DOCUMENT RESUME

ED 288 044 CE 048 939

AUTHOR	Crozier, Carl
TITLE	Soil Conservation Techniques for Hillside Farms. A Guide for Peace Corps Volunteers. Appropriate Technologies for Development. Peace Corps Information Collection & Exchange Reprint Series No. R-62.
INSTITUTION	Peace Corps, Washington, DC. Information Collection and Exchange Div.
PUB DATE	Nov 86
NOTE	110p.
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	Adult Education; *Agricultural Education; Agriculture; Conservation Education; *Developing Nations; Development; Economic Development; Federal Programs; Fertilizers; Foreign Countries; *International Programs; *Rural Extension; *Soil Conservation; Soil Science; *Technical Assistance; Voluntary Agencies; Volunteers
IDENTIFIERS	*Peace Corps

ABSTRACT

This guide provides agricultural extensionists with basic information that will help them design plans for the conservation of soils and the management of water runoff in specific agricultural plots. It is based on experiences with small hillside farms in Honduras and takes into account the resources and constraints commonly encountered there. Following the introduction are three sections on soil conservation: traditional Honduran farming techniques and resulting problems, soil conservation strategies, and soil fertility and its maintenance. Section V on extension methodology includes some sample work activities, guidelines for evaluating work, motivating techniques, and types of groups with which one may be involved. A conclusion precedes a listing of suggested references and the following appendixes: an English-Spanish vocabulary list, dichotomous key to the selection of soil conservation practices, results of the Santa Cruz Extension Project, instructions for two simple levels for use in surveying contour lines, and some demonstrations useful in promoting new techniques. Eight tables and 46 figures are provided throughout the text of the guide. (YLB)

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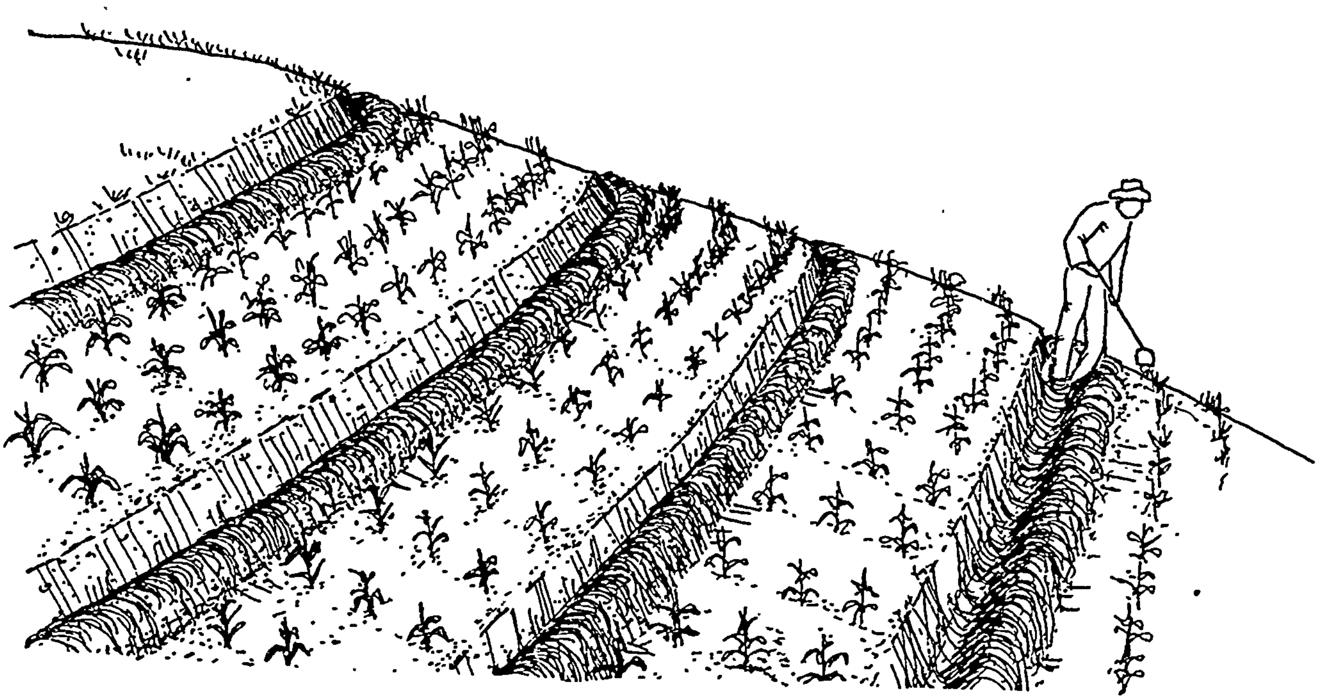
Peace Corps

PEACE CORPS HONDURAS

SOIL CONSERVATION TECHNIQUES FOR HILLSIDE FARMS

A Guide for Peace Corps Volunteers



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May, 1986

Printed By:
PEACE CORPS
Information Collection and Exchange
November 1986

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ACKNOWLEDGEMENTS

I would like to thank the many people who have helped and encouraged me in preparing this guide.

