Note:

Enter the various farm work activities for the crop indicated in the heading in the order in which they occur. Indicate the time it takes to complete each task from beginning to end by blocking in the respective rectangles in the body of the table. Thus if clearing for your crop starts at the beginning of February and ends in mid-March, you would block in the three corresponding rectangles. This form gives a more detailed picture for one crop whereas the other form makes possible a less detailed analysis of several crops at a time.

CALENDAR OF FARM WORK

(FOR ONE CROP ONLY)

CROP UNDER OBSERVATION:................

Month

farm work activity																								

CROP MONTH								
JANUARY								
FEBRUARY								
MARCH								
APRIL								
MAY								
JUNE								
JULY								
AUGUST								
SEPTEMBER								
OCTOBER								
NOVEMBER								
DECEMBER								

2.3.3. SURVEY SCHEDULE ON FARMING IN THE COMMUNITY

What crops are grown on the farms of the community?

crop	for consumption	for home consumption & for sale	for sale only
(1) CROPS CONTAINING MOSTLY STARCH AND SUGAR			
a) cereals:			
maize	( )	( )	( )
guinea corn	( )	( )	( )
rice	( )	( )	( )
b) root & tuber crops:			
yam	( )	( )	( )
cassava	( )	( )	( )
cocoyam	( )	( )	( )
colocasia	( )	( )	( )
sweet potatoes	( )	( )	( )
Irish potatoes	( )	( )	( )
c) other crops:			
plantains	( )	( )	( )
bananas	( )	( )	( )
sugar cane	( )	( )	( )
fruit	( )	( )	( )
(2) CROPS CONTAINING MAINLY PROTEIN			
beans	( )	( )	( )
cow peas	( )	( )	( )
(3) CROPS CONTAINING FAT AND PROTEIN			
groundnuts	( )	( )	( )
egusi melon	( )	( )	( )
(4) CROPS CONTAINING MOSTLY FAT			
oil palm	( )	( )	( )
(5) OTHER CROPS			
vegetables	( )	( )	( )
spices	( )	( )	( )
kola trees	( )	( )	( )
coffee trees	( )	( )	( )
cocoa trees	( )	( )	( )
rubber trees	( )	( )	( )
tobacco	( )	( )	( )

Please tick where appropriate!

2.3.4.

INTERVIEW GUIDE
FOR A
SURVEY ON TRADITIONAL FARMING

In order to acquire a good understanding of traditional agriculture in your community, we would suggest that you collect information from individual farmers, both women and men. The best way to do this would be to discuss with them their various plots one by one. Such an investigation could be done with small groups of pupils. In that case, however, only a few of the topics treated in this guide should be taken up at one time.

1. Size of the Farm

See together with the woman or man in question as many of her/his plots as possible

1.1. number of plots farmed by men in the household ...
by women in the household ...

1.2. size of plots

It is difficult to know the approximate size of traditional farm plots since size in itself does not usually matter to the farmer. Plots rarely have straight boundaries, which makes exact measurement very time-consuming and difficult. We shall therefore propose methods of estimating the size of the plots approximately.

- If the farmer knows the size of his farm plots, enter this information in the table below and specify the unit of measurement (hectare, acres,...)
- If the farmer does not know the area of his farm plots, proceed as follows:

  (1) in the case of tree crop farms (coffee, cocoa oil palms, raffia, etc.)

- if the farmer knows the number of trees, find out the average planting distance between the trees (by pacing the distance between a number of trees). Once you know the average distance you can estimate the total area of the plot using the formula:

$$\boxed{\text{area} = \text{number of trees} \times \text{planting distance}^2}$$

- if the farmer does not know the number of trees, walk around the farm boundary, pace it out and draw a sketch on a piece of paper. Where the boundary is curved, draw it in your sketch as a series of short straight lines joining up the main points. Find out the average planting distance between trees. Estimate the area of the plot from your sketch (for details see instructions at the end of this section). To get the number of trees, use the formula:

$$\boxed{\text{Number of trees} = \frac{\text{Total area of plot}}{\text{planting distance}^2}}$$

(2) in the case of food crop farms

Proceed as with tree crop farms where the number of trees is unknown and estimate the size of the farm plot from your sketch.

Plots with tree crops:

Plot No	Kind of trees	average planting distance	number of trees	area of trees	other crops grown between the trees

Plots with food crops (annual and biennial):

Plot No	area of plot	Crops grown				

Many farmers have a large number of small plots scattered over a wide area. If this is so, you may not have the time to inspect all of them, although it would be desirable. Try to get an estimate of their size by asking the farmer and his wife/wives to compare them with the plots you have seen.

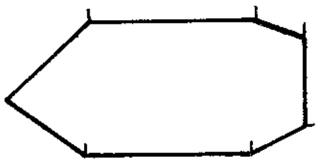
As far as farm size is concerned, you should now be able to find out

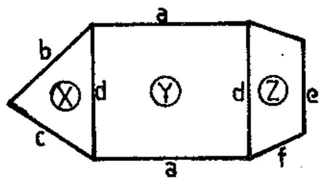
- the total area of the farm plots (by adding all the estimates of size)
- the largest and the smallest plot,
- the average size of the plots (dividing the total area by the number of plots)

How to calculate the area of a farm plot

Walk around the plot to get an idea of its shape. You may stake out each main angle. Measure the distance between each angle (if you have not staked them out and if you are with someone, ask him to go to the next angle and walk up to him counting your steps).

On a piece of paper, draw the shape of the field, after selecting a scale (e.g. 1 square on the paper = 1 meter)





Divide your drawing into common geometrical shapes (squares, rectangles, triangles, trapezoids).

Calculate the area for each of the shapes. Here is the example of the above Figure:

the area of triangle $X = \frac{C \times B}{2}$

the area of rectangle $Y = A \times D$

the area of trapezoid $Z = \frac{E + D}{2} \times F$

Total area = Area X + Area Y + Area Z
Convert the total area into ares
100 M^2 = 1 are
1 hectare = 100 ares = 10.000 M^2

GEOMETRY REMINDERS

The area of a rectangle is the product of two adjacent sides (length multiplied by width)

The area of a triangle is one-half the product of the base and the corresponding altitude.

The area of a trapezoid is the product of its altitude and one-half the sum of the length of its bases

The slope of a farm plot is important because it has a major influence on erosion. Especially in hilly areas it would be a good exercise to find out the slope, and also whether farmers control erosion, and if so, how. The following is a very simple method of finding out the gradient, which is a recognized measure of the slope.

How to measure the slope of a farm plot

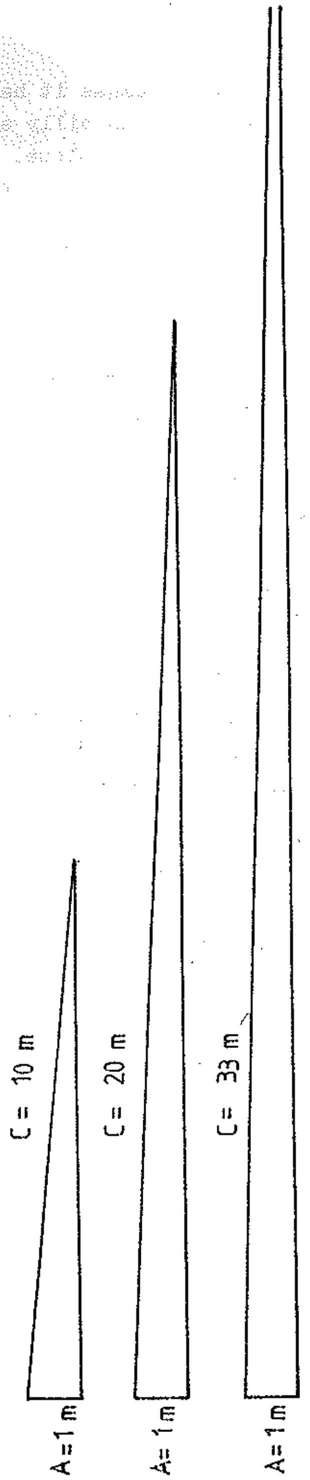
- Cut a one-meter long pole and vertically place it in the ground at the bottom of the slope. (A)
- Ask someone to climb the slope until you see his feet on a level with the top of the pole (B) (Your own eye must also be on a level with the top of the pole).
- Measure the distance between the base of the pole and your friend's feet (C)

The gradient will be equal to $\frac{A}{C}$

Example: if = C = 10 m., the gradient = 1/10 = 10%
if C = 20 m., the gradient = 1/20 = 5%
if C = 33 m., the gradient = 1/33 = 3%

With a little practice you will soon be able to estimate the slope of a farm plot simply by looking at it.

The figure below shows the 3 gradients.



2. Crops Grown

As you find out the size of each plot, make a note of the crops grown and enter them with the plot number and its area in the tables on the preceding page. Complete for each plot by checking with the farmer, and ask him for information about the plots not inspected.

The tables now show for each plot the crop associations in multiple cropping for the current year. How far do these crop associations agree with the ones shown in our documentation?

Indicate which crop will be harvested first and which ones later. Which crops are planted systematically all over the plot and which ones are dotted here and there? Use your own symbols to show this information in the tables above.

3. Farming Methods

3.1. When you prepare an unused plot for farming, how do you usually clear it?

	forest	grassland
cutting down grass	( )	( )
cutting of shrubs and bushes	( )	( )
felling trees	( )	( )
ringbarking trees	( )	( )
burning trees on the farm	( )	( )
leaving some trees for shade	( )	( )
covering grass with soil	( )	( )
leaving grass on the surface without burning it	( )	( )
burning grass	( )	( )
using machinery	( )	( )
uprooting trees	( )	( )

other work involved in clearing

....

....

3.2. Prepare several tables of the type shown below amd fill in one for a plot with food crops that has been burned, one for a food crop plot that has not been burned, and at least one for a newly established tree crop farm. (If there are not any, ask what was planted when the present tree crop farms were originally established.).

Type of plot: tree crops ( ) food crops only ( )
first clearing with burning ( ) without burning ( )

year of farming	crops grown				
1					
2					
3					
4					
5					
6					
7					

These tables will repeat at least some of the crop associations which have occured in previous tables. But they do more than that. They also show typical crop sequences according to the type of clearing used and the main crops grown (tree of food crops). The questions to ask are:

- What do you plant in the first year after clearing?
- What do you plant in the year after that? And what in the next year?

Continue the questions until the informant says that the soil would by then be exhausted, and the plot must be allowed to lie fallow.

Do the sequences and rotations match with any of those shown in the documentation? Which one is it? Do people in the community agree on the crop sequences or does every farmer have his own sequences?

You can now also see how long food crops are grown in tree crop farms. How do people justify what they are doing in this respect?

3.3. For how many seasons can the farmer continue to

farm a newly cleared piece of land until the soil is so exhausted that it must be allowed to lie fallow.
Number of years of continuous farming: ..... years

3.4. Some crops exhaust the soil faster than others. Can you tell, for the main crops in the respondent's farm, how long they can be grown continuously?

crop	Number of seasons of continuous farming

3.5. Once a plot is exhausted, how many years or seasons is it left fallow before it can be used again?
Number of years left fallow: ....

3.6. The table shows for each crop which methods could and should be used. Check for each of the crops farmed by the respondent which methods she/he uses and which ones she/he leaves out.

Methods used on the farm

C R O P S

Method	Coffee	Cocoa	Oil Palm	Yams	Maize	Cassava	Rice	Ground nut	Irish Potato	Pineapple	Banana Plantain
Staking	☒	☒	☒		☒	☒	☒	☒	☒	☒	☒
Planting with cuttings, sets, suckers			☒		☒		☒	☒			
Standard planting distances											
Digging holes for planting					☒	☒	☒	☒	☒	☒	
Shading/capping					☒	☒	☒	☒	☒	☒	☒
Pruning					☒	☒	☒	☒	☒	☒	☒
Chemical fertilizer											
Manuring											
Mulching						☒	☒	☒	☒		
Insecticides						☒	☒	☒	☒	☒	
Irrigation	☒	☒	☒	☒	☒	☒		☒	☒	☒	☒
Transplanting				☒	☒	☒		☒	☒	☒	☒
Grafting		☒	☒	☒	☒	☒	☒	☒	☒	☒	☒
Thinning	☒	☒	☒	☒		☒		☒	☒	☒	☒
Hoeing											
Propping	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	
Earthing up	☒	☒	☒			☒	☒	☒			☒
Tapping	☒	☒	☒		☒	☒	☒	☒	☒	☒	☒

Key: ☒ = Method not used with this particular crop

3.7. In order to compare results (e.g. total yield per hectare or yield per crop per hectare) in multiple cropping with yields from single cropping in "scientific agriculture", you need to know how many plants there are per hectare. The number of plants per hectare is the plant density. It is not possible to count all the plants, on a given plot, and standard planting distances will not have been used from which the density could be easily calculated. Therefore, you can proceed by sampling. Your sample is a small area in which you count all the plants growing in it. From there you generalise to one hectare. The easiest way of taking a sample of this sort is to use a density square.

HOW TO BUILD A DENSITY SQUARE

- Take a 20-meter long rope and 4 stakes. "Country-rope" will do.
- To find out where to make your survey, stand in the field and throw a stick behind you at random (your density square should be a random sample).
- Around the spot where the stick has fallen, draw a square of 5 x 5 meters (on a ground-nut field, 3 - 5 squares of 2x2 meters) by planting your sticks at the 4 corners and stretching the string around them.
- Count the number of stands or single plants of each variety within the square.
- Enter the figures in the table below and calculate the density per hectare using the formula:

density per hectare = density per 25 square meters x 400

NOTE: You may add to your list rare species present on the field but not found within the square.

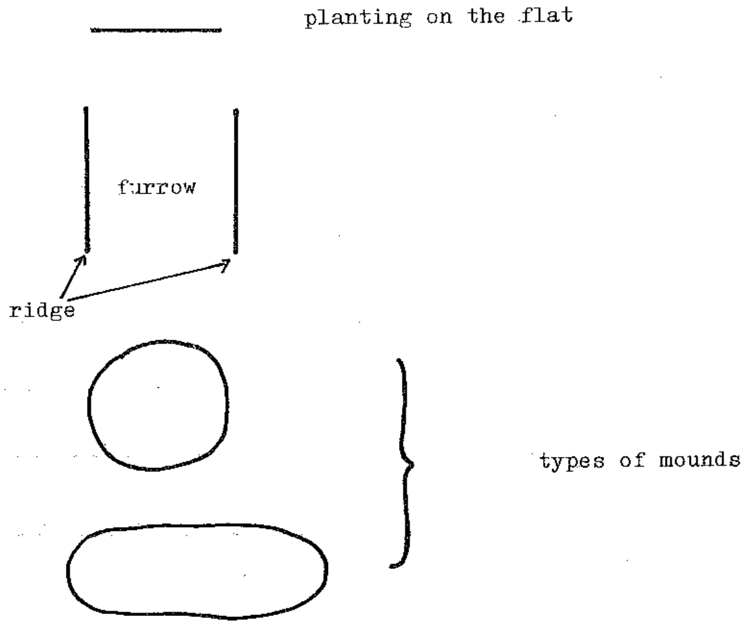
- **For a large (e.g. 1 hectare) farm, you will have to make several density squares.**

Density table

Crop	N° of plants in density square	estimate for one hectare
Total plot		

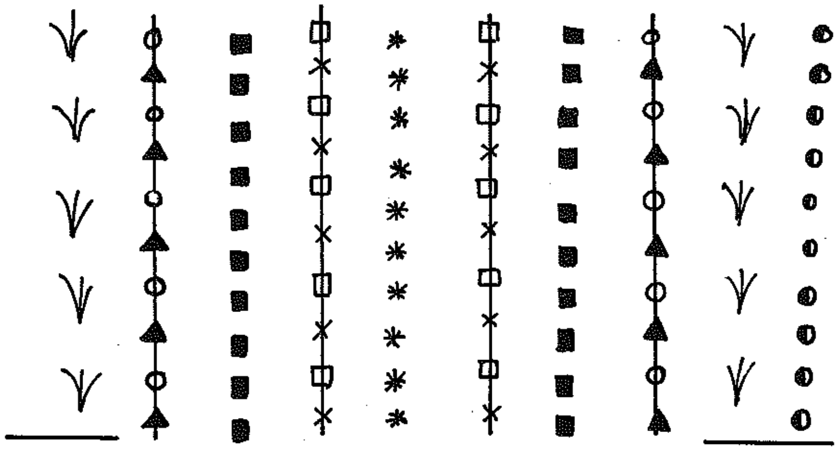
You will need one such table for each of the plots on which you use a density square.

3.8. In order to see more clearly how multiple cropping is being done make a simplified graphical representation of the way crops are arranged on the farm. This means you will have to use two sets of symbols. First you will need one set of symbols to indicate the tillage.



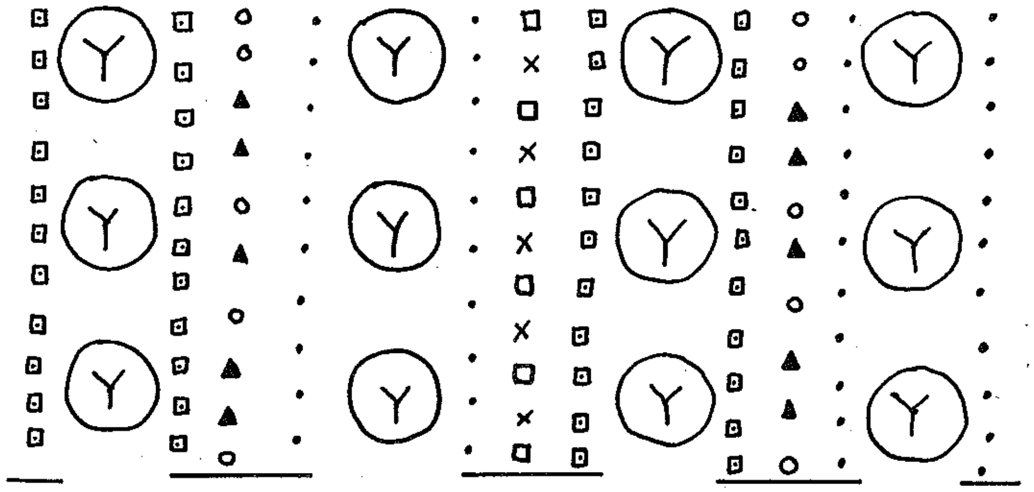
You will need to invent another set of symbols to represent the crops. Examples are given in the documentation in the section on planting and sowing. The following figure gives two more examples:

Graphical representation of multiple cropping systems in Northern Ghana



K E Y

○	Early Millet	✻	Rice		
▲	Late Millet	Ψ	Pigeon Peas		
■	Cowpeas	◐	Pepper	Ⓨ	Yams
☐	Maize	•	Groundnuts		
×	Guinea Corn (Sorghum)	⊡	Bambara Groundnuts		



In example (a), starting from the left pigeon peas are planted on the flat, then there is a ridge where early and late millet are planted. Next, there is a furrow planted with cowpeas, and on the next ridge, guinea corn and maize alternate. The following furrow has upland rice in it. The next ridge again has guinea corn and maize, followed by a cowpea furrow and another ridge of early and late millet. After that, two rows are planted on the flat, one row of pigeon peas and one row of pepper.

In example (b), again starting from the left yams are grown on mounds, and they form rows. The rows of yam mounds have on each side of them rows of either groundnuts or bambara groundnuts planted on the flat. Between two rows of leguminous crops, there is one row of cereals, either late millet interplanted with early millet or maize alternating with guinea corn.

(Graphic representation adapted from Bennet and Schork, 1978, p 112)

4. Yields

Crop	Amount harvested	unit of measurement	market price per unit

In order to get information on this touchy question, ask the following:

<u>For cash crops:</u> How many bags ....can you harvest in a good year, and how many bags .... in a bad year? Write down the range thus obtained.

<u>For food crops:</u> How many baskets or bags ....did you (your wife/wives) harvest last year, both for sale and for consumption? If you had to buy a basket/bag on the local market, how much would you pay? Enter the price per unit in the last column.

<u>For plantains/bananas:</u> How many bunches per week do you usually harvest? How many bunches do you eat in a week which come from your farm?

Of course it is difficult to get reliable information by asking questions. Except for cash crops, farmers simply may not be able to remember things in terms of numbers. Since you live in your school community, a more direct approach is possible. You can measure yields directly. Here are some guidelines on how it could be done for one crop at a time:

- If the farm plot has been completely harvested:
  - count the number of baskets, bags or sheaves.
  - weigh one basket or bag or sheaf.

  By multiplying the number of baskets by the unit weight (remembering to deduct the weight of the bags, baskets, buckets, basins etc. used as containers) you can calculate the yield of the field. By dividing the yield by the area of the field (which has already been calculated) you will also obtain the yield per hectare for each variety.
- If the plot is not fully harvested:
  - You can estimate the average production of one plant (tuber, ground-nut) by weighing the tubers or the products of some twenty plants and dividing this weight by the number of plants whose production you have measured.
  - Subsequently you can use the sample established in your density square to calculate the average production of one are (knowing that the 5 X 5 m^2 density square = 0.25 are)

    Example:

    average production of one yam plant = 2 kg.
    density noted = 9 plants/0,25 ares
    density per are = 9 x 4 = 36 plants/are
    production per are = 36 x 2 = 72 kg/are.
  - You can then estimate the yields per hectare (in the above example: 7,2 T/Ha)

- **Since you have already measured the area of the field, you will have no difficulty measuring the total production of the field (if the field is 20 ares, yam production may be calculated: 72 kg x 20 ares = 1,440 metric ton.**

3. Scientific Agriculture

3.1. The Meaning of Scientific Agriculture

School farm work so far has been guided by principles of scientific agriculture. Scientific agriculture in this context may best be described as the traditional European land-use system systematically changed and improved by applied science.

Any traditional land use system in the world tends to be well adapted to the conditions under which it works - the climate, the soil, the existing technology, the population density and social conditions. If changes in these factors occur slowly, the land-use system will be able toadapt to them, but adjustments are not usually fast enough to cope with rapid change. The slow pace of natural change in farming systems is due to the fact that a change of habit derives exclusively from everyday experience. Experience comes in the form of shortcomings and disasters on the one hand, and successful innovations on the other. Such innovations are often due to good luck and chance as much as to conscious efforts to remedy a deteriorating situation. Since these innovations, these new and better ways of farming, are always introduced by individual farmers, they will spread only very slowly, depending on how widely the farmers travel.

Scientific agriculture in Europe was the result of an approach that put the findings of scientific disciplines such as biology, chemistry, geology, and physics to the task of solving agricultural problems which European farming traditions alone, faced with an increasing population and urbanization, could not solve. This has resulted in a variety of land-use systems all permitting permanent cultivation. These

systems all did away with the fallow year in the traditional three years' rotation. The major breakthrough in this respect was the application of chemistry to the problem of soil fertility. The exact properties of the plant nutrients were identified. Chemistry found ways and means of producing these nutrients so that the farmer did not have to rely exclusively on the slow natural processes by which they were made available in the soil. The resulting development of chemical fertilizers (also called inorganic fertilizers) has been very successful, and did more than anything else to establish the firm belief in the omnipotence of science in agriculture. Pesticides and insecticides, the systematic breeding of high-yielding varieties of all sorts of crops, farm machinery, sophisticated techniques of soil improvement and systems of crop rotation are all instances of the application of science to agriculture.

The following table contrasts scientific agriculture with both the approach followed in Rural Science as taught and practised in Cameroonian primary schools, and traditional Cameroonian agriculture. The table warrants careful reading since we shall comment only on some of its elements.

