started with short-season fallows of pigeonpea and mucuna (*Mucuna pruriens* var. *utilis*). The pigeonpea tests exposed the very exhausted soils, where this crop barely grew, but mucuna seemed to perform better in similarly poor spots. Mucuna tests were initiated mainly on farmers' initiative, not so much to address the soil fertility issue, but to tackle a serious problem from the weed, *Imperata cylindrica*. Farmers were very impressed by the smothering of this weed in the demonstration field. The trials decisively confirmed mucuna's effectiveness in smothering imperata (Versteeg and Koudokpon 1990), and they also showed its powerful soil fertility potential (Table 1). As a result, mucuna became very popular during the successive years.

In 1989, farmers with very exhausted fields were invited to plant either mucuna (annual cover crop solution) or *Acacia auriculiformis* (perennial agroforestry solution). In that same year, an animal production section was added to the on-farm research (OFR) team, which assisted in installing alleys of leucaena and gliricidia in six farmers' fields. Here, emphasis was put on additional forage production for goats and sheep, especially during the cropping season. Even so, for most of these farmers the soil fertility aspect was very important as well.

These experiences were discussed in periodic farmers' meetings. They demonstrated the importance of the soil fertility problem in the region and the interest of farmers in several of the tested methods, including the alley cropping option. We learned, however, that due to the very high

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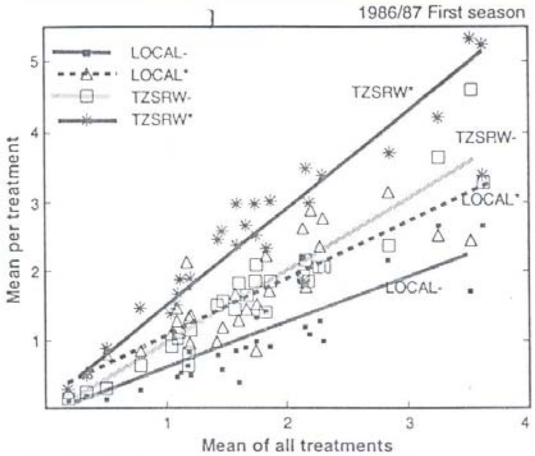

Figure 1. Stability analysis of maize yields measured during the first seasons of 1986 and 1987, of a local and an improved variety (TZSR-W) measured in farmers' plots with (+) and without (–) fertilizer (NPK: 37-23-14 kg ha^{-1}). Broken lines show the linear regression for nonfertilized treatments, continuous lines those for fertilized treatments.

variability of the farmers' households (regarding physical as well as socioeconomic factors), different options are probably needed for different situations.

Participative experimentation on soil fertility, as from 1990

Because the situation was complex and different types of farmers needed different solutions, they were invited to take part as a group to discuss the soil fertility issue on the basis of experiences obtained so far (including their own indigenous methods) and to continue or to start testing options that were judged interesting for their individual situations. Physically, two situations were distinguished: (i) fields with still reasonable fertility; and (ii) completely exhausted fields, for which special ("shock") treatments would be necessary.

For the first group of fields, we discussed two technologies:

1. Alley cropping, with alternating hedgerows of (directly sown) *Gliricidia sepium* and *Leucaena leucocephala*, similar to the system introduced on-farm by the International Livestock Centre for Africa (ILCA) in Nigeria (Atta-Krah and Francis 1987).

2. A pigeonpea (*Cajanus cajan*) short-season fallow, where pigeonpea is intercropped with maize during the first rainy season (one row of pigeonpea per two maize rows) (Versteeg and Huijsman 1991). The latter system allows the pigeonpea to cover the field completely during the second season and the following dry season. After the grains and the thicker stems (for firewood) have been harvested, the rest of the biomass is used as mulch and as green manure for two maize crops the following year.

For the exhausted fields, we suggested that farmers consider two other options:

3. Planting (with seedlings) an improved fallow (Rocheleau et al. 1988) of densely planted *Acacia auriculiformis* trees (2600 trees ha^{-1}), a fast-growing leguminous species which is able to grow under very poor soil conditions and can produce an important amount of slowly decomposing litter and high quality fuelwood.

4. Relay planting a leguminous cover crop of *Mucuna pruriens* var. *utilis* 1 month after sowing the first-season maize, which gives a dense mucuna cover during the second season (Versteeg and Koudokpon 1990). During the dry season, the cover dies and dries, and the mulch is used to fertilize a new first-season maize crop, which will be again relayed with mucuna, etc. After a number of such mucuna covers during successive second seasons, soil fertility is expected to regenerate.

After restoration of maize yields to an acceptable level, the farmer may decide to continue with one of the first two options for maintaining the achieved soil fertility level of the plot.

Problem-oriented groups in technology testing

Grouping of farmers who shared an important problem helped to increase farmers' motivation and participation. Discussing different technologies appropriate for different situations and leaving it to the farmer to decide what to test in his/her own field appeared to further increase participation and motivation. Discussions in the group were very lively. Farmers also became well informed about results and formed impressions of methods other than those they were using themselves.

Test results

Maintaining fertility of reasonably fertile fields

During the first 2 years of the discussion group, 52 farmers established the alley cropping option and 35 farmers the pigeonpea one. Although in trials during 1988/89 the pigeonpea option had only given an average 24% maize yield improvement (of 375 kg) in the season immediately following the pigeonpea (Table 2), several farmers were attracted by the fact that pigeonpea is a marketable product in the region. Many of the pigeonpea farmers, and among them most women

Table 1. Average maize yield (kg ha^{-1}) obtained on the Adja plateau during different seasons in plots treated as indicated.

Trial and season[1]	Continuously cropped plots (crop rotation)		Plots after pigeonpea	Plots after mucuna
Demonstration plot 1988A	(Maize/cowpea)	910	1540	2070
Farmers 1989A: local variety	(Maize/various)	1380	1570	1910
Farmers 1989A: improved variety	(Maize/various)	1660	1920	2430
Farmers 1989B: local variety	(Maize/various)	430	530	1150
Farmers 1989B: improved variety	(Maize/various)	660	780	1450
Mean		1008	1270	1802

1. A = 1st (main) rainy season; B = 2nd (small) rainy season.

farmers, were nonowners, who did not have the possibility to choose the alley cropping option.

In 1991, effects similar to those of 1989 were observed for the pigeonpea fallow in terms of maize and pigeonpea yields. An improved pigeonpea variety increased its yield from 350 kg ha^{-1} to 550 kg ha^{-1}, but farmers unanimously rejected it because of bad cooking and taste characteristics. The modest soil fertility improvement and lack of better alternative varieties for the low-yielding local pigeonpea seemed to cause a general decline of farmers' interest in this alternative. The alley cropping option was chosen by a highly motivated group, who had generally no problems with the installation of the hedgerows, after some group training concerning a hot water treatment of leucaena seeds and the use of a simple sowing device for accurate distance and seed depth (Fig. 2). The two alley species were relayed into the maize crop after its first weeding. Of importance was the additional training of farmers regarding the extra care needed for the first two weedings of the hedgerow lines. Thereafter, plants were sufficiently developed and no more difficulties were observed in maintenance. Among landowning farmers, the alley option was usually chosen because it left them with the possibility for continuous cropping during both rainy seasons. The prospects of producing forage for small ruminants and good quality firewood were additional attractions for this choice. Finally, the two "pioneer farmers" had been satisfied about the efficiency of the alley system and persuaded many other farmers to test it.

Several of the alley farms in the Mono province were planted in rather marginal, relatively less fertile fields and one of the "shock treatments" would probably have been a better option. Another problem that came up during the dry season was that free-roaming goats discovered the young leucaena hedgerows of some plots and grazed them all successively, causing considerable damage. Gliricidia hedgerows were, however, barely touched. In this densely populated region with many hamlets, goats may become a serious practical problem. The goat issue was extensively discussed within the group and most farmers thought that it would not be a problem in fields located > 500 m from the village.

As expected at this early stage, no significant maize yield differences could yet be observed between check fields and alley plots. Even so, several more farmers wished to establish an alley the next year (1992). As we did not include these new farms for biological measurements, we limited our assistance to providing seed and advice. The objective was to let these farmers install the new alleys mainly on their own, with assistance from their more experienced colleagues, who had the examples in their field. In this way, we hoped to maximize the farmers' own adaptations and interpretations of the introduced alley farming concept.

Figure 2. Simple sowing device for securing the direct sowing of *Leucaena leucocephala* and *Gliricidia sepium* alley rows at the right depth (2 cm) and the right within-row spacing (12.5 cm, or 8 plants per m alley).

Regenerating very exhausted fields

A large part of the group who tried one or the other shock treatment started these treatments in 1989. About half of them chose the mucuna option, the other half the acacia option. Benchmark yields of the first season (relayed or mixed-cropped) maize were indeed very low: less than 200 kg ha^{-1} on average for both subgroups. But the next year (1990), we obtained very encouraging results from the effect of the preceding mucuna on the exhausted plots, where average maize yields improved 10-fold, to about 2 t ha^{-1} after only one year. Before this result had been measured, a majority of the new "shock" farmers chose the mucuna option, but it appeared that most of them got rather high benchmark yields, and thus did not fall within the group with exhausted fields. This pointed to an increasing popularity for mucuna as a soil fertility improver, as so far it had primarily been popular for its ability to smother the imperata weed. Similar positive effects of mucuna mulching on maize and soybean yields under poor fertility were reported in Indonesia (Suwardjo and Sukmana 1987).

As a consequence of these spectacular first results with mucuna, 20 new farmers with exhausted fields chose this option in 1991, a threefold increase over the year before. The benchmark yield of this new group was 540 kg ha^{-1} for the local maize variety, and 757 kg ha^{-1} for the improved maize. The impressive yield increases in only 1 year with mucuna resulted also in only a few farmers choosing the agroforestry option with acacia in 1990

Table 2. Summary of yield averages (kg ha^{-1}) obtained in farmer-managed pigeonpea short-season fallow trials. Each trial took two years. First year (1988 and 1990): pigeonpea/maize intercrop and second season fallow; second year (1989 and 1991): effect of preceding pigeonpea fallow on maize yields.

Trial, year, and season	No pigeonpea			With pigeonpea				
	Local maize	Improved maize	Mean maize	Local maize	Improved maize	Mean maize	Pigeon-pea	LSD (5%)[1]
First trial (1988/90: 25 farmers)								
1988, 1st	1620	1890	1755	1460	1940	1700	—	NS
1988, 2nd	910	1120	1015	—	—	—	310	
1989, 1st	1350	1730	1540	1590	2240	1915	—	205
1989, 2nd	435	665	550	530	780	655		NS
Total production of 1988 and 1989	4315	5405	4860	3580	4960	4270	310	
Second trial (1990/91: 29 farmers)								
1990, 1st	1190	1660	1425	1070	1550	1310	—	
1990, 2nd	not measured[2]			—	—	—	300	NS
1991, 1st	800	1200	1000	1250	1450	1350	—	170
1991, 2nd	not measured[2]			not measured[2]				

1. LSD at 5% for differences in means of maize yields (over both varieties) from plots with and without pigeonpea fallow treatment. NS = not significant.
2. No measurement because of workload from monitoring 70 more parallel farmer plots with other soil amendments in 1990/91.

and 1991, despite the actual acacia plots showing very vigorously growing trees, much better than leucaena and gliricidia in comparable marginal plots.

Maintaining scientific rigor in long-term participative studies

Farmers are generally not very interested in the necessary provisions for drawing sound scientific conclusions, such as the installation of a permanent check plot and a fertilizer treatment of only a randomly chosen part of the field. Often, such measures are seen as a burden that makes no sense to them. Insisting on their compliance could mean that the total activity becomes a peculiarity of the researcher, resulting in a substantial loss of farmer participation and involvement.

On the other hand, sound scientific interpretation of on-farm trials is very important for acceptance of results by on-station researchers, which is vital for effective use of the feedback to improve the efficiency and relevance of station research efforts in plant breeding, soil fertility improvement, and other agronomic issues.

The art is to find ways to keep the farmers interested in the trial and enable them to monitor it independently from the researchers. Much is already gained when the research subject is oriented toward one of the farmers' own important problems. Second, the design chosen must be sufficiently uncomplicated and clear for independent farmers' interpretation, such as two or three treatments in adjacent plots for one-factor trials, a crisscross design for trials with two factors (Versteeg and Huijsman 1991), and a stepwise trial set up for three or more factors (Mutsaers et al. 1986).

Another method to maintain farmers' interest is to include a subtreatment, such as one or two improved maize varieties, or a basic fertilizer treatment, which involves a fringe benefit for farmers because the necessary inputs are provided by the researchers. An extra treatment also increases the interest for other on-station researchers, such as breeders or soil scientists. When using a crisscross design, the farmer feedback becomes more interesting as well. Finally, by using one or two common maize varieties for all the trials, there is a possibility for mutual comparison of these tests, as, for example, in comparing the pigeonpea fallow trial with the results obtained with the alley cropping farmers.

Input incentives, such as fertilizer or improved maize seeds, should not be so substantial, however, that the farmers' interest becomes mainly "the gift" and not the research subject. It is, therefore, wise to set a limit to the experimental area. If the farmer's plot is larger, the surrounding field can be an interesting observation area as a check plot or as a place where the attractiveness of the innovation can be judged from the level of "auto-extension" of the technology concerned, without such input incentives.

In the case of the Mono province, where there is much pressure on land and farmers' plots are commonly rather small, a special problem for long-term trials is how to obtain proper check plots. Farmers reason that they do not need a check for their own interpretation, as they know the reference level by heart. They like to solve the problem in the total plot and do not like to be left with the problem unsolved in a significant part of the field.

To solve this dilemma, we tried two approaches for long-term observations:

1. The "benchmark level" method, especially for the shock-treatment plots. Here, the first determination of the yield gives the benchmark, which is already so low that one can expect only improvements if the method is working. By repeating the trial during successive years with new farmers, new benchmarks are established, which serve at the same time as checks for the fields that are in their second or third year.
2. The "check plot farmer" technique, in use with alley cropping farmers who do not possess large plots. Here, we ask the farmer to look for a colleague who is still practicing traditional farming and who cleared his land in the same year as the alley farmer concerned. The alley cropping effect can then be determined easily via a paired t-test of the maize harvests.

Conclusions

Five years of participative research with farmers has taught us several specific approaches and methods aimed at increasing farmers' participation, while maintaining the possibility of sound scientific interpretation. For more complicated technologies such as alley cropping, farmers' participation improves clearly if participants are in need of such a technology for a pressing problem of their own. In addition, chances of adoption by such farmers will probably be higher, especially if the benefit is significant but not spectacular.

Another challenging method is parallel testing of several technologies at the same time with different subgroups of farmers, who all belong to a larger discussion group focusing on a central problem. This will increase farmers' participation and probably lead to more meaningful evaluation of the technologies, both in a technical and in a socioeconomic sense.

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