Alfonso Barahona, Director of the Peace Corps Honduras Agriculture Sector, who first conceived the idea of preparing this guide and was constantly involved in making suggestions and revisions. Fred Tracy was a valuable source of aid because of his personal experience in teaching soil conservation techniques and also permitted me to use some of his prepared material. Jim O'Donnell, Don Anderson, John Murphy, Mark Dripchak and José García provided helpful suggestions after reviewing parts of the guide. Kimball Koch deserves a special thanks for this skill and patience with the illustrations. Jack Johnson also provided initial sketches and suggestions for illustrations.

Most of all I owe thanks to the many honduran farmers willing to try out the techniques described, and to former PCV Rory William Steinke, the promoter of the Santa Cruz Extension Project. The variety of techniques employed by these persons provided me models of many soil conservation methods.

Funding for the production of this guide to date has been provided by Peace Corps Honduras.

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I. INTRODUCTION

Agricultural extensionists in a mountainous country, such as Honduras, are faced from the start with an almost infinite number of variables which may affect decisions about optimal land use. The rugged topography provides a wide variety of macro and microclimates, bedrock types, soil types, soil depths, and drainage conditions. Equally important at times may be the variation in economic resources and markets available to farmers. Therefore, as an extensionist strives to develop solutions to the problems most seriously affecting farmers of an area, it is found that each plot must be examined individually in light of the physical, economic, and possibly social or political factors which may affect an individual farmer's land use decisions.

The purpose of this guide is to provide agricultural extensionists with basic information which will help them design plans for the conservation of soils and the management of water runoff in specific agricultural plots. It was written based on experiences with small hillside farms in Honduras, and takes into account the resources and constraints commonly encountered there. Included in this guide are also some demonstrations which may prove helpful in the promotion of this technology. Through the use of this guide, it is hoped that extensionists will find it easier to solve some of the common problems faced by hillside farmers.

This guide is not intended to replace more detailed technical works such as Hudson (1981) or Suarez Castro (1980). The main purpose of this guide is to provide a more concise reference work geared more specifically towards small hillside plots. In doing so, much technical information and many techniques appropriate to larger, more mechanized farms are omitted. Information presented in other sources should be consulted, when possible, for the solution of specific technical problems. There are also many important topics not covered in this guide, such as improved seed varieties, pest control, marketing, etc., which nevertheless should be considered by extensionists in developing a complete plan for improving farming practices of an area.

II. TRADITIONAL HONDURAN HILLSIDE FARMING TECHNIQUES AND RESULTING PROBLEMS

Traditional hillside land-use patterns in much of Honduras are based roughly on the following series of events:

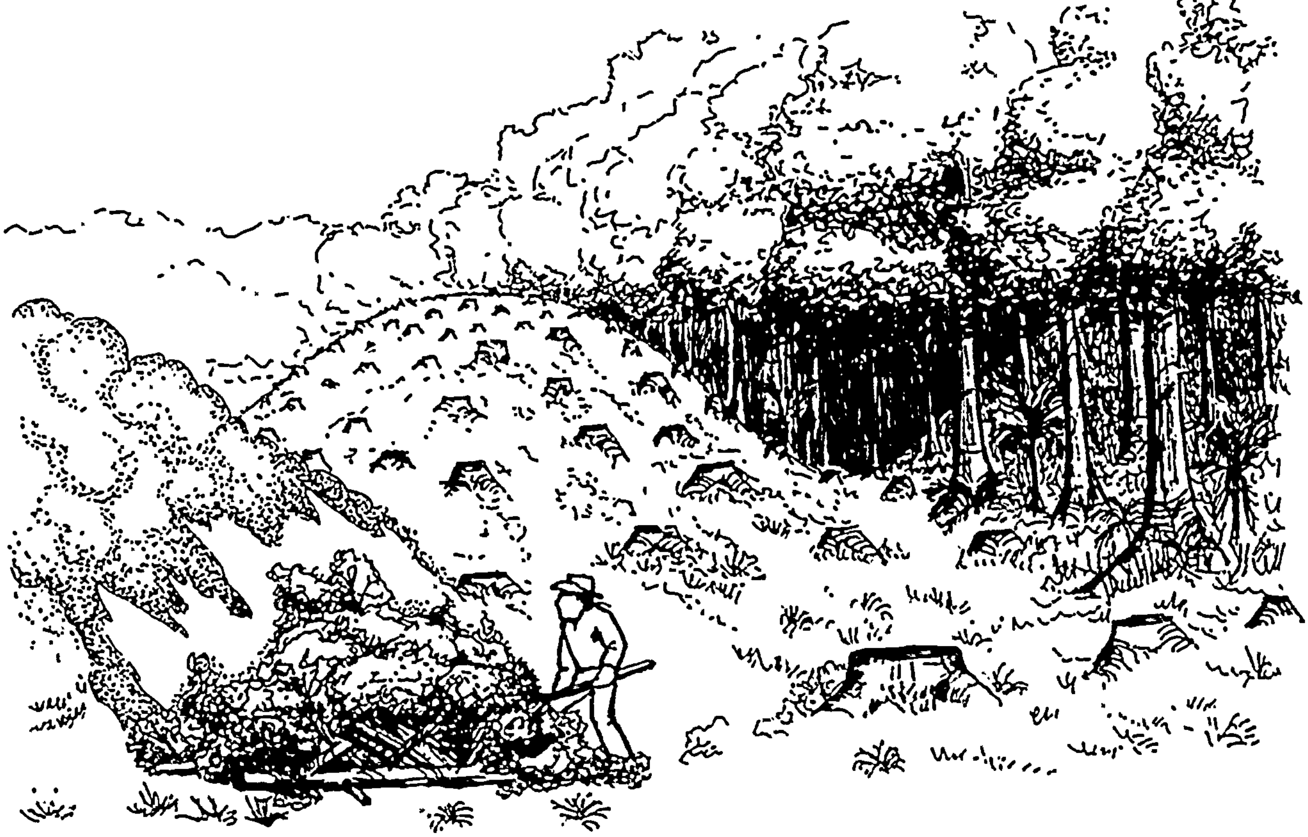


Fig. 1. A forested lot is clearcut and residues are burned

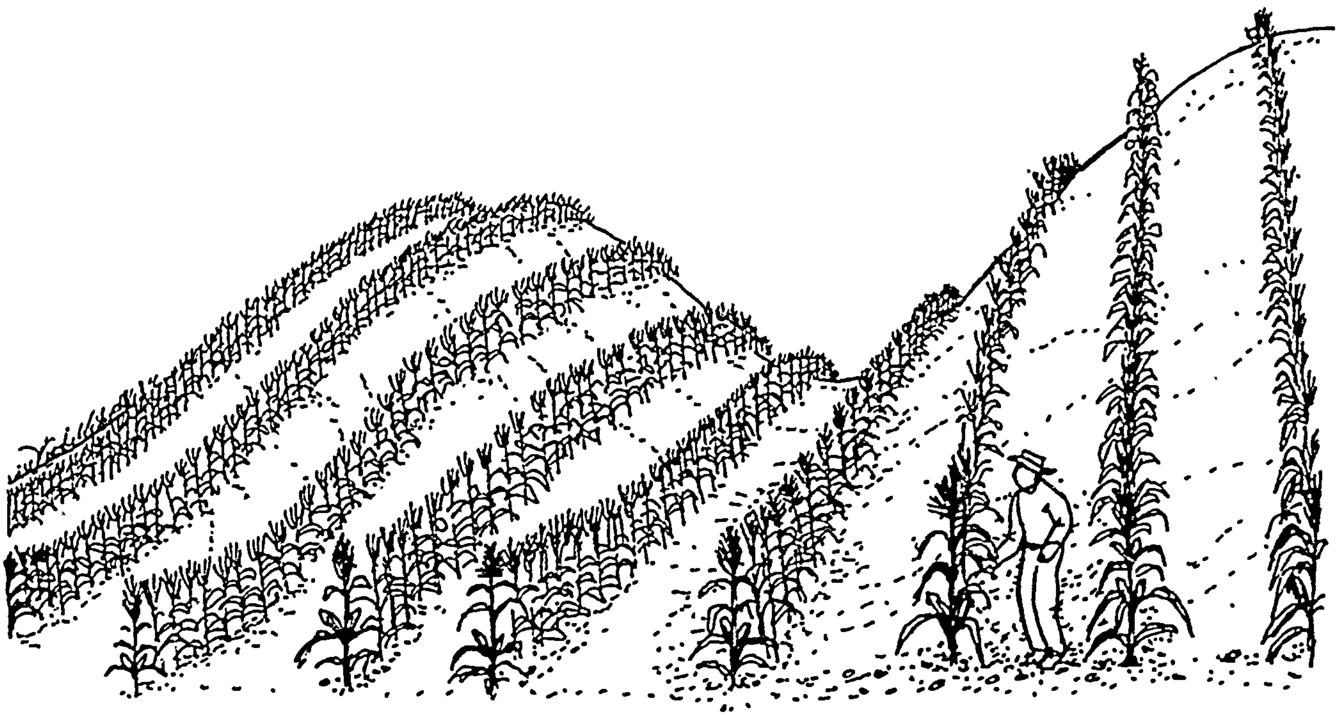


Fig.2. Crops are planted with rows oriented up and down the hillside

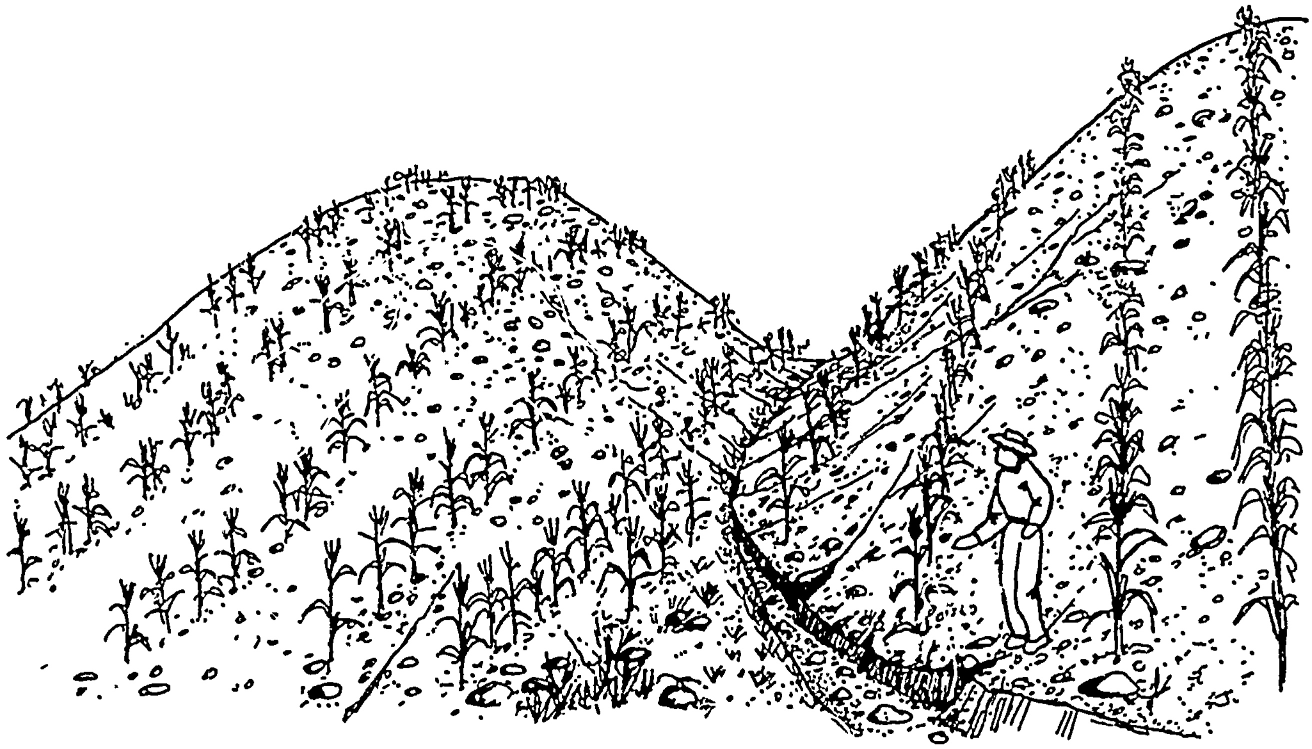


Fig. 3. Crop yields decline each year as soil erodes

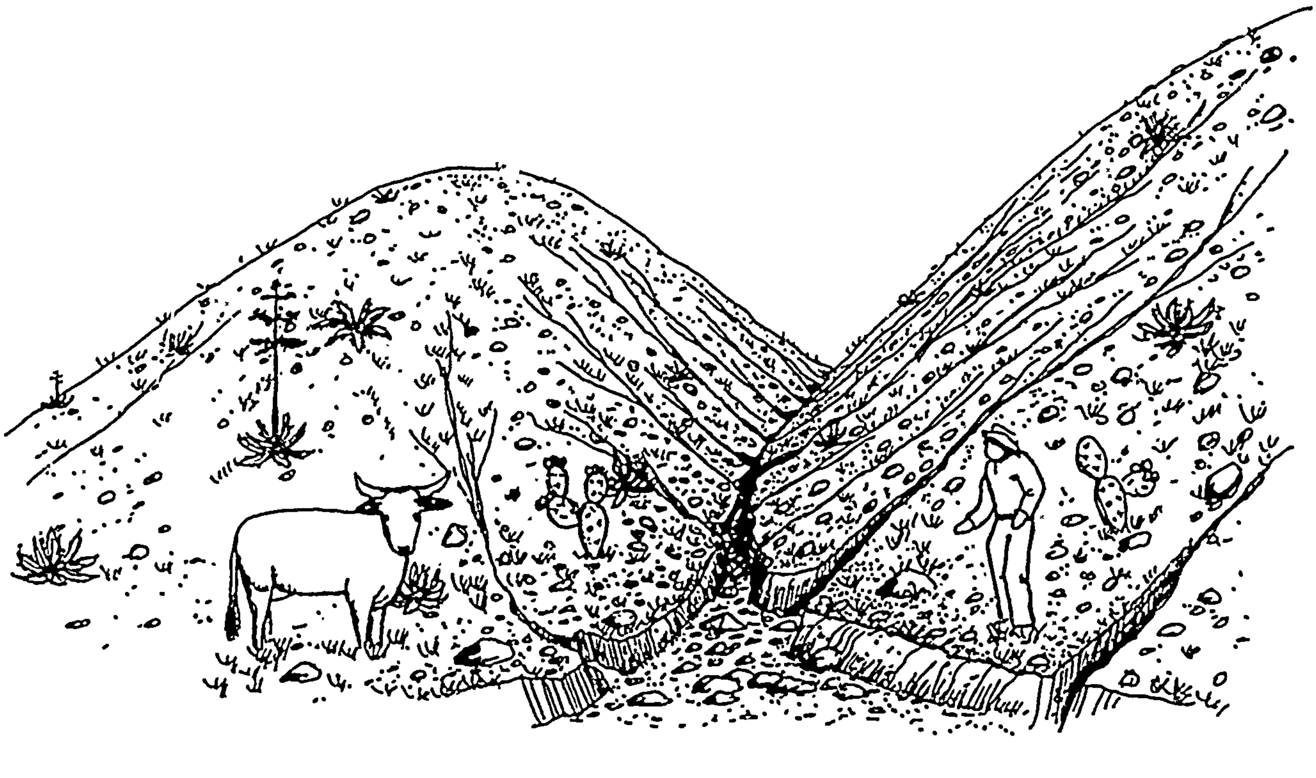


Fig. 4. The land is planted in perennial pasture grasses or abandoned after having been cultivated for a relatively short time (often only 1-20 years, depending on site-specific factors).

This pattern of land use may avoid some problems with crop pests and the need for supplemental fertilizer. However, in a densely settled area land soon becomes scarce, and mature-forested, fertile plots are not always available to be cleared and cultivated. In such densely settled areas, a land use pattern which results in a permanent cultivation of the same plots is desired.

There are three related problems associated with this traditional land use patterns which must be corrected if permanent cultivation practices are to be successfull: soil erosion, rapid water runoff, and decreased soil fertility. As the native vegetation is cut and burned, the soil surface is exposed to the impact of raindrops. The force of the raindrop impact dislodges soil particles. These soil particles and the valuable nutrients they contain can then be carried out of the area by the water flowing over the soil surface. This rapid rainfall runoff means that less water infiltrates into the soil to be available later, exagerating any natural flood/drought cycles.

When the native vegetation is intact, the force of falling raindrops is mostly absorbed by the vegetation, as there is much less bare ground surface exposed. The decaying leaf litter on the ground and in the upper soil layers also protects the soil, acting as a sponge, absorbing much of the rainfall and decreasing the amount that can freely run over the land surface. Since more of the rainfall remains in the soil rather than running off, the soil retains its moisture longer in the absence of rainfall. Since fewer soil nutrients are lost in runoff water, soil fertility is maintained.

A comparison of these two scenarios illustrates how in the traditionally farmed field, characterized by the absence of protecