CHAPTER 3

NOTHING SO DIFFICULT AS A BEGINNING

The etiquette of development

The rules of the development game are well established. The game may be played by an infinite number of players and continues indefinitely. The objective (surprisingly) is not development but rather is modelled on the children's game of "Pass the parcel". In the development game, however, it is not a parcel that is being quickly shoved on to the next person but the blame for failure to meet development activity objectives. Development activities range from simple projects through to sector and national development plans. For convenience (and to avoid offence to individual players) the players are more or less divided into teams such as 'the donors', 'the government', 'NGOs'. Each team is allowed to criticise the other team loudly and publicly, but individual criticism is normally done only in private and amongst members of a common team. If the game is being played properly, no team listens to any other.

This is not a cynical figment of imagination. In the previous chapter, we saw how important addressing the soil fertility constraint was to African farmers. We also saw that much of what was being done simply failed to deal with the problem as faced by actual farmers. In one version of the development game, the problem is simply political and economic. The technology is there – all that is needed is to put the correct policies in place and farmers would quickly increase their use of fertiliser and yields would quickly respond. A competing scenario will argue bitterly that there is a conspiracy of donors and multinational corporations to gull farmers into purchasing improved modern agricultural inputs and to dispense with their traditional seeds and husbandry methods. Once farmers are 'locked into' this system they effectively become sharecroppers for the benefit of these same corporations, to the detriment of local development. Yet another perspective is that tradition encrusted village life prevents innovators from taking up the opportunities offered by modern technology, thus condemning farm families to inevitable poverty.

There is truth in each of these views. But it is a partial truth. Creating change – and development is about change – is never easy. Change can rarely be neutral; there will be some who do better and some who do less well as a consequence of change. Those who lose out will almost certainly lack the enthusiasm of those who benefit. The changes that Africans have faced in the past century have been enormous and highly disruptive. Unsurprisingly, many Africans, especially those in rural areas who have largely been bypassed by the benefits of past change, are cautious about new initiatives. Yet the change needed to arrest the decline in rural living standards and to create new, positive trends in much of Africa is considerable – and beyond the capacity of many communities to achieve on their own. So outside help is a central component of effective change.

It is truly difficult for any outsider fully to comprehend the effects of change and to understand how they impact on individuals and on the community. In an ideal world, outsiders and locals would work and learn together over extended periods, putting together the necessary pieces to create a benevolent development environment. Time is not on Africa's side and a faster process is needed if well meaning efforts are not to be submerged in the wash of other events. This and the following chapter show how science can contribute to such a process.

The approach is not, and cannot be, a complete answer. But it is a very positive and significant step in creating the kind of benevolent change environment which African farmers seek. The examples show how it is entirely possible, even in a highly unfavourable policy environment, to use logical scientific methods to provide real answers to real world problems faced by farmers. In each instance, farmers play a central role in the development exploration, but they do not work alone. The best skills of scientists are brought to bear on well defined and analysed priority issues as defined by farmers and those who work closely with farmers.

Importantly, the development game rules are cheerfully disregarded. It does not matter that other players are not pulling their weight or working cooperatively. It is nice if they do but the fact that external factors make life difficult is not an excuse for failing to deliver useful technology to farmers. If things were easy there would be no need for research and associated development projects. The challenge taken up by the 'termites' of the following pages is to make things happen even if conditions are unpromising.

Making fertiliser profitable for Zimbabwe farmers

We have seen previously how difficult it is for smallholders in Africa to sustain the fertility of their lands as population growth eliminates the traditional practice of long fallows. Good husbandry and the long term viability of farming requires that nutrients removed by crop harvesting be replaced in time for the next crop cycle. Nutrients are lost both through soil erosion and from the crops taken from the land. We saw in a preceding chapter the difficulties faced by farmers in using traditional organic methods. We also saw that inorganic fertilisers were expensive and difficult to purchase. Thus if this last technology is to contribute significantly to soil fertility management by African farmers, it will need to yield substantial and reliable responses to its use.

The obvious approach to efficient fertiliser use is to use only that fertiliser that is necessary. Firstly the soil should be analysed to determine what nutrients are already there. Then an appropriate fertiliser can be purchased, and applied in the correct amount to compensate for any deficiencies. This ideal, which requires fast, cheap, and reliable laboratory facilities, is simply impractical over much of Africa. As a compromise, scientists have worked out generalised fertiliser recommendations which can be used by farmers working on areas of somewhat similar land. But the crop response to fertiliser is not solely determined by the nutrient status of the soil. Rainfall also has a major influence, and African rainfall patterns are highly unpredictable. At 533mm of rainfall less than 2 tonnes of maize per hectare is harvested. With the same fertiliser use, at 610mm rainfall, nearly 8 tonnes of maize results.

Thus a good fertiliser recommendation needs to reflect both the soil and the weather conditions. The farmer (and his or her advisors) may be able to make inspired and reasonably accurate estimates of soil fertility conditions in advance. Foreseeing the weather is much less reliable.

Piha (*op cit)* took on this challenge. He chose seven locations in Zimbabwe to set out fertiliser trials using the dominant food crop of maize. Each site was chosen because its soil properties and past management was typical of much of Zimbabwe smallholder agriculture. The sites were on run down, problem soils that were yielding poorly for the farmers that were working them. Each site was on coarse grained, sandy granitic soils which had been cropped for at least seven years and had not received any organic manures for at least three. Past rainfall at the sites ranged from a mean of 616mm (semi-arid) to 736mm (relatively well watered).

Calculating the need

Nitrogen (N) is the nutrient in most demand by maize in Zimbabwe. It is also a very transient nutrient. If the plant does not take it up, it is quickly washed out of the soil by rainfall, or lost to the atmosphere due to breakdown by soil microbes, The other major nutrients required by maize include phosphorus (P), potassium (K), and sulphur (S). These nutrients are much more stable and, if not used one season, largely remain in the soil to be available to the plant in a subsequent one.

These facts gave Piha his first entry point. He decided to add a uniform amount of P, K and S each year of his experiment. P and S came entirely from fertiliser. However, the literature showed that, on the soils concerned, nearly 75% of the K could be expected to come from the natural weathering process of the soil. His strategy was to add P, K, and S in amounts sufficient to meet the needs of an optimum maize crop in an average season[1]. He reckoned that this was an efficient long-term strategy for fertility management and good maize husbandry. If the rainfall was poor (and thus the crop yield low), the crop would take out less P, K and S, leaving a balance for the following season. If the crop was exceptionally good, it would use up the balance from previous years. His plan, therefore, was to adjust the N application to suit the rainfall pattern. If the rain was poor, then he could add only a modest amount of N. If it was good, he could add more and thus get a much better yield.

His second decision was to determine what amounts of nutrients were required at each site. Piha analysed the chemical composition of maize in Zimbabwe and showed that each tonne of maize produced required 20kg N, 4.5kg P, 18kg K, and 4.5kg S. Reviewing experience from farmers and local experts, he concluded that in an ‘average’ year, his drier sites could produce 3.8 tonnes of maize if correctly fertilised, and, on the wetter sites, 5.8 tonnes. From this he calculated the quantity of nutrients (N, P, K, and S) required at each site.

Here we need to move from theory to practice. Farmers typically apply a compound fertiliser – which contains a number of nutrients – early in the season. They then topdress with nitrogen fertiliser one or more times during the season. Nitrogen is easily lost so farmers will often topdress nitrogen at one or more times during the season. Piha’s programme involved adding a small amount of N – and all the P, K, and S – in a compound fertiliser which was broadcast

(1) In simple terms, an optimum crop is one which meets its yield potential as constrained by the rainfall of an average season.

and incorporated into the soil before planting. He then added nitrogen as ammonium nitrate fertiliser in separate topdressings at four weeks after planting, six weeks after planting, and at the time the maize tasselled. The amount of nitrogen added at each date depended on the rainfall conditions. If the crop was severely stressed, no nitrogen would be added. If it was moderately stressed, then 17kgs of N were applied. And if conditions were good, 34 kgs of N were used. In the higher rainfall sites, where the yield potential was greater, a further level of 50 kgs N was used if the rain was particularly good. Piha and his researchers applied the fertiliser, the farmers did all the other tasks – planting, weeding, and harvesting.

The results were very promising. Over a five year period, Piha's system gave 25-42% more yield and 21-41% more profit than did the existing fertiliser recommendations. Further analysis suggested that the estimate of 'average' yields were probably overoptimistic in the drier areas. Lower applications of P, K, and S would have reduced the riskiness of fertiliser use. The key to the system was its flexibility. In poor years, fertiliser (or N) use was reduced but yields would be poor in those years in any case. In good years, the farmer could get good yields.

From theory to reality

Piha brought more farmers into his programme. He selected and trained seven agricultural extension workers so that they fully understood how to explain the soil management package to farmers. These extension workers then chose well established farmers in their areas. Thirty five such farmers were supplied with enough maize seed and fertiliser to plant 0.5 hectare (or 0.75 hectare in very poor rainfall sites). The farmers were not given the inputs; they were loaned them and each agreed to use the inputs only as instructed. The loan would be repaid in the form of maize grain at the end of the season and, if they repaid as agreed, a further loan, under the same conditions would be made the following season. The maize grain would be valued at the standard market price offered at harvest. And the value of the loan was the cash cost of the inputs plus a fifty percent mark up to cover transport of inputs and grain, inflation, and service charges. If a farmer was unable to pay the full amount, an arrangement was made for partial repayment.

This programme was run for three years so that the effects of poor and good seasons could be seen. All farmers also planted a separate area of maize using their traditional practices so that comparisons could be made. Each extension worker thus ended up with five good farmers using the soil management package together with fields in which they used their traditional methods. They also monitored five neighbouring but comparably good farmers who grew maize in the conventional way, and five poorer farmers who were also growing maize.

The results again were very promising. Overall, participating farmers' profits were 105% higher than those of the control group of comparably good farmers. Yields were 78% higher[2]. Loan repayment was excellent at 90%. Some farmers did less well than expected. In some cases, this was caused by shortages of other nutrients such as zinc, magnesium, or calcium. Some fields were exceptionally acid. Adjustments could easily be made to the package to deal with these problems. One important case involved the use of too much N in a particularly wet season. If maize becomes waterlogged, yields fall but the rules of the package had not included a provision for reducing N use in the case of excessively high rainfall. This, again, was

(2)Yield increases ranged from 55-111%, and profits from 25-146% greater than the comparative controls.

easily adjusted and much valuable information in the practical operation of the system was gained.

Widening the scope

Piha and his colleagues (and importantly the farmers with whom they were working) were now convinced that their package was robust and did what farmers wanted. They had eight years of data which showed consistently, in good years and in bad, and in dry as well as well watered areas, that the package was much more profitable for farmers than the standard fertiliser recommendations. They needed now to see how it would work with less direct supervision from the research team.

They set up a collaborative programme with a local NGO. The NGO would implement the package and arrange the finances. The research team would simply provide technical input and advice. The results were impressive. Farmer yields and profits were double those of their neighbours, or what they would normally expect. The loan payback increased to nearly 100%. Neighbouring farmers were desperate to join the programme. So the effort was scaled up. The NGO (the Self Help Development Foundation – SHDF) and Piha's group worked to carry out campaigns in selected project areas to introduce the package and the associated savings clubs. Farmers were helped in the formation of savings clubs which were set up with specific guidelines. These guidelines, developed through discussion with farmers, required that group members be compatible, hard working, honest, that they had sufficient land and were prepared to work as a group, and that the group would be responsible for the loan.

Insert Voice Piha here

Each group comprised between 7 and 15 people and could be formed from existing project groups if these were around. Each group purchased a bulk pack of the management package fertiliser which was then divided amongst the group so that each member could plant a 0.1 hectare promotional plot. If the group worked well together and the package was acceptable, the group could then proceed in the following season to purchase fertiliser on credit from SHDF sufficient for 0.375 hectares each. In 1999, participating farmers increased their profits by 227% and their yields by 143% over normal practice. In the 1999/2000 season some 500 farmers formed 53 savings clubs to move onto the next phase of the scheme.

Piha and his team have shown clearly that, with simple but different practices, fertiliser use can be made profitable for poor farmers in Zimbabwe. They have tested their method over a twelve year period, with a variety of farmers and over a range of seasons and ecologies. They have shown that, using existing farmer groups (and forming groups where necessary) it is possible to promote and encourage the adoption of the system without bringing in whole new groups of advisors and their associated costs. Farmers have clearly indicated that they like the approach and have collaborated fully throughout the period. The block they currently face is getting those who have the capacity to move the effort to the scale needed to bring about widespread change.

Bringing nitrogen fixing legumes into farming systems

Inorganic fertiliser management has a strong history of solid science behind it. Yet it took Piha and his team over a decade to move from his original hypothesis that inorganic fertiliser management could be made profitable to having the quality and depth of analysis necessary to convince sceptical outside and national development agencies. As Piha noted in the previous section, the task of verifying his approach remains incomplete. Organically based fertility technologies have a more complex, and less well understood science behind them.

All good agriculturalists know that reliance on a single crop and a single technology is unwise. The progress that Piha made with inorganic fertility was impressive but not sufficient. Crop rotations are a fundamental part of good farm husbandry. Rotations break the cycle of pests and diseases, farm income is not dependant on a single output, and, where the rotation crop is a food crop, this can provide a more varied diet for the farm family. Legumes are a favoured rotation crop because they fix nitrogen from the air and because many of them also provide food for humans or livestock. The legume itself does not fix nitrogen. Legume roots provide shelter for symbiotic bacteria (often *Rhizobia* species) which fix the nitrogen and pass it on to the plant. Of the nitrogen fixed, part may remain in the soil to be used by the following crop – thus reducing the need to buy in nitrogen fertiliser – and part may go into the legume plant itself to provide valuable protein when consumed by humans or livestock. Different legumes divide up the nitrogen they fix in different ways. Some leave most in the soil, others pass most on to the grain. Not all legumes fix lots of nitrogen. Legumes which grow vigorously in one ecology will barely germinate in another. Some legumes need to be treated with the correct rhizobia at planting, others are 'promiscuous' and will happily build a relationship with a wide range of naturally occurring soil bacteria.

The choice of the correct legume to use in any particular circumstance is not easy. But again, systematic science can be used to move quickly to determine what legumes are best suited to specific circumstances. Gilbert and his team[3] have provided an excellent model in their work in Malawi. Malawi is a small southern African country with an extraordinarily diverse agroecology. Altitude goes from 0 - 2000 metres above sea level, and average annual rainfall from 600 - 2000 mm. There is a single rainy season of 4-6 duration followed by 6-8 months of drought. The long dry period makes legumes difficult to grow as dry season growth and survival is poor for most species.

Malawi is unusually dependant on maize as the staple food. Over 90% of total cultivated area is planted to maize, mostly by resource-poor smallholders. Soils are deteriorating noticeably. One important measure of soil quality, soil organic matter, is falling sharply. Mean organic carbon levels in three regions declined 10 - 31% over a 20 year period.

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(3)E.Gilbert, L.C.Phillips, W.Roberts, M-T.Sarch, M.Smale and A.Stroud (1993) Maize Research Impact in Africa: The Obscured Revolution. Report prepared for the Divison of Food, Agriculture and Resources Analysis, Bureau for Africa, U.S.Agency for International Development. 185pp

Fertiliser use on maize does not pay[4] and farmers are desperately searching for other sources of fertility. This provides a real opportunity to explore the potential of legumes for soil fertility improvement. But Malawi farmers are hungry. Less than a third of farm families produce enough food each year to feed themselves through to the next harvest. Malnutrition is rife, child mortality high, and most Malawi farm families are desperately poor. Farmers plant maize as a priority as it is the most reliable source of calories to feed themselves

The socioeconomic and biophysical contexts of Malawi have important connotations for leguminous cropping systems. Farmers are searching for ways to ameliorate soil fertility that reduce the need for fertilisers, which provides an important entry point for legumes. However, the intense land pressure means that any leguminous system must be competitive with continuous maize on the basis of calorie production per hectare and economic net benefits. Table 1 lists tentative criteria for success and adoption of leguminous systems in Malawi. Legumes that can satisfy economic and caloric criteria while still improving soil fertility are termed “best bet” systems because they are most likely to be adopted by smallholder maize producers.

(4)T.Benson (Ed), Maize Commodity Team Annual Report 1995/1996, Department of Agricultural Research, Ministry of Agriculture and Irrigation, Chitedze Research Station, Lilongwe, Malawi, pp 135-144

Table 1. Criteria for the success of leguminous cropping systems in Malawi.

System	Malawian Example	Caloric Criteria	Economic Criteria	Soil Fertility Criteria
Grain legume -maize rotation	**1. CG7 groundnut** **2. Magoye promiscuous soyabean**	• Caloric output > continuous maize	• Economic net benefit > continuous maize • Market for legume seed	• N addition > 20 kg ha^{-1} yr^{-1}
Maize/grain legume intercrop	**Maize/ pigeonpea**	• Maize PLER* > 0.7 • Total LER* > 1.2 • Caloric output > sole maize	• Economic net benefit > sole maize	• Net increase in soil N and organic matter over time
Maize/green manure intercrop	**Maize/*Tephrosia vogelii***	• Maize PLER > 0.8 in year 1. • Maize PLER > 1.4 subsequent seasons	• Cost of N produced < equivalent cost of urea • Economic net benefit > sole maize	• N addition > 60 kg N ha^{-1} (>3 t ha^{-1} biomass produced)
Mucuna pruriens - maize systems	***Mucuna pruriens* - maize rotations**	• Maize yield following *Mucuna* > 1.5 times continuous maize • *Mucuna* seed yield >= unfertilised maize	• Economic net benefit over 2 years > continuous maize • Market for *Mucuna* seed	• N addition of > 80 kg ha^{-1} yr^{-1} by *Mucuna*

* PLER, LER refer to partial land equivalent ratio and land equivalent ratio. PLER is the ratio of maize yield in an intercropping system to sole maize yield. A PLER of 0.7 means a 30% maize yield depression in the intercrop. Land equivalent ratio is the sum of the PLERs for all crops involved in an intercropping system