Farmers' assessment of techniques

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According to what criteria do farmers choose how to intensify land use? Anne Floquet found that farmers rejected many recommended techniques not because they don't match with farmers' objectives and constraints, but rather because they are not effective in agronomic terms.

How do farmers in southern Benin cope with problems of land scarcity and degradation? Our research team explored why farmers chose their current farming practices and economic activities and what factors limited their choices. We spoke with farmers who had tried but abandoned using fertilisers to restore soil nutrients. We brought farmer groups to researchers' field trials with sown fallow and to farmers' field trials where green manure, sown fallow and alley cropping were being tested. The sample of farmers was stratified so that their assessment of the techniques, which differ in resource requirements, could be related to their economic situation.

The "terres de barre" area

Crop yields in this area depend mainly on the organic matter content of the soil. As long as a dense bush fallow could grow before the land was cropped again, fertility could be restored. Where land has become scarce (more than 150 people/km2), the fallow is shortened, its composition degenerates and the soil becomes acidic and poor in N, K, P and S. The maize (the main crop) then has only shallow roots and is more sensitive to dry spells. The yields fall until, eventually, maize can no longer be grown and is replaced by groundnut, cowpea and cassava.

In the face of land scarcity, the farmers have tried different strategies such as:

- cultivating all available (even marginal) land and integrating oil palms into the rotation;
- including cassava as intermediate fallow, growing more legumes in rotation with maize, ridging and incorporating residues into the soil, in order to extend the cropping period;
- intensive compound farming using household refuse, in some densely populated areas with very impoverished soils;
- part-time farming purely for home consumption, and seasonal migration, off-farm work, processing activities etc to earn cash;
- collecting and selling tree products from fallow land;
- resettling on vacant land in the north.

Farmers have not adopted green manure to improve soil fertility. Some farmers, however, adopted Mucuna utilis to control Imperata. Photo: Wim Hiemstra.

As soil degradation is a gradual process, most farmers are not aware of it. This ecological deterioration is occurring in a very unfavourable economic context of general recession, characterised by a tight local market due to rising unemployment and low salaries and by a diminishing standard of living in rural areas. This affects nutrition, health and education and, thus, the productivity of labour.

Various research institutes have long been working in the "terres de barre" area, studying fertiliser use, green manure, improving fallow with fast-growing trees, and alley cropping. However, thus far, few farmers have integrated these practices into their cropping systems.

Fertiliser to replace lost nutrients

Fertilisers have long been advocated but farmers adopt them only in cotton-growing areas. This has both agronomic and economic reasons.

The extra yield gained from applying fertiliser on local varieties in not high enough to justify the costs. Improved varieties (IITA composites), which would profit more from fertiliser, are not acceptable to farmers, as they do not store well and have a long cycle (120 days). Farmers have been replacing their 120-day varieties by 105- or even 90-day varieties because the risk of flowering during a dry spell has become too high.

On degraded land, applying fertiliser without sufficient organic matter accelerates soil impoverishment. On newly cleared land, where the crop can still profit from the ashes of the burnt vegetation, the extra yield brought by fertilisers is also very low. The extension services have not yet adjusted their recommendations to the fertility status of the soil, and few experiments have been conducted on the synergy between organic and non-organic manure.

Even when some farmers tested fertilisers on maize and obtained good results for a few seasons, many were eventually discouraged by cash losses. As the climate is very variable, there is a high risk of not having enough extra yield to pay for the fertiliser. Moreover, some farmers are not sure if they will be able to do the required cropping practices in time because of illness or other unpredictable events. The probability that these occur and yield losses result is particularly high in the case of farmers with small families and of women with insufficient income to hire labourers.

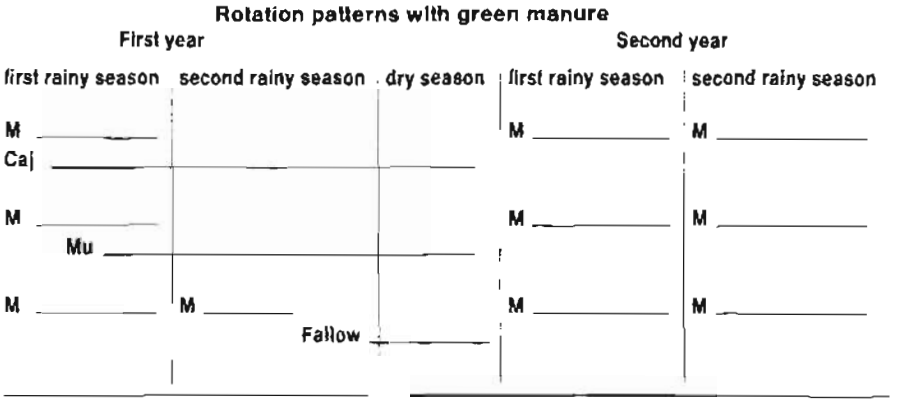
Investing in fertilisers?

Where cash income is low and unpredictable, it is difficult to save money to invest in farming. Farmers regard cash as the most limiting factor. If they make an investment, it must be profitable. Assessment of profitability differs from farmer to farmer, depending on their objectives.

Those farmers who are sure of having a marketable surplus and could invest money in hiring labour or renting more land compare the cash returns of this with other activities, especially distilling palm wine. Returns to investment in distillation can be more than 100%. A development project in a neighbouring province chose this as a threshold to evaluate the profitability of fertiliser use by farmers and found in on-farm trials that this threshhold was reached by less than 50% of the farmers.

Farmers who are not sure of having enough maize for family needs will try to secure this first. They do strive for extra yield but with minimal extra costs. In cases where no family labour can be mobilised, these extra costs must include labourers' wages. Comparison of costs revealed that extending the normal cropping period (3-4 years) by applying fertiliser is not as profitable as renting and clearing fallow land, as long as the farmer cannot be sure of getting an average yield higher than 975 kg (using family labour) or 1000 kg (using paid labour) with fertiliser. As long as fallow land is available to rent or borrow, farmers will not invest in fertilisers.

Rotation patterns with green manure



M = Maize; Caj = Cajanus cajan; Mu = Mucuna utilis; Fallow = Bush regrowth between the weeding of the second season and the hoeing of the next first season.

Green manure

Farmers have not adopted green manure to improve soil fertility, although few economic factors impede this. Green manure does not require extra labour, as a shrub like *Cajanus cajan* or a herbaceous vine like *Mucuna utilis* can be sown in association or in relay with the main crop in the first rainy season. They form a pure stand in the second rainy season and the dry season (see Fig. 1). Clearing is easy, the soil is weed-free and no work must be done in the second rainy season. Thus, over two years, the labour balance is positive. So, the next obvious question is: what are the agronomic benefits of green manuring?

Results of green manuring trials are contradictory. On IRAT's 6-year researcher-managed trials on "terres de barre" in Togo, the loss of one maize harvest a year because green manure (*Crotalaria juncea*) is sown in the second season was compensated by a better yield in the subsequent maize crop. The system produced as much maize as maize monocropping in both wet seasons. These plots were fertilised. In trials conducted by CARDER Atlantique on farmers' fields with a rotation of maize + Cajanus / Cajanus / maize / maize (see Fig. 1) on non-degraded land, the additional maize yield in Year 2 did not compensate for the loss of a maize harvest in Year 1. In similar trials conducted by farmers on degraded land, the maize yields were equal in both alternatives.

A rough comparison between incorporating green manure and incorporating crop biomass (cassava, maize, groundnut) as mulch indicated that *Cajanus cajan* brings more biomass than crops at sites where it grows well, but it requires fairly fertile soils. Still, on farmers' fields where the fallow was still vigorous, the biomass of bush regrowth during the second rainy season and the following dry season, added to the biomass of the crop residues, appeared to be just as high as the biomass produced by sown Cajanus. On degraded "terres de barre", Cajanus does not grow well and probably does not produce as much biomass as cassava.

Palm trees have a good market value and are the farmer's best savings. Photo: Wim Hiemstra.

Some farmers are, however, adopting *Mucuna utilis* to control Imperata. If this weed invades a field, they have to invest much labour to reclaim it, or even have to abandon it. Farmers are therefore prepared to invest work in establishing a green manure crop, if it helps control the weed.

Planted vs natural fallow

Researchers regard fallow merely as a way to enhance soil fertility; farmers also see it as a way of generating cash. Marketable products can be collected from fallows and – especially firewood in periurban areas – are in high demand.

Natural fallow was – and, on some areas, still is – the most efficient way to "wake up" the soil (the local expression for land regeneration). The optimal length of fallow is 7-9 years, but when the cropping period is short enough (5-7

years) that many roots of fallow shrubs survive, a fallow of 3-4 years is still sufficient to produce firewood and bring acceptable yields after clearing.

Sown fallows with fast-growing species (*Cassia siamea, Acacia auriculiformis*) produce firewood and stakes within 2-3 years. They may be more productive than natural fallow, but relevant measurements have not yet been made.

An interesting case is the indigenous palm agroforestry system: as land becomes scarce, palms are integrated into the seasonal cropping system. They are planted together with maize, which ensures their weeding during the first years. Later, they grow as a pure crop together with bush regrowth, which is sometimes cleared yearly. As soon as the trees mature, they are sold and/or felled for wine extraction and distillation. Palm trees have a good market value and are the farmer's best savings. Some of these systems also restore soil fertility. For these reasons, farmers with access to enough land will plant palms on it.

The profitability of fallowing must therefore be assessed in terms of the cash income it brings and the capital accumulation it permits. For farmers who can save and invest in productive activities, the return to investment is higher in agroforestry than seasonal cropping, especially if labour is employed. Larger farmers and urban dwellers were interested in planting teak in the 1980s and, after the market for stakes collapsed, they started planting palms.

Participatory evaluation could help farmers to define their own objectives and criteria for assessment. Photo: Wim Hiemstra.

Return on investment

For farmers with little land and insufficient maize production to secure family needs, any reduction in cropped area for sown fallow must be offset by higher subsequent maize yields. Even so, this happens only after 2-4 years and these farmers cannot wait so long. One partial solution is to mulch the cropped area with litter taken each year from the growing sown fallow.

Farmers who have more land and a secure food supply but not enough income for investment try to maximise their income and compare what they can gain from different systems: sown or natural fallow or seasonal crop rotation. Near towns where firewood commands a high price, the income from agroforestry is sometimes higher than from seasonal cropping, especially for farmers who hire labourers, as the agroforestry system requires less labour. But the two incomes differ in "quality". In the agroforestry system, farmers obtain a fairly high income all at once and can choose the period of harvest to coincide with large expenditures. In seasonal cropping, the income is more evenly distributed over the years and, if the market is poor, the crops can be consumed. Therefore, although an agroforestry system may bring a higher total income than a food cropping system, it can be established on only part of the farm. Nevertheless, the agroforestry system may be more profitable than natural fallow, especially on degraded land in overcropped areas, on account of its favourable effect on the soil.

Land ownership

Not all farmers are free to choose how to use the land. Less than half the arable land is cultivated by its owners; the rest is rented or borrowed. Women do not inherit land and cannot buy large plots. Tree planting symbolises ownership. Where there is enough land, farmers rent fallow to use it for 3-4 years. If the owner needs money urgently, tenants rent fields "in advance" when the fallow is still young, and wait a few years before clearing. Any measure which restores the soil and produces wood more quickly than natural fallow could be advantageous to both parties.

Another form of tenancy is planting palms for the field's owner in return for the right to grow annual crops for as long as the palms are sensitive to weeds. This "taungya" system could be extended to other trees, if these are profitable to the owner.

Here again, non-adoption of sown fallow seems to be due neither to economic considerations nor to noncompatible land-use rights but rather to the lack of proven agronomic benefits. Data on the effect of sown fallow on the productivity and sustainability of local cropping systems are scarce, and the fallow species being researched are exotics. Little has been done with local species, not even those which farmers value for their multiple uses and their capacity to restore soil fertility.

Alley cropping

This is an elegant system of integrating fallow shrubs within cropped fields to reduce leaching and runoff losses and to continuously produce and recycle biomass. However, agronomic results of alley cropping with *Leucaena leucocephala* and *Gliricidia sepium* on "terres de barre" have been disappointing.

Competition between crops and shrubs can be so great that less maize is produced in the alley system than in open fields. Competition for water is particularly high in the second rainy season, and any delay in pruning the shrubs causes high crop losses. To improve the water balance, trials have been made with shrub species with slower regrowth and litter which decays more slowly. Researchers are also trying to reduce the crop/shrub interfaces (e.g. wider alleys, double rows of shrubs).

But the fact remains: alley cropping is time-consuming. For small-scale part-time farmers who cultivate for subsistence and gain cash income from off-farm activities, alley cropping must produce an extra yield which pays for the extra labour at a higher rate than the off-farm activities. Similarly, farmers who invest savings expect a cash return at least as high as their alternative investment possibilities. The higher the labour costs, the lower the probability of gaining such a high return with the surplus produced. ▶

Farmers with large families might be interested in adopting alley cropping to "employ" their dependents, if the system brings them more maize to consume or sell. These farmers also run less risk of not being able to prune the shrubs in time. They can gain extra income by selling some of the shrubs for acadjas (branches planted in water to attract fish). For these farmers, the system might be profitable if it can be modified to reduce crop-shrub competition. Good farmers might be better able to optimise the management of this system than researchers, who tend to stick to a trial plan. But, even then, this system will probably interest only a small group of farmers.

Individual techniques?

The major criteria on which the farmers in southern Benin based their decisions were food supply, cash income and return on investment. For farmers without a secure food supply, a land-consuming innovation such as green manuring or sown fallow has to increase maize yields on a smaller area. In the case of labour-consuming practices (alley cropping), if the extra work obliges the farmer to reduce off-farm activities, this work has to be renumerated as well as the abandoned activities. For farmers with secure food supply but insufficient income for investment, an innovation must raise income either after payment for inputs and wages or on a smaller cropped area. Farmers who invest regularly in productive activities try to maximise not the income but rather their cash returns on investment.

Each of the techniques might become profitable for some category of farmer: nutrient-restoring fertilisers as soon as fallow land becomes scarce, if the risk of losses is reduced (appropriate varieties, better water balance with mulching etc). Green manuring and sown fallow to replace degraded natural fallow could be profitable to small and medium-scale farmers, there being no risk of cash losses as in the case of fertilisers. Cash-saving activities are likely to be profitable to large farmers, as cash returns will be improved.

Combining systems

However, none of these techniques would, on its own, fulfil all the objectives of the farmers, e.g. well-distributed income vs secure savings. Therefore, each farmer has to combine several systems. Assessment of the techniques has to take the specific situation of each farmer into account. Ideally, the evaluation process would help the farmers define their own objectives and criteria for assessment.

Researchers should verify that the techniques they propose fulfil certain minimum criteria. Farmer testing of innovations is meaningful only when the problem they are meant to solve actually arises. As long as land is still available, farmers will look for natural fallow to clear rather than investing labour and cash to intensify land use. But if a problem is critical, e.g. invasion of Imperata, an innovation such as *Mucuna utilis* will spread very quickly among farmers as soon as they see it works.

Above all, new practices must perform well in agronomic terms. Species for green manure and improved fallow have to be screened for different locations, and the productivity and stability of the new system must be compared with that of the existing cropping system(s). Too little relevant research has been done in such a way that results from different stations can be compared. Nor can the results be compared with farmers' systems. Detailed research is conducted on very specific topics before the system as a whole has been assessed. Such assessments have to be done by researchers before truly sustainable farming practices can be adapted, improved and assessed by farmers. ■

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More to life than money

Agricultural experimentation has usually been judged in purely physical terms – especially by the criterion of maximum gross yield. One of the first agricultural research organisations explicitly to recognise that farmers might have considerations and priorities other than yield maximisation was CIMMYT. They produced a training manual in 1976 which recently has been revised completely (CIMMYT 1988). Nevertheless the economic analysis has hitherto had the limitation of considering "the farm" as a business more than is properly justified by the reality of many societies for which subsistence is at least as important an objective as earning some cash.

Wider set of criteria

The Adaptive Research Planning Team (ARPT) looked at a wider set of criteria more likely to reflect farmers own criteria than cash return only. In Luapula Province, Zambia, ARPT carried out trials on sunflower with the aim of improving nutrition, and secondarily, on labour reducing technologies in women's activities. The trial derived from a perceived need for cooking oil. Sunflower is already grown in the area as a cash crop. Comparisons were made between the local seed and an improved variety; between no use of fertiliser and the application of both basal and top dressings; and between the cultivation on small ridges and the traditional practice of incorporation of weeds under large mounds.

Energy as measure of food value

A problem with taking food as an important criterion is how to measure food value. According to nutritionists energy deficiency in general is the most serious problem in third world countries. ARPT therefore decided to use energy to represent food value as a whole. This has the nice advantage in subsistence farming that the main input is in the form of human or animal labour, fueled by food energy. So there is a very direct relationship between output and input. In addition, it is the only measure which describes the effort involved in work as compared to the time taken. There are even calculated values for the energy values for various fertilisers.

Results depend on objectives and constraints

These experiments are showing that the results very much depend on objectives and constraints of farmers. In short, where cash is a constraining factor and the major objective, local seed planted on ridges will give the best cash return to cash invested. Where labour is constraining, mounding is less laborious than ridging and the application of fertiliser to local seed gives the best returns. Where the output is to be consumed at home, as expelled oil, the improved variety, which gives a higher food energy output than local seed, and mounding without the use of fertiliser, give the most efficient combination. In all cases, the next best option is current farmers' practice.

Technologies more appropriate

Measures of energy expenditure in various types of agricultural work are difficult to calculate. But as long as there are only a handful of esoteric scientists who are collecting this information this situation is likely to remain unchanged. The more economists seek such information the more accurate will be the rules of thumb, and the more appropriate the technologies.

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