Factor	Scientific Agriculture	Rural Science Teaching	Traditional Agriculture
SOIL			
- preparation	- deep tillage - removal of all shrubs and trees - levelling - boundaries with straight lines and right angles	- shallow tillage - removal of all shrubs and trees - boundaries with straight lines and right angles	- shallow tillage - tolerance of selected shrubs and trees - shape of plots not important

Factor	Scientific Agriculture	Rural Science Teaching	Traditional Agriculture
- improvement of soil quality	- drainage - anti-erosion measures - addition of limestone etc.		- terracing in some areas (e.g. North Cameroon)
Crops	improving the quality of plant material through breeding for - high yields - adjustment to climatic and soil conditions - nutritive value - resistance to diseases and pests - taste, etc. introduction of new crops	careful selection of planting material introduction of new crops	careful selection of planting material introduction of new crops
CROP HUSBANDRY	- single cropping - planting/sowing along straight lines - exact planting distances - clean weeding (use of chemicals) - chemical plant protection (pesticides, insecticides)	- single cropping - planting/sowing along straight lines - exact planting distances - clean weeding - no plant protection	- mixed cropping - phased planting - planting at random on a given area - no exact planting distances - some weed tolerance, weeds used as mulch - plant protection assured by mixed cropping
SOURCE OF POWER	traditional: man, draught animals modern: fuel-powered motors, electricity	man	man
TOOLS AND IMPLEMENTS	traditional: specialized hand tools, animal-drawn implements modern: sophisticated engine-powered machinery	- African all-purpose hand tools - specialized European tools for gardening	- African all-purpose hand tools - a few European-type hand tools

Because of the great successes achieved through science in European agriculture, methods developed for agriculture in temperate zones were transferred to tropics with only minor adjustments. It took people some time to realize that scientific farming in the tropics meant more than identifying and breeding high-yielding varieties of crops. It meant that science would have to take an altogether new look at principles of soil preparation and crop husbandry, and that basic procedures and methods would also have to vary according to climatic and soil factors.

We shall comment briefly on the above table:

Deep tillage using the plough needs farms without trees and shrubs as these would disturb ploughing. Advanced farming machinery such as the various sowing machines and harvesters need levelled land, i.e. farm areas where small depressions and holes are filled in and small elevations are levelled down so as to make a smooth surface. Farming along straight lines is also a requirement of cultivation techniques (weeding, application of fertilizer) that use animal-drawn or engine-powered equipment. This has so much shaped the appearance of the European and American countryside that the newcomer to Africa has difficulty in distinguishing a food-crop farm from the bush, especially in the forest and tree savannah zones.

Manuring differs for gardens and farms. Traditionally, farms were fertilized with farmyard manure. But farmyard manure is available only where animals are kept in stables so that their dung, mixed with the straw used for bedding, decomposes to form a very rich mixture that is ploughed into the soil. In Africa, where farming and livestock rearing are usually done by quite different groups of people, farms do not produce any farmyard manure. Compost is prepared and used in vegetable gardens that are much smaller in size than fields. Preparing good compost is so much work that it cannot possibly be applied to farms far away from the compound, although it might prove feasible for the compound farm. As mentioned above, compound farms are manured by all sorts of household refuse and animal droppings thrown on top of the soil as a kind of mulch. Composting all these items and hoeing them into the soil at the time of farm preparation and/or planting would provide more soil nutrients.

The science-based methods of improving soil quality have permitted the cultivation of land formerly thought unsuitable for farming. By careful drainage, waterlogged areas have been put to use. By adding limestone and other substances, the structure of the soil has been changed to suit various crops.

"The Green Revolution", (in use long before such a movement was launched in the United Republic of Cameroon), is a slogan denoting spectacular developments in agriculture due to the breeding of high-yielding varieties of rice, maize, and wheat. With cereals such as these, the most surprising yields were achieved by careful crossbreeding of a large number of varieties of the same cereal. Similar attempts have now been made in the case of root and tuber crops, and specialists assert with confidence that they can breed almost any desirable quality into a given plant. However, as far as high-yielding varieties are concerned, there is a drawback: they thrive only under optimal conditions and thus are very demanding on the farmer. The right planting time, correct spacing, the right amount of water, no competition from weeds, chemical fertilizer and chemical control of pest - all are required in order to assure the heavy harvest these varieties are able to yield.

Some of these requirements involve a lot of work, some mean heavy financial expenditure. It is not surprising, therefore, that the result of this kind of Green Revolution has been that the rich landowners have profited most while smallholders have not been able to buy the necessary artificial fertilizers and pesticides even when seed material was distributed free.

Exact planting distances are justified by considerations about the growth of roots and competition between plants. The best planting distance obviously is such that the root systems of neighbouring plants just touch each other when fully grown. If they are further apart, parts of the soil are not used. If they are closer together, they compete for soil nutrients and will not grow to be healthy plants. This is certainly true for single cropping where all the plants on a plot - apart from the weeds - need the same kind of soil nutrients. One would have to reason differently when it came to mixed cropping.

In case of single crops, pests and diseases particular to the crop being farmed find ideal conditions. Many high-yielding varieties are more vulnerable to pests and diseases than varieties with lower yields. Plant protection by means of chemicals therefore becomes important. Since in mixed cropping plants of the same species are further apart than in single cropping, pests and diseases do not spread as fast as in single cropping, and, some plants, even some weeds, seem to keep away pests from other species. The best known example is the pyrethrum flower which East African farmers grow as a cash crop, and which forms the basic ingredient of most insecticides. Vegetable gardeners in Europe know, for instance, that it is advantageous to plant carrots and onions in alternate rows. The onions drive away certain insect pests which attack carrots, and the carrots keep out a pest which feeds on onions.

Finally it must be pointed out that today's modern scientific farming is highly mechanized and labour saving. It would not be possible, otherwise, for five per cent of the population of the industrialized countries to feed the rest and produce surpluses for export. But this type of agriculture is certainly not suitable for areas where unemployment is a big problem and where all the farm machinery would have to be imported from abroad, using up scarce foreign exchange.

3.2. Scientific Agriculture in Cameroon

3.2.1. The Plantations

Scientific agriculture is most evident in the large tree crop plantations in the South-West and Littoral Provinces, in the tea plantation of Ndu, North-West Province, and, on a more limited scale, at the former Santa Coffee Estate. The plantation crops are grown strictly as single crops, soil preparation is done with huge, powerful machines, and planting distances are carefully measured out. Weeds along the edges of the rubber plantations are killed by chemicals. At certain times of the year an aeroplane sprays pesticides over the banana plantations between Muea and Ekona, and, under the trees, a leguminous cover crop prevents any weed growth. But the care of the trees and the harvest cannot be mechanized, and therefore the plantations employ a large number of labourers.

3.2.2. Research Stations

Research into improved farming methods is carried out at a number of research stations spread over Cameroon. Selected seeds and planting material are adapted to

local conditions and multiplied, promising species from abroad are adapted to conditions in Cameroon, etc. These research stations are administered by ONAREST (Office National de Recherche Scientifique et Technique - National Office for Scientific and Technical Research). Those located in the two anglophone provinces are

- Barombi Kang station near Kumba,
- Ekona CDC station on the Buea-Kumba road,
- Bambui research station near Bamenda,
- Santa research station and smaller stations at Mankon and Bali.

It is suggested that teachers in the neighbourhood of these centres should establish contact with them with a view to obtaining suggestions, advice, and planting materials. The Teacher Training Colleges could also profit from some kind of cooperation with these research stations.

3.2.3. Higher education

Scientific agriculture at the post-secondary level is taught at the École Nationale Superieure Agronomique (ENSA) at Dschang, Province de l'Ouest. ENSA is part of the University of Cameroon in Yaounde and trains agronomists. Members of its staff have published highly technical books on a number of tropical crops. Some of the books are available in English. (see list of references).

3.2.4. INADES

In Douala there is an institution called INADES which offers correspondence courses to groups of farmers with at least one literate farmer among them. These courses teach the basic elements of modern agriculture in the tropics. Like Rural Science in primary schools, they tend to ignore traditional African farming methods. The course covers a period of three years and is very well adapted to the language level of the small farmer. Booklets are available in French and English. Schools with some funds from school farm work might do well to enrol in this course.

3.2.5. Rural Development Projects

There are a number of large and small rural development projects where modern scientific agriculture methods are put into practice and taught to the local population. In the North West Province there is W.A.D.A. (Wum Area Development Authority) with extension activities geared to food crops and coffee and, as a very special feature, the introduction of oxen as draught animals. In 1978 the project, now almost entirely run by Cameroonian management and staff, had three programmes. The programmes all aim at improving the living conditions of the rural population through better farming methods. They are

- a so-called 'Block Extension Programme' in the area immediately surrounding Wum, where farmers are settled on a 2.5 hectare farm and benefit from intensive advice on farming methods and planting programmes,
- a Group Farming Programme in areas further away, mostly dealing with upland and swamp rice,
- an Animal Draught Programme training oxen as work animals, teaching farmers how to use them, and selling them to farmers on credit (see our text: Farming Becomes Easier).

In the Ndop plain, the U.N.V.D.A. (Upper Nun Valley Development Authority) fosters rice farming in the plain which is flooded every year. It is therefore

ideally suited for irrigated or swamp rice (see text on Rice), and as a consequence, rice production has increased at a fast rate. People in the area are rushing to buy land suitable for rice farming.

Other development schemes are run by the churches. The Presbyterian Church runs two Rural Training Centres (R.T.C.s), one at Kumba and one at Mfonta. Here, young farmers receive a one-year training course in modern methods of farming adapted to Cameroon. The Catholic Church initiated a resettlement scheme for young farmers involving rice cultivation in the Mbo-Nso plain, and also several cooperative oil palm schemes (Mbonge, Mamfe, Widikum). Nearly all of these development projects produce annual reports and teaching materials such as brochures and extension leaflets. Schools could very well benefit from this experience and knowledge by writing to ask for copies of these documents.

3.2.6. Commercial Farming and Production under Supervision

In areas immediately bordering the North-West Province and between Bafoussam and Foumban there are a few large commercial farms growing vegetables for sale in the urban centres of Cameroon and abroad. In order to increase production, they pass contracts on to local farmers whom they then instruct in the appropriate methods. The farm management also organizes the supply of necessary materials such as seeds, fertilizer, and insecticides.

3.2.7. Peasant Farmers

In general the average farmer in Cameroon - man or woman - continues to use traditional farming methods, especially for food crops. The cultivation of coffee and cocoa has been a major concern of the extension service. Since the crops were formerly unknown in Cameroon, farmers were willing to take advice. The following list shows how many farmers of a sample surveyed by IPAR-Buea use methods advocated by scientific agriculture:

Method	per cent of sample farmers	remarks
Single cropping in food crop farms	4.2	
preparation and use of compost manure	4.7	very demanding in terms of labour
crop rotation or sequence	9.8	
use of selected planting material for coffee, cocoa or oil palms	15.9	most farmers raise seedlings themselves from coffee berries or cocoa beans. Some farmers establish nurseries and sell seedlings. The department of agriculture is setting up nurseries for the distribution of selected plants.
fencing the farm	16.4	farms not fenced suffer damage from animals - mainly goats in the forest zones and goats and cattle in the grassland savannah.
use of chemical fertilizer	20.6	Fertilizer is only applied to tree crops. Farmers lack confidence in the beneficial effects of fertilizers and are poorly informed about the way it acts. Also, there are frequent shortages of supply.
shade trees in young coffee and cocoa farms	28.5	
single cropping in tree crop farms	32.2	Even if allowance is made for the growing of food crops in young tree farms, intercropping is done to a large extent on mature tree farms.

Method	per cent of sample farmers	remarks
insecticides and pesticides	32.7	spraying against pests and diseases on coffee or cocoa farms is recognized as important, but the necessary chemicals were in short supply at the time of the research.
correct spacing of trees (planting distances)	44.9	for details see table on planting distances
mulching	46.3	mulching is mostly done in young tree crop farms and in yam farms.
pruning	75.7	

The table below shows what planting distances have been recorded on coca and coffee farms.

▭ = acceptable planting distances

Planting distance in m	Coffee farms		Planting distance	Cocoa farms
	forest	savannah		
below 1.5	5.7	5.5	1.0 - 1.5	5.9
1.5 - 1.99	20.8	13.7	1.51- 2.0	2.9
2.0 - 2.29	17.0	30.1	2.01- 2.5	11.8
2.3 - 2.49	3.8	6.8	2.51- 3.0	17.6
2.5 - 2.89	9.4	15.1	3.01- 3.5	17.6
2.9 - 3.49	15.1	13.7	3.51- 4.0	8.8
3.5 - 4.49	15.1	8.2	4.01- 4.5	8.8
4.5 and obove	13.2	6.8	4.51- 5.0	8.8
			5.0 and above	17.6
Total	100.0%	100.0%		100.0%
number of farmers	53	73		34
percentage of farmers with acceptable planting distances	41.5	50.7		44.1

Planting distances depend among other things on the fertility of the soil. Therefore, we have defined a range of planting distances as being correct rather than just one. For coffee, this range lies between 1.5 m and 2.5 m. For cocoa it is higher and lies between 2.5 m and 4.0 m. A relatively high proportion of coffee and cocoa farms in the forest zones show very high planting distances, sometimes double the required distance. This is due to the fact that on some farms cocoa and coffee trees are mixed which requires larger distances between the trees of one species. From advanced statistical analysis one can conclude that modern methods of tree crop cultivation have a comparatively small effect on the income derived from the tree crops. Taking the example of coffee, the most important factors accounting for high income are

1) the total number of trees owned,
2) the employment of skilled labour (e.g. for pruning and spraying)
3) the use of modern methods like skilled pruning, weeding, and mulching, the use of fertilizer and chemicals for spraying,
4) the use of selected planting materials, especially important in the South-West Province.

Thus, for the average farmer with his limited resources and financial possibilities it was, at the time of the research, more profitable to extend his coffee or cocoa farms in size than to increase his own efforts or to employ hired labour in order to apply the recommended farming methods, or to buy costly materials like fertilizer and insecticides or pesticides.

We have already seen the large differences in the use of modern, scientific farming methods, even in tree crop cultivation where these methods are better adapted to tropical conditions than in food crop farming. What could be the reasons for these pronounced differences? One important factor is certainly the availability of training and good examples. Thus, coffee farming in the communities around the Santa Coffee estate was much better than, for example, in Bui Division. Surprisingly well kept farms were also found in Nwa subdivision, from where people migrate to the coffee estates between Foumban and Bafoussam, and in the nothern Bakossi area where people migrate to the coffee farms around Nkongsamba for seasonal work.

In many cases, plantation workers came back to their place of origin, took over the farms of their parents, and tried to apply what they had learnt during plantation work. This was evident in Ngolo-Batanga area (zone of influence of PAMOL-plantations) and even in an isolated community like Akwa in Mamfe-Overside, to cite only remote areas. It is common in the better accessible areas like Widikum, Ekenge, Kombone. But even in a newly opened area like Okoromanjang/Momo Division, an ex-CDC worker was starting a modern type oil palm plantation and a cocoa farm.

3.2.8. Teachers, Schools, and School Leavers

The methods advocated by Rural Science as taught in Cameroon, are a blend of African and European farming methods, applied largely to African crops but also to vegetables and other garden crops brought in from Europe. All the expensive methods of scientific agriculture have been left out as schools would not be able to pay for them. "Rural Science" emphasizes crop husbandry where much more efforts is required than by traditional crop husbandry procedures. The contrast between Rural Science and traditional farming is striking although many of the new methods of scientific agriculture, like soil improvement, plant breeding, and equipment in the form of sophisticated tools and machinery have been left out. A detailed account of present school farm work is to be found in the IPAR-Buea report on the reform of Primary Education. Summarizing the findings one might say:

> "The results are not very encouraging. Many parents are not convinced that the agricultural techniques of the school are superior to their own. Student graduates (i.e. school leavers, H.B.) seldom apply their acquired knowledge."
> (Bergmann, H., 1978, p. 9)

> "How alien the content of the instruction has remained is evident in the fact that many teachers themselves do not even see to it that their own fields are tended in accordance with the methods prescribed by the curriculum."
> (Bergmann, H., 1978, p. 10)

A hand-out distributed by IPAR-Buea states this as follows:

> "Most teachers are not convinced as to the usefulness of 'scientific agriculture'. They therefore either apply local farming methods wholesale or practise a mixture of the two sets of methods. Educationally, this is disastrous, because children know what is happening very well (often, some of them are sent to work on teachers' farms during periods of manual labour). Teachers should therefore feel free to seriously reconsider local ways of farming and should have the courage to apply what seems useful to them on the school farm."
> (Bergmann, H., 1977, p. 3)

The conclusion therefore is:

> "The basic mistake of existing curricula is that they apply European principles to the agricultural field. This makes translation of the subject matter into practical application for daily living difficult, and this applies to teachers as well as to parents and students."
> (Bergmann, H., 1978, p. 10)

If what is taught in school is not applied in practice, this means that the teaching has failed. If, despite such failures, teaching is not changed to incorporate

methods that can be used, this shows a frightening lack of realism.

3.3. Conclusion

It is not only the school which experiences this failure. In a study on farming in Northern Ghana, Bennet and Schork state:

> "The question should be posed, however, why then, after so many years of discouragement by extension agents and technical advisors, do so many farmers in Northern Ghana, as well as other parts of West Africa, continue to practice these methods (the traditional ones, H.B.). A critical examination may yet prove these techniques to be of the highest value as a basis for the upgrading of the indigenous farming predicament."
> (Bennet and Schork, 1979, p. 103/104)

The Rural Education Centre at Umuahia, well known to many of the older teachers in the anglophone provinces of Cameroon, has attempted continuous cultivation based on a heavy dressing of compost manure. As the figures on crop yields over a period of 20 years show, yields seem to be stable at or even above the initial level. Maize yields rose from one ton per hectare to roughly 2.4 tons per hectare, yam yields fell from eight to below seven tons per hectare but rose afterwards to nearly nine tons per hectare. Cassava yields did fluctuate strongly but seem to be generally on the rise. Yet this experience seems unique, and is limited to areas small enough to be manured by compost.

Another experiment conducted at the Agricultural Research Station at Umudike leads to rather pessimistic conclusions. Here are the main facts:

> "The problem of declining soil fertility resulting from washing and leaching of the principal soil nutrients led to the question of whether continuous

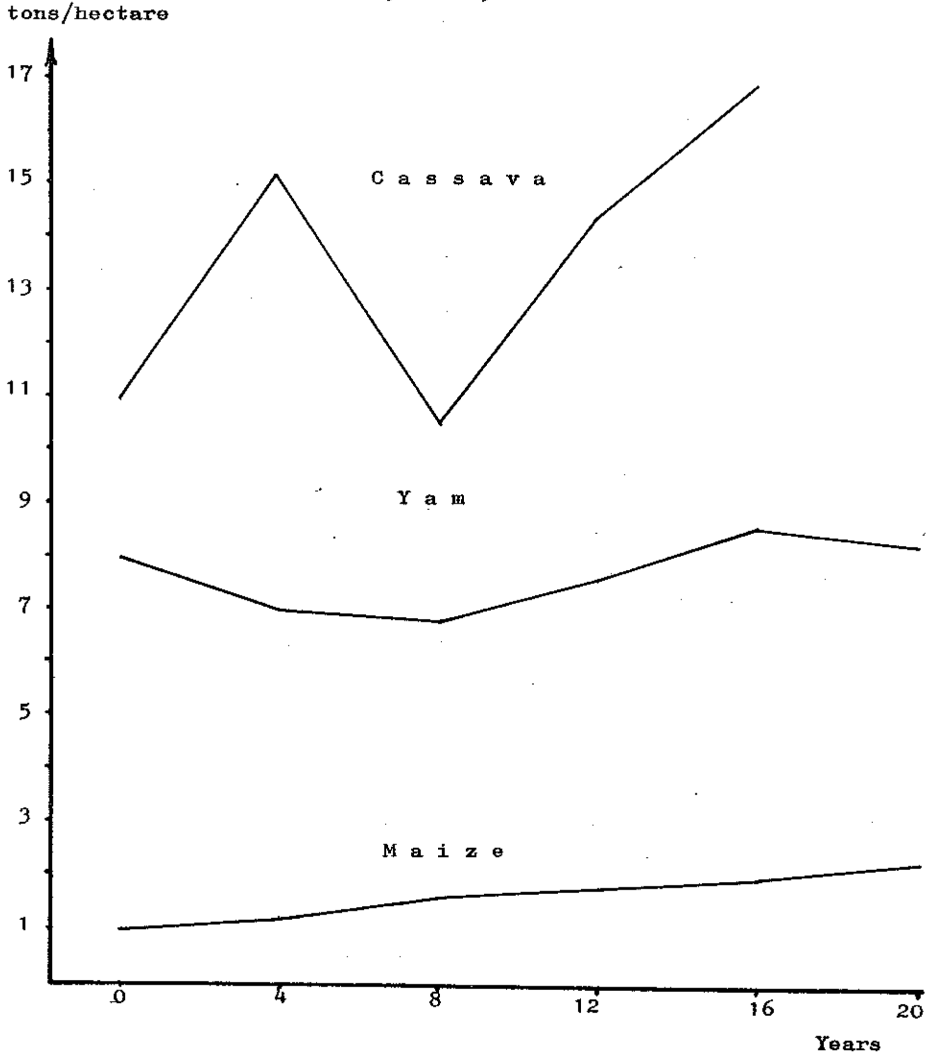
> cultivation could be introduced. Researchers conducted experiments with green manuring in order to replace fallowing. For this reason a six-year trial rotation incorporating different cover crops was set up in 1924 at the Agricultural Research Station at Umudike ... During the first years the reports were optimistic ... After ... completion of the experiment a total failure had to be reported: "As a result of seven years experimental work with continuous cultivation, incorporating green manure, it has now been established that the system as practised at Umuahia is not compatible with the maintenance of soil fertility ... whereas the fertility of the 'native' plots was just as high as it had been in 1925, that of the continuously farmed plots had fallen practically to nil'."
> (Lagemann, J., 1977. p. 14/15)

14 native plots were checked for comparison. They yielded an average of 12.2 tons of yams per hectare. The plots under continuous cultivation yielded, after seven years of farming, 4.7 tons per hectare. Lagemann concludes:

> "The search for a feasible technology which is able to hold or even improve soil fertility under continuous cultivation has not found an adequate answer and this is still one of the main problems for research in the humid tropics."
> (Lagemann, J., 1977, p. 17)

But scientific agriculture as conceived by those who drew up the syllabuses for Rural Science has not only disappointed its supporters in the tropics. Fertilizer and chemicals against pests and diseases are used in such large quantities and often so carelessly that health hazards and widespread pollution of the environment have become a real danger. Alternative farming methods are being tried out by a number of people. A fresh look at traditional African agriculture would therefore be in keeping with this worldwide movement.

Average Yields of Three Crops - Rural Education Centre Umuahia 1940 - 1960



Source: Obi, J.A., and Tuley, P., as reproduced in Lagemann, J., 1977, p.17, Fig.1

4. New Approaches to Farming in the Tropics

4.1. The Need for a New Approach

The approach to the development of agriculture favoured by the colonial powers in Africa must be considered a failure. The following statement bears out the concluding remarks of the previous section.

> "In spite of extension efforts, mixed cropping has given way to pure cultures+ in only a few regions in Africa, and it is relevant to consider whether technological progress could be achieved more widely through the improvement of mixed cropping than by persisting in attempts to replace this practice by pure cultures."
> (Tourte, R., and Moomaw, J.C., 1977, p. 304)

Accepting the old approach to agricultural development as wrong is one thing, recognizing the traditional farming systems as reasonable and well-founded is something different:

> "We consider it wrong to characterize the farmer as dumb and backward and to consider his working methods as something which must be completely replaced by modern methods"
> (Egger, K., and Mayer, B.J., 1979, p. 8)

The two statements do not mean, however, that one can safely sit back and rely on individual farmers making the adjustments necessary to cope with changing conditions. There is widespread agreement that the old, stable system of shifting cultivation has given way to a system of bush fallowing with ever shorter fallow periods. This is due mainly to population pressure and it cannot restore the fertility of the soil. The old system with very long fallow periods has been replaced by

> "mining" systems of farming which generate a more or less rapid decline of the soil fertility ... land becomes a limiting factor ... while natural fertility diminishes ... the capital resource of the land is likely to be degraded by extensive cultivation."
> (Tourte, R., and Moomaw, J.C., 1977, p. 298)

The International Institute of Tropical Agriculture (IITA) at Ibadan plainly states:

> "The fact is that the countries in the humid tropics are finding it harder and harder to grow enough food for their people."
> (International Research in Agriculture, 1974, p. 34)

At the same time, with really suitable farming methods, food shortages need not become a problem for a long time to come.

> "The food-producing potential of these lands is unknown - some estimate it to be very great."
> (International Research in Agriculture, 1974, p. 34)

> "... the abundance of rain in conjunction with high temperatures endows this zone ... with high production potential: nearly 4 times that of the temperate zones."
> (Tourte, R., and Moomaw, J.C., 1977, p. 296)

This means that one hectare of land in the humid tropics could produce four times as much as one hectare of land in a temperate climate. If this is true, then most African countries could feed, from their own resources, a vastly higher population than the one they have at present. Yet, an equatorial country like Rwanda is likely to face problems of acute food shortage, of famine, in the immediate future. One of the main reasons is that tropical soils are very vulnerable. The same factors that sustain dense vegetation can constitute a major danger:

> "Under continuous cropping, the abundant sunshine

+) pure cultures = single cropping, monoculture

> and rainfall soon become a liability, tending to aggravate soil erosion, leaching, and nutrient depletion."
> (International Research in Agriculture, 1974, p. 35)

But erosion and leaching are already a danger now that the fallow periods are being shortened. The conclusion from all the arguments presented above is simple:

> "If the practice of shifting cultivation is to be superseded[+] - and pressures on land and food supply rule that it must be - new means have to be found to conserve moisture, restore organic matter and preserve soil fertility, prevent erosion and leaching, control weeds, keep down insect and nematode populations (all of which the bush fallow achieves), and in addition support continuous cropping and produce higher per-unit yields."
> (International Research in Agriculture, 1974, p. 35)

This situation holds both great dangers and high hopes. The old approach to agricultural development could be seen as one attempt at realizing the hopes, but in fact it has not brought the solution. The more clearly this is seen, the more important it becomes to look for better solutions, new approaches. We shall discuss a limited range of such approaches because

- they justify a departure from the view of farming embodied in the old Rural Science,
- they offer new lines of teaching and learning,
- they contain suggestions that could be tried out in school farm work and in observational activities,
- they link up with traditional farming techniques, encouraging teachers to do away with the break between what is taught in school and what is put into practice by parents, pupils, and teachers out of school,
- they indicate areas of fruitful cooperation between school and research geared to national development.

These approaches are

1) the zero tillage or minimun tillage approach,
2) "biological" farming,
3) the development of farming systems for the low-land tropics (IITA),
4) eco-farming.

All these approaches are very similar to each other. They all agree that modern agriculture as practised in the industrialized countries should be rejected. They differ with regard to the emphasis placed on various cultivation methods.

4.2. The Main Approaches

4.2.1. The Zero Tillage Approach

Zero tillage is an attempt to cope with soil erosion. Where it can be applied, it also reduces the amount of labour needed. For a description of the approach and the reasoning behind it we shall turn to an article by an American, John Holway:

> "For centuries American farmers have been turning the earth every spring or fall and laboriously cultivating weeds all summer. Now they're discovering that, without their plows, they can grow as much - and sometimes more - while also saving money, time, labor, energy, water, and - perhaps most important of all - saving soil.
>
> . . .

[+] supersede = to replace by something else

No-tillage - it's also called "zero tillage", "minimum tillage", "conservation tillage", etc. - rests on two revolutionary principles:

● One, the plow may be the soil's worst enemy, breaking it up and leaving it at the mercy of wind and water erosion.

● Two, mulch from last year's crop may be a valuable tonic for both soil and seedling. It holds moisture around the plant and helps choke off weeds.

. . .

The plow was good for Europeans with their soft rains. It increased their food supply so they could colonize the rest of the world. But they also carried the plow with them, and now the whole world is battered by this European system which isn't suited to any area of the world except Europe.

. . .

William S. Greiner, Iowa's director of soil conservation, estimates that the state loses an average of 10 tons of soil per acre (25 tons per hectare) every year. On sloping land that could reach 25 tons per acre (62 tons per hectare). "We are losing about an inch of topsoil every 12 years", Greiner says. A century ago Iowa had an estimated 14 inches of topsoil over most of the state. Today half of it is gone. If no conservation is practiced, the rest will be lost in another 36 years, he predicts."

(Holway, J., 1978, p. 16)

. . .

"Nearly 25 percent of our cropland is being damaged at a rapid rate of erosion. This is an area of something over 100 million acres of cropland. The productive capacity of much of this highly vulnerable land will be permanently damaged and around 500.00 acres a year ruined for further cultivation unless and until it has the benefit of sound conservation farming within the next 10 to 15 years. On another large area (around 115 to 120 million acres) of cropland, erosion is taking place somewhat less rapidly but still at a serious rate."

(Smith, R., 1977, p. 7)

Soil erosion can be checked, however
"The way to do it is to plant on terraces following the contour of the land, without plowing, and leaving last year's stalks and other residue on the ground as mulch.

About 40 years ago some U.S. farmers began leaving a stubble mulch on their fields after harvest. It was the first step toward a minimum-till system. It was not until the 1950s that farmers discovered that they could prepare their seedbeds and plant all in one operation, eliminating at least one trip over the field. But without plowing, weeds multiplied and yields went down. Then, with the introduction of the new herbicides such as 2-4-D, farmers could give up plowing too, letting the chemicals do the work that plows had formerly done.

Ingenious new machines were developed to open a narrow slot in the soil, deposit the seed, cover it lightly, fertilize it, and deposit herbicides and pesticides, all in one operation. The biggest machines could do up to 16 rows at one time. The mulch left between the rows catches and holds the rain water, while helping to suppress weeds. The need for additional trips over the field is reduced. The fewer trips over the soil, the less it is compacted.

. . .

No-till has also extended croplands into thousands of acres of hillsides too steep to plow, into other soil impossible to plant, and even into sandy soil formerly fit only for pasture. In fact, no-till works best on hills - it needs plenty of drainage. It's not so good on poorly drained land or on clay soils - the mulch holds too much water there.

... about one-third of the energy consumed on U.S. farms is in tractor fuel. By eliminating unnecessary trips over the field, this bill can be cut in half. Average savings nation-wide: an estimated 850 million gallons a year.

One-fourth of a farm's energy expenditure is in the manufacture of nitrogen fertilizer. Because no-till cuts down on water run-off, less of this expensive fertilizer is washed into the rivers as pollution. Insects and plant diseases are a problem - but no more so than in conventional tillage. In fact, the mulch cover in no-till fields protects the earth worms that keep the soil aerated. And no-till farmers report yields at least as high as under conventional tillage. Often they are higher: The U.S. 1975 record crop yield was set on an Illinois farm that hadn't been plowed in six years. When double-cropping is added, the yield per acre is even higher.

No-till saves the soil

Erosion protection is even more dramatic. In one Ohio test plot, a single five-inch rainfall washed 20 tons of soil off a conventionally plowed field with a seven percent slope. A neighboring no-till field with a 20 percent slope lost only 100 pounds.

. . .

Wind erosion can be even more damaging than rain.

In the 1930s in the U.S. Southwest, clouds of dust obscured the sun and drifts of earth covered the highways. In a recent test in Ohio, in a severe windstorm a plowed field lost 130 tons of soil. The loss on a no-till farm in the same storm: two tons.

Yet only one out of seven erodable acres in the United States is planted in minimum-till. Only one in 40 is planted in no-till. Why? For generations farmers have been taught to be proud of their "clean" fields of black, weed-free soil between the rows. Stubble or mulch on the field looks like "trash" in some farmer's eyes. But as they see their neighbor's no-till fields producing as much or more with less work and money, they make the change themselves.

Solution for the Third World?

Can no-till succeed overseas? Even Europe, which invented the plow in the first place, is beginning to use it. Many authorities warn that it cannot be used successfully in the developing countries. Herbicides are essential to the system, they say, and their cost is prohibitive. The no-till planting machines are another prohibitive capital cost. And a very sophisticated level of management is required, these experts say. Nonsense, say others. The system is working now in Brazil, Argentina, Colombia, Uruguay and Rhodesia, Professor Young of Kentucky maintains. The high temperatures of tropical soils can damage seedlings. A mulch helps keep the temperatures down. For farmers who can afford to, small two-row planting machines are available for under $ 1.000. They can even be drawn by an ox. For others, a hoe can do the same job. Much subtropical agriculture is now very near no-till farming. A farmer can easily substitute labor for herbicides, hoeing weeds by hand as farmers have for centuries.

. . .

Buchele worked with farmers in Ghana in 1969. They harvested grass for the extra mulch they needed, raked the straw off the seedbed by hand, planted, and raked the straw back over. They planted on ridges eight inches (20 centimeters) high. "Our tests show" he says, "that you should leave one ton of crop residue per acre."

Kimberlin has had similar experiences working with farmers in Paraguay. They set up new colonies using very simple tools, no chemicals and an ample supply of family labour. They chopped off the weeds to form a mulch, planted their crops in rows of 90 degrees to the slope, and let the mulch catch the rains. A man just about has to use no-till where only the simplest tools are available. In some climates, for instance in parts of Europe, and in some soils the plow is still needed. But around the world more and more farmers are learning how to turn a profit without turning the soil".

(Holway, J., 1978, p. 17)

The IITA at Ibadan is experimenting with this approach, and the institute's appraisal of the method is encouraging:

"Mulching and minimum tillage, in combination with weed control measures, have been found to have several advantages, including keeping top soil in place, holding moisture reserves in the upper layer of cropped soils, and lowering soil temperature. Marked benefits were recorded in both yam and maize crops.

Leaving crop residues on the ground after harvest ... and sowing the new crop through the layer of felled weeds, are variations of the same approach. Like mulching and zero tillage, they mimic the bush fallow system, and are ... a good deal handier. This tactic has given good results with maize ..."

(International Research in Agriculture, 1974, p.37)

4.2.2. Biological Farming

"Biological" Farming is a farming system which tries to do without inorganic inputs as much as possible. The soil is fertilized with farmyard manure and compost instead of chemical fertilizer. Weeding replaces the use of herbicides that are highly poisonous. The crops are protected against insect pests and diseases by careful crop rotation, by a certain amount of mixed cropping, and by interplanting certain plants that are known to keep insects away. Biological farming in this sense must be seen, in the industrialized countries, as a conscious rejection of certain forms of industrial and scientific progress. It is a reaction against environmental pollution: some of the chemicals in common use do not decompose fast enough and start poisoning people and animals. Insecticides do not only kill insect pests but also a large number of harmless or even useful insects like bees. At the same time, they favour the development of pests that are immune to insecticides so that higher and higher quantities of insecticide and more and more poisonous substances have to be applied. Often, too great a quantity of chemicals is used. Some of them get washed into the soil, disturbing soil life. A lot of the fertilizer applied to the land is not used up by the crops. It leaches away into the underground water and seriously affects life in rivers and lakes. As people became aware of these large-scale harmful effects of agricultural "progress", the idea of "biological" farming was evolved in order to counteract them. What it does do in the African context is to serve as a warning against uncritical acceptance of just any kind of "progress" and "modern methods".

4.2.3. Farming Systems for the Lowland Tropics

Let us take the case of the I.I.T.A. at Ibadan to illustrate various attempts to arrive at viable farming systems. We have seen above how pessimistically the institute views the future of agriculture if things remain the way they are. One major task of the institute is to develop farming systems which are stable, i.e. which maintain soil fertility. At the same time, they have to rely on existing technology - the mechanization available in the industrialized countries is no solution for a variety of reasons. Also, the farming systems must be adapted to the farmers' present level of knowledge and skills. Farmers will not agree to change their work habits thoroughly unless the benefits from such change are substantial. The new farming systems furthermore must not require too many farm inputs like fertilizer and pesticides since a steady supply of them cannot always be guaranteed and their cost keeps rising. Therefore the proposals for new farming systems include such features as

- minimum tillage: apart from its beneficial effect on sloping land it reduces the amount of labour required, compared with traditional methods;
- multiple cropping: crop combinations are recommended that cover the soil throughout the rainy season, thus

reducing erosion; they ought to incorporate crops that fix nitrogen, and crops producing a large amount of residue. Residues like stalks and leaves are needed for mulching;
- mulching: this has the advantage of further reducing erosion and leaching. At the same time, the mulch provides soil nutrients as it decomposes;
- tree crops: they are to be included for their climatic effects - they provide shade and humidity - their usefulness in checking erosion, but also for their function as "nutrient pumps" (see below for further explanation)
- chemical fertilizer and insecticides: "High rates of fertilizer are needed to produce the required mulching material. Insecticides are needed to decrease the risk due to insects, and are usually required to maintain luxurious growth of crops. Chemical inputs can therefore be a substitute for the use of expensive machinery. The application of inputs is possible even on very small fields ..."
(Lagemann, J., 1977, p. 133)

One such proposal for a complete farming system for the lowland tropics is presented in the study of traditional farming systems in Eastern Nigeria. Taking account of differences in soil characteristics, it contains the following elements:

- valley bottom development,
- modern tree crop plantations,
- improvement of farming methods for annual and biennial foodcrops in farms at a distance from the compound;
- multi-storey cropping on compound farms.

The study maintains that in Eastern Nigeria, valley bottoms with their fertile, humid, but often poorly drained soils, are hardly used. A similar situation certainly exists in Cameroon in the regions bordering

Nigeria. Swamp rice is suggested as a rainy season crop, locally consumed vegetables as dry season crops. Swamp rice means learning to farm a new crop altogether (see section on rice) but it fetches a high price, and since rice is in high demand in Cameroon, growers are assured of a large domestic market independent from changes to prices on the world market. Where valley bottoms are already used for the cultivation of raffia palms, this proposal might have limited application.

Vegetable growing is highly profitable when urban markets (Douala, Kumba, Mamfe, Bamenda, Banso) can be supplied. Since the land need not lie fallow in swamp rice cultivation, two crops per year could be harvested from the same area on a continuous basis. As tree crops, the study suggests high-yielding oil palms. Tree crop plantations should be established especially on land threatened by erosion "...because erosion and leaching are much more easily reduced by tree crops than by annual or biannual crops." (Lagemann, J., 1977, p. 121)

High yields are possible only if palms are not intercropped with food crops, but on the area between the palms a cover crop could grow producing mulching material for the food crop farms. Improved oil palm varieties should replace the local ones, the study suggests. Yields per hectare could thus increase five to seven times, compared with yields from wild palms, and the fat content of the improved varieties is higher. Introducing hand-operated oil presses to replace the traditional method of oil extraction would further increase oil production and income.

<u>The improvement of food crop farming</u> would have to

happen <u>within the traditional farming system</u> instead of replacing it by something entirely different. Multiple cropping, minimum tillage and mulching are regular features here. Research at IITA has shown that multiple cropping produces higher yields per hectare than single cropping; this is shown in the following table:

Trial N°	Crops			Month of planting cassava	Total yield (tons/hectare) (dry matter)
	Maize	Melon	Cassava		
1	x				4.49
2		x			1.02
3			x	April	14.95
4	x	x			4.66
5	x		x	April	15.17
6	x	x	x	April	16.15
7			x	May	15.79
8	x		x	May	15.63
9	x	x	x	May	15.96
10			x	June	11.84
11	x		x	June	16.59
12	x	x	x	June	23.73
13			x	July	10.47
14	x		x	July	14.15
15	x	x	x	July	12.99
16			x	August	7.46
17	x		x	August	11.73
18	x	x	x	August	10.30

Note: Maize and melons are planted in April. Cassava was relay intercropped (i.e. planted later than maize and melons) in most of the trials. Yield refers to dry matter. This means that after harvest the whole crop including leaves and stalks were dried and weighed.

<u>adapted from</u> Lagemann, J., 1977, p. 129, table 47

For I.I.T.A. it is obvious that mixed cropping needs a certain minimum of chemical fertilizer if soil fertility is to be maintained under conditions of continuous cultivation. But it is known from scientific research that certain types of chemical fertilizers are much more effective used in conjunction with mixed cropping with its high plant density than they are with single cropping. It follows, therefore, that yields from mixed cropping would rise faster than the amounts of fertilizer needed.

Since mulching is a necessity in the improved farming system, farmers must make sure that enough mulching material is available. Two alternatives are proposed:

> "-arable crop and mulch production on seperate plots but close to each other. Mulch production has to be very high on a relatively small plot ... A production of 30 t mulch/ha requires 25% of the total land available for arable crops for mulch production if 10 t mulch/ha are to be reapplied to the crops,
>
> - trees with a cover crop alternated with narrow but long strips of arable crops, e.g. improved oil palm grown in monoculture with a mulch cover, which serves two purposes: firstly high outputs from oil palms can be expected, and secondly large quantities of mulch will be produced which is applied to nearby fields ..."
>
> (Lagemann, J., 1977, p. 134)

Finally, the multi-storey cropping system has emerged from careful analysis of the farm compound. The name is due to the fact that on a well-cultivated compound - much like in the forest - there are several layers

or canopies of leaves at different heights. These layers are then likened to the various ceilings in a house with several storeys, hence the term "multi-storey cropping".

> "The crops (in a multi-storey compound farm, H.B.) can be divided on a height basis into 10 different groups:

Tree crops

- oil palms, coconuts;	(20 - 25 m high)
- breadfruit, raffia palms, oil beans, avocado pears;	(12 - 20 m high)
- cola-nuts, mangoes	(8 - 15 m high)
- oranges, grapefruit, limes paw-paws	(5 - 10 m high)
- bananas, plantains	(3 - 8 m high)

arable crops

- yams	(3 - 6 m high)
- maize	(1.5-2.5m high)
- cassava, cocoyams, pepper etc.	(1 - 2 m high)
- groundnuts, melons, vegetables	(0.1-0.3m high)

> Various trees form the upper part of the storey whereas arable crops (food crops, H.B.) grow under the shade of the trees. The leaf canopy becomes denser the closer it is to the ground, and hence it
> - reduces erosion by absorbing rainfall,
> - shades the land and so reduces soil temperature,
> - provides a leaf litter for nutrient recycling,
> - maintains reasonable levels of organic matter and
> - conserves soil moisture during dry periods."
>
> (Lagemann, J., 1977, p. 32)

The land-use system of multi-storey cropping closely resembles the natural vegetation of the forests and tree savannahs. Apart from the advantages mentioned above it has the following:

- There are always leaves to convert the energy of the sunlight into plant food. Light is used by leaves at various levels of the multiple storey system.
- "Growth of weeds is suppressed by the close cover

of the leaf canopy." (Lagemann, J., 19777 p. 135)

- The roots of the various plants making up the multi-storey system reach different depths. A root system like this can absorb moisture and nutrients effectively. Also, nutrients supplied by chemical or other fertilizers are used efficiently due to the dense root system.

Because of their deep roots, trees have been termed "nutrient pumps" in this and related systems of farming. In fact their roots reach down much deeper than those of the food crops. They tap water and nutrients inaccessible to the annual plants. They use these nutrients to grow leaves and fruits. A large proportion of the water they use evaporates into the surrounding air, thus creating an environment favourable to the growth of other plants. Finally, leaves and fruits decompose on the soil and release nutrients to the top soil which would not have become available without the trees. Since they take nutrients from deep down and add it to the top soil, in the form of fallen leaves, twigs and fruits they have been called "nutrient pumps".

A word of caution is in order, however. Neither the system described here nor any other new farming systems of the lowland tropics have yet been extensively tested. In particular, the economics of the various systems have not been worked out. "Nothing is as yet known about costs and returns under the conditions of practical farming." (Lagemann, J., 1977, p. 134)

4.2.4. Eco-farming

Eco-farming is a shorthand expression for ecological farming. Here the term to be explained is "ecological".

It comes from "ecology". Ecology is the science of the way plants and combinations of plants adjust to their environment and finally form a stable system if they are left undisturbed. It is a special branch of biology. Ecological farming starts from the idea that most geographical zones with their climatic and soil characteristics sustain a natural vegetation producing a relatively large amount of plant materials, and that this natural vegetation continues to thrive indefinitely, without any such inputs as chemical fertilizers and insecticides. Is it possible to farm in such a way that the natural conditions, i.e. conditions undisturbed by human activities, are preserved as much as possible? The proponents of eco-farming are positive about this. Their main concern is to maintain the productivity of the farmland. They reject farming systems which, with the help of current, advanced farming methods, produce high output but at the same time tend to destroy the productivity of the "natural" setting. Destroying the natural fertility means that

- unless large quantities of inputs are supplied, production will drop drastically. High-yielding varieties depend on fertilizer, insecticides, mechanical or chemical weeding, and the right amount of water at the right time in order to realize their potential fully.
- the desired level of production can only be reached if increasingly large amounts of such inputs are used. As insect pests, bacteria, and viruses become gradually resistant to farm chemicals, more powerful chemicals have to be used in order to keep them in check.

Keeping up the productivity of an environment means, among other things:

- maintaining and/ or building up soil fertility;
- controlling erosion;
- breeding and/or selecting varieties resistant to climatical hazards, pests, and diseases;
- maintaining a good water-level.

A stable ecological system where the natural vegetation of an area remains unchanged for very long periods of time is governed by a set of natural laws involving biology, chemistry, and physics. Maintaining and improving the productivity of a system is only possible if those laws are known and applied.

Eco-farming incorporates the principles of minimum tillage with its emphasis on erosion control, for reasons both of soil conservation and saving labour, since mechanization is not envisaged. It also includes the principles of biological farming, rejecting the unconditional use of farm chemicals. It advances recommendations quite close to the ones presented above under the heading of "farming systems of the lowland tropics", but it has a deeper insight into the biological laws and mechanisms that keep a stable natural environment going. But while the search for viable "farming systems of the lowland tropics" seems to accept traditional farming largely because the farming population cannot change their behaviour fast enough or are not willing to do so, eco-farming has a much more positive approach to traditional farming. Traditional farming is farming without machines and chemicals. The fact that it has been stable under conditions of low and medium population density shows that it respects and uses biological laws to a large extent. Therefor, traditional farming is not seen as a hindrance to progress but as a source for learning.

Learning from traditional farming from the point of view of eco-farming would mean, first of all, finding out and documenting the many successful methods used in various places. Since traditional farming has evolved slowly and without any conscious attempt at coordination, some methods are in use in one area but not in others. One such example in Cameroon is the use of tephrosia as an intercrop and a fallow crop with maize in Kom area, North-West Province. The usefulness of tephrosia for the maintenance of soil fertility and the provision of firewood is known in an area of 3.000 to 4.000 square km. Documenting the more successful traditional farming methods would make them available to other farmers in distant areas, and this might lead to major progress in increasing crop yields.

It must be recognized, however, that there is a limit to the usefulness of knowledge about traditional farming. People hardly ever know the exact reasons why traditional methods work. This is all right as long as all other factors remain as they are. It is then, and only then that a farming system developed by trial and error and adjusted to the environment will continue to function without people knowing why it works.

Building on the knowledge of general laws of nature and making use of well-tested experience from similar climatic and geographical zones all over the world - in other words eco-farming - involves at present the following practices:

- <u>The integration of trees in agriculture</u> for the reasons outlined in the section on farming systems for the lowland tropics;
- <u>The integration of animal husbandry</u> not only for

the production of foodstuffs like meat, milk, eggs, but also for the production of farmyard manure.

- Fodder production for the animals. Traditional grazing soon leads to erosion and uses large areas compared with growing fodder crops.
- Erosion control by living contours. On slopes, lines of trees, shrubs and tall grass are planted across the slopes. This means very little work compared with terracing, but it has the added advantage of checking soil run-off during rains and of finally building up terraces as soil is caught in the anti-erosion lines.
- Contour planting also acts as a form of erosion control, but especially on steep slopes it is not sufficient in itself and needs to be supplemented by the erosion control measures described above.
- Intercropping or multiple cropping is retained because of its many advantages (for details see below).
- Rotation in a system of multiple cropping is a way of making multiple cropping more rational and of ensuring some control of soil pests like nematodes. Well-chosen crop rotations are a standard feature of permanent cultivation.
- Seasonal Fallow as opposed to the fallow periods of the traditional farming systems does not just mean leaving a plot without crops and allowing any spontaneous vegetation to grow. It means planting selected fallow crops particularly suited to help in rebuilding soil fertility. Often these are non-edible leguminous plants. A careful mixture of plants sown as a fallow crop would not only enrich the soil but would also kill nematodes and harmful soil bacteria.
- Weed tolerance essentially means an end to clean weeding but not to all weeding. One instance has been found in the Usambara Mountains of Tanzania, East Africa, and is described as follows:

> "In young cultures weeds are allowed to grow in a considerable amount together with the crop. After some time, weed 'control' takes place when it is thought to be neccessary. The weeds are germinating, but now the crops are strong enough to support themselves. The competition between these and the growing weeds ... is balanced by the decomposition of the mulching layer.
> (Egger and Mayer, 1979, p. 21)

According to the authors the soil bacteria make available the nitrogen which is contained in the mulching material, provided there is enough phosphate. If the soil is not too dry, weeds continue to grow and produce green manure. They must not be cut before they produce seeds. When they are dry they are left as mulch on the soil.

> "Both the growing weeds and the layers of mulch result in effective erosion control ...
> As a result, more water is available for the crops. Both weeds and mulches lower the daily changes in temperature in the soils, thus reducing the evaporation in a considerable measure. This system retains more water - and the water remains longer in the soil. Humus formation, nitrogen assimilation, improvement of water balance - the secret of the tremendous success of the system of weed tolerance!"
> (Egger, K., and Mayer, B.J., 1979, p. 21)

- Mulching,
- Composting is regarded as necessary since well-prepared compost is a better fertilizer than mulch left on the surface of the soil.
- Resistant varieties rather than high yielding varieties are what is required. High yielding varieties, up to now, have proved very sensitive to poor growing conditions.

- Limited use of fertilizer and pesticides - if all the other methods which together make up eco-farming are applied properly, there should not be much need for farm chemicals.

Egger and Mayer, whose concept of eco-farming we have presented, point out that the limited use of farm chemicals (and machinery) not only happens to suit the habits and attitudes of the farming population (who simply are not used to spending much money on farming, and who would need a lot of guidance in order to apply these innovations correctly), it also takes into account the economic interest of countries that want to save foreign exchange and maintain as much independence as possible from foreign aid and foreign suppliers.

Concluding remarks: How much is known about the new approaches?

The new approaches discussed above all result from the application of modern science to agricultural problems in the tropics. It is a recent field of investigation, and none of the approaches have been really field-tested in the tropics. Zero tillage is practised in the United States of America as one variant of a highly mechanized system of farming which uses farm chemicals freely. Eco-farming has so far been tried on an experimental scale in an agricultural development project in Rwanda. Below there is an extract from a report on the project. As with the "farming systems for the lowland tropics", the economic viability of eco-farming has not yet been investigated. But even in the field of natural sciences such as biology, soil science etc., much remains to be discovered. Nevertheless, quite a number of interesting findings are available, and we shall list certain of them in order to show some of the more promising lines of thinking and to stimulate teachers' curiosity.

4.3. Backing for the New Approaches

4.3.1. A Project on Eco-Farming

The initial aim of the project in Rwanda was to start up a dairy and the attendant veterinary service. Another dimension was soon added, the development of peasant agriculture in a country where land was becoming increasingly scarce and where erosion is a major problem.

> "One of the aspects of the project ... and which is of the greatest importance in the 'poor man's energy crisis' is the planting of various kinds of trees. Tree nurseries have beenestablished in a distance of some kilometers from each other, so that they can easily be reached on foot by the local farmers, who traditionally live in individual family holdings "dans les collines", Rwanda's ten thousand hills and not in villages or towns. Each nursery produces seedlings twice a year, and 95 percent of them produce after having been replanted in the specific areas, i.e. both forest and fruit trees such as grevillia, eucalyptus, jacaranda, and papaya, coeur de boeuf, and avocadoes. The latter are of particular interest since they make an improvement of the farmers' everyday diet.
>
> Trees are mainly grown on the family holdings of individual farmers. We learnt that a farmer, who

plants 150 trees, can not only expect to supplement his diet, but after 15 years, also cut down one tree every two months without endangering the ecology, and thus solve his own energy crisis.

. . .

Soil quality can improve only if the right kind of mixed plant system is introduced.

This is where the so-called "planned disorder", the planting together of useful plants and weeds comes in. For the aim is to create a new balance of plants, whereby, for example, weeds are planted and left to grow profusely. They are plants that give a mass of foliage twice as great as that of "good" plants. When cut and left to rot on the ground they can produce up to 20 centimeters of humus. In encouraging mixed cultivation the Nyabisindu experts go against commonly accepted European prejudices against planting in close neighbourhood cocoyams, cassaya, soybeans, sweet potatoes etc. Whereas traditionally coffee was grown in isolation, with the soil under the trees being kept clear, in Nyabisindu an attempt is being made to grow coffee and pineapples together, using the open space between the coffee trees. The main aim is to keep the soil constantly covered, thereby preventing the loss of humidity and stopping erosion when the next rains come. And although at the time, when we visited the project, it was already well into the dry season we could see that the underlying soil was still fairly humid.

The experts prefer the growth of leguminous plants which produce a lot of foliage and up to 200 kilograms of nitrogen per ha. Fodder plants, which have a life of six years, are especially welcome during

the dry season or hivernage, when fodder is scarce. And in general these plants provide much better and richer food than the poor pastures in the valley.

To a layman then, who in so many years has seen so many "white elephants"[+] the Nyabisindu project looks like the start of something revolutionary new. The success so far seems to be mainly due to the confidence created among the local population by the efficient and remunerative collection of milk and the veterinary service, upon which all the other activities could be built.

It also seems to reside, however, to a very large extent in the willingness of the foreign experts to learn from the local farmer. Once the innate intelligence of that farmer had been recognized it was fairly easy to "bundle together" various findings and "to enrich them with modern ecological findings" and "offer them back to the farmer." Acceptance seems to have been all the more willing since those new methods were "directly comprehensible and accessible."

The total and continuing success, however, will only be assured, if the experts in cooperation with the farmers "constantly integrate new findings", keep the system open.

(Meuer, G., 1977)

[+] a 'white elephant' is something which costs a lot but is of no practical use to the purchaser.

4.3.2. Evidence from Research

The following findings all refer to multiple cropping. Since multiple cropping figures in all the approaches presented above, research results in this area are of considerable importance. They have been taken from a number of sources and are meant to stimulate the reader's interest.

Firstly, they show that even after only a few years of systematic research valuable knowledge is becoming available. Secondly, simple experiments on the school farm and careful observation of local farms might reveal similar things. Once one knows what to look for one stands a good chance of finding something of interest.

Yields

There is evidence that multiple cropping produces yields per hectare and per working hour that substantially exceed yields from single cropping under comparable conditions:

- In a study of three villages in Northern Nigeria the gross return from mixed cropping was 60 per cent higher than if the same crops were grown alone.
- "Tardieu and others in the wet highlands of western Cameroon demonstrated that intercropping maize, taro (Colocasia) and macabo (Xanthosoma) under both traditional and improved methods of culture resulted in improvements over single-crop cultures ..."
  (Tourte and Moomaw, 1977, p. 303)
- A combination of three crops, millet, maize, and sorghum "produced not only higher yields but nearly doubled the gross return." (Tourte and Moomaw, 1977, p. 303)

- When a certain species of beans was grown together with maize, in an experiment in the Philippines, the maize yield was greater than when maize was grown alone, and the weight of weeds decreased. (cf. Litsinger, J.A., 1979, p. 302)
- "The combination of minimum tillage and intercropping seems to prevent erosion and to produce yields which are higher than from sole (single, H.B.) crops"
  (Lagemann, J., 1977, p. 133)

Here are a few possible reasons for the higher yields obtained from multiple cropping:

- Often, the different species in a combination of plants use the growth factors of a given plot - soil nutrients, water, light - in different ways. Instead of competing with each other, one plant uses what the other crop does not need. It is quite easy to turn this into a rule for finding productive crop combinations.
- Different crops use growth factors at different times. Once this is known for the plants of a particular crop combination it can be used to advantage:

> "Relative planting dates of the two crops (maize and beans, H.B.) influence yields of the bush beans. Bean yields were reduced from 939 kg/ha in monocrop (single crop, H.B.) to less than 400 kg/ha when maize was planted before the beans. A 15-day advantage for the beans gave the highest yields, a result confirmed by small farmers."
> (Francis, Flor, and Temple, 1979, p.241)

When pigeon peas were grown with maize they grew less well in the first four months of growth than when grown as a single crop. When the maize was ripe, however, it no longer competed for growth factors. The pigeon peas caught up and produced yields comparable to those achieved under single cropping. The plot in question thus produced a full crop of pigeon peas and a full crop of maize.

Observations at the IPAR-Buea demonstration plot showed a similar pattern: two plots were planted with cocoyams. On one plot, cocoyams were planted between maize. On the other plot, cocoyams were planted as a single crop. When the maize was ripe, it was quite clear that the cocoyams in the maize plot were much smaller than the ones in single cropping. But since they had another twelve months of growth before they were ready for harvesting, one could be quite sure that the smaller ones would catch up in size with the single crop.

Summing up these findings one could say:

> "When the earlier component has matured, conditions become especially favourable for the other component."
> (Trenbath, B.R., 1979, p. 155)

- If leguminous plants are grown together with other crops, the legume gets much of its nitrogen from the nitrogen-fixing bacteria living in its root nodules. It competes hardly at all for nitrogen with the other crops. Therefore, adding a crop like beans, cowpeas, pigeon peas, groundnuts or soya beans to a crop of cereals or tubers will increase the total yield.

> "Intercropping leguminous green manure crops with cereals is another possible way to supply nitrogen. Agboola and Fayemi reported that yields of four successive corn crops, each of which was fertilized with nitrogen, were comparable with corn yields from a corn-legume intercrop without nitrogen fertilizer. When the corn was neither fertilized nor grown with a legume, grain yields from the fourth crop of corn were reduced to one half that of the first."
> (Oelsligle, D.D. 1979, p. 287)

- Some plant species seem to be able to cure nutrient deficiencies in neighbouring plants of other species, but just how this works is not completely known.
- Pests usually do not attack all the crops of a plot with multiple cropping but only one or two. The plants which are attacked are weakened and thus compete less effectively for growth factors (light, soil, nutrients, water) than before. The plants not under attack now stand a better chance of growing. They may produce enhanced yields compensating for the poor yields from the attacked plants.

Soil Fertility

Soil fertility is less threatened by multiple cropping than the proponents of single cropping usually fear. Reasons for this are:

- Plants in viable crop combinations have root systems of various depths and get their nutrients from different layers of the soil.
- The root system of the plot is denser than that of a plot under single cropping. It therefore uses available nutrients more effectively. (This is due to the fact that some soil nutrients are not available in liquid form and are therefore highly localised. Unless a root happens to come across them, they cannot be used by plants).
- When fertilizer is applied to a plot under multiple cropping, it is used more efficiently than under single cropping. Less fertilizer is lost by leaching since the total root system goes down deeper into the soil.
- Fertilizer in multiple cropping does not necessarily lead to higher yields from all the crops:

"Increasing fertility levels in two multiple cropping patterns in Costa Rica (Latin America, H.B.) caused an increase in yields of beans and corn, a moderate increase in yields of cassava, no change in soybean yields, and a decrease in sweet potatoes."
(Oelsligle, D.D., 1979, p. 278)

- Soil fertility cannot be properly guaranteed by the use of chemical fertilizers alone. Organic matter in the form of mulch and compost is of great importance. Good-quality humus which results from mulch and compost has the following properties:

"1. it breaks down readily to yield the available forms of mineral nitrogen, sulphur, and phosphorus, but does not decompose so rapidly that excessive losses of nutrients occur ...
2. it improves the constitution of the soil, thereby improving its water retention and diffusibility of carbon dioxide and oxygen through the soil.
3. it provides food for soil micro-organisms, especially the nitrogen fixers.
4. it provides sandy soils with an improved water holding capacity thus reducing the incidence of soil erosion."
(Benret and Schork, 1979, p. 116)

Weed Control

In multiple cropping, weeds are often kept down by the dense leaf cover close to the ground of one of the crops. Egusi and other melons, cucumber, and pumpkin grown between maize or yams cover the ground so completely that weeds have not much chance. Some species of melons and related plants also release a poison through their roots which prevents other plants from germinating.

Insect Pests

- Intercropping of maize and groundnuts reduced the damage caused by the stem borer to maize. The distance between plants attacked by an insect is an important factor. In a plot under multiple cropping, the proportion of maize plants attacked by the stem borer was smaller when the plants were further apart.

- "Because of severe insect damage, cowpeas are seldom planted as a sole crop in Northern Nigeria."
(Litsinger, J., 1979, p. 302)
- Where there is a mixture of crops, the tall plants tend to obscure the short ones and make them invisible to insect pests.
- Plants other than the ones attacked by a given insect pest may either attract the pest and thus protect the other plants, or may actively repel them. Thus, some plants drive insect pests away by releasing some kind of poison into the air.
- Plant combinations provide more cover for predatory insects that feed on insect pests (spiders etc.)

Soil Pests

- Certain plants - crops or weeds - release chemicals from their roots that repel or kill nematodes. One of them is marigold (tagetes), another one is crotolaria. In the Usambara Mountains, there is a common weed that also seems to kill nematodes.
- In many areas farmers know of plants that "clean the farm". Schools should document these plants and try to find out what effect they really have.

The effect of plant-produced chemicals

As mentioned above, some plants release chemicals through their roots into the soil. These chemicals not only influence soil pests, they may also affect other plants. In some cases they prevent other plants from growing, in other cases they stimulate growth. Little systematic knowledge is available to date. Some species of eucalyptus and of the cucumber family (to which melons etc. belong) are known for effects of this kind. It would seem that there is a lot of opportunity here for plant breeders. Once such characteristics are known they can be reinforced by selective breeding.

4.4. Suggestions for School Activites

Since new approaches to farming have not yet become an established practice, teachers can not rely on mere classroom teaching to transmit them to their pupils. On the other hand, there are no model farms for teachers to turn to for observation. The best method of teaching therefore seems to be the experiment. Experiments can be done on comparatively small plots on the school farm. (For details on the experimental method see the section on experiments). Here are a few suggestions for experimentation:

- experimentation with <u>various patterns of mixed cropping</u>:

  Select two crops (e.g. maize and beans) to be grown on the same plot. Grow 5 rows of maize in single cropping. Then grow 10 rows, one row of maize alternating with one row of beans. Finally, grow maize and beans in the same row, one row using the standard planting distance for maize but replacing every other maize stand by beans, and one row following the traditional method of planting.

- experimentation with <u>planting times in intercrops</u>:

  Select two crops to be grown on the same plot, e.g. crop A and crop B.
  a) Plant crop A 2 weeks earlier than crop B.
  b) Plant crop A 1 week earlier than crop B.
  c) Plant crop A and B at the same time.
  d) Plant crop A 1 week later than crop B.
  e) Plant crop A 2 weeks later than crop B.

Observe the development of the two different plant species under the five different conditions and record yields for each plot and crop seperately.

- experiment on the <u>fertilizing effext of a leguminous crop</u> in mixed cropping:

  Plant one plot with maize as a single crop and a second plot with maize and beans as mixed crops. Repeat this on the same plots for at least three farming seasons and record total yields for each of the plots separately. At the end of the last season, you should be able to see whether yields have declined on the two plots in the same way. If yields on the plot under mixed cropping have gone down less than on the plot under single cropping, this indicates that the leguminous crop has a beneficial effect on soil fertility.

- experiment on the <u>effect of egusi melons or pumpkins on germination and growth of other plants:</u>

  Select a crop usually grown together with melon or pumpkin (maize or yams). Plant three small plots in the following way:

  a) Plant maize or yams first. When this crop is well established, plant egusi or pumpkin.

  b) Plant maize or yams and egusi or pumpkin at the same time.

  c) Plant egusi or pumpkin first. When the seeds have germinated and are well developed, interplant maize or yams. Water the crops planted later if necessary.

  Observe:

    - germination of the two crops grown together
    - growth of the two crops
    - weed development

  for each of the plots a, b, and c.

- experimantation with <u>zero tillage</u>:

  This experiment should be done on sloping plots or well drained flat plots only.

  a) Till one plot according to the methods normally used on the school farm.

  b) Mulch one plot but do not till, and plant into the mulch using a digging stick or a cutlass.

Compare yields for the two plots.

- experiment on <u>erosion control</u>:

experimentation with mulch and live terracing on slopes:

design: 4 small plots of equal size on a slope

a) no erosion control measures, the crop or its residues (stalks, leaves) are left on the farm,

b) heavy mulching with grass and crop residues as an erosion control measure,

c) anti-erosion rows at a distance of 7 - 10 m. Along these rows bananas, plantains, and/or strong, tall grass are planted,

d) heavy mulching and anti-erosion rows as described in (c) are used as erosion control measures.

This is an experiment for the rainy season. It could be set just before the beginning of the long holidays. It can be evaluated when school reopens. On each of the four plots, look carefully for signs of erosion. Estimate the amount of soil caught in the anti-erosion rows of plots (c) and (d).

- experiment on the <u>effect of shading</u> on various crops:

design: Two plots farmed with maize and cocoyams mixed:

a) The plot is fully exposed to the sun

b) The plot is shaded by a light roof made from palm fronds

Observe:

- the growth of the two crops under conditions (a) and (b),
- the maize yield under conditions (a) and (b),
- weed growth under conditions (a) and (b),
- the cocoyam yield under conditions (a) and (b).

- experiment on the <u>effect of thinning</u>:

design: two plots of equal size farmed with maize

a) maize is planted in rows, three to four seeds per planting hole. All the plants which come up are allowed to grow.

b) maize is planted in rows. Three to four weeks after germination, each stand is thinned down to one plant only.

Observe:

- the growth of ten to twenty stands on plots (a) and (b),
- the yield per plant (number and size of maize cobs) for the ten to twenty stands selected,
- the total yield of plot (a) as compared to plot (b),
- the average weight of a cob on plots (a) and (b)

- experiments with <u>weed control</u>:

Maize is particularly sensitive to competition from weeds. The effect of weed control is therefore easy to see.

design: four plots and two methods of dealing with weeds: heavy mulching and weeding.

a) after germination, maize is left without weeding or mulching,

b) maize is carefully weeded with all weeds removed from the plot,

c) after germination, the plot is heavily mulched. No weeding is done,

d) the plot is weeded at the appropriate time, weeds are left as mulch and more mulch is added

Observe:

- plant growth on the four plots. When do differences in height and colour become marked?
- growth of weeds on plots (b), (c), and (d)
- yields from the four plots.

- experiments with <u>burning</u> when a plot is cleared:

The effect of burning is controversial. Crops grown on the plots of this experiment should include crops that do particularly well after burning.

design: three plots all planted with a crop combination that includes a crop responding favourably to burning

a) The plot is cleared and the grass and crop residue are burned on the soil.

b) The plot is not burned. Tilling is done as usual.

c) The plot is not burned. There is no tilling (zero tillage).

Observe:

- growth of the two or three crops,
- growth of weeds,
- damage done by insects and other pests,
- yields from the three plots.

- experiment on <u>insect control</u> by certain plants:

Some plants and flowers are known to drive away insects. If there are some in your area, do the following experiment:

design: two class plots farmed with a crop usually attacked by insects (borers, weevils),

a) The crop is farmed as usual

b) plants know to drive away insects are interplanted with the crop

Observe:

- growth of crops
- signs of insect attack during growth
- yield of the two plots.

Collect information, together with the pupils on plants known locally to "clean the soil" and to indicate a return of good soil fertility. Write up the findings. Collect the seeds of these plants and try them out as fallow crops.

Take a crop under single cropping and the same crop under multiple cropping, and look for insects that feed on other insects (e.g. spiders, praying mantis etc.). Also, look for insects harmful to the crops (e.g. borers, weevils, grasshoppers, locusts, etc.). Is there any difference in the number of the various insects you find on the two plots?

4.5. <u>Some Terms used in connection with farming methods</u>

single cropping,
sole cropping
farming in pure stand
monocropping
monoculture

are all synonymus. They all mean that only one crop is grown on a given plot.

<u>Multiple cropping</u>

<u>Multiple cropping</u> means growing several crops on one and the same piece of land in one year.
We distinguish between two cases:

1) Farming several crops during one year. The emphasis here is on a succession of crops:

1.1.) successive cropping: as one crop is harvested, the plot is prepared for a new crop which is planted after harvesting the first one. This is <u>sequential cropping involving monocultures</u>;

1.2.) <u>relay intercropping</u>, on the other hand, means that a second crop is planted on the plot while the first one is still growing. This is also known as <u>phased planting</u>.

2) Growing several crops on the same plot at the same time. The set of crops grown is called a <u>crop mixture</u> or a <u>crop combination</u>. Synonyms for this meaning of multiple cropping are <u>mixed cropping</u>, <u>polyculture</u>, and <u>intercropping</u>. There are several ways of arranging different crops in a polyculture or system of mixed cropping. The one most common in traditional agriculture is

mixed intercropping, i.e. planting the various crops without any strict order. Beans growing from the same planting hole as maize would be an example. One method is alternate strip intercropping where rows or strips of one crop alternate with rows or strips of another crop, e.g. one row of maize with one row of beans.

Multi-storey systems

The idea of multi-storey systems is linked with the concept of multiple cropping. Storey in this context refers to the leaf canopy. If plants of the same species are planted roughly at the same time, their leaves will all spread out at roughly the same height, forming a canopy. If different species grow on one plot, they will form canopies at different heights. Single cropping always leads to one storey. Multiple cropping with crop combinations containing plants that reach different heights leads to multi-storey systems. This is particularly pronounced when trees are part of the crop combination.

Classification of farming systems based on the duration of farming and fallowing

- shifting cultivation (see text)
- bush fallowing
- degraded bush fallowing
- permanent cultivation; synonyms are:
    continuous cultivation,
    permanent cropping systems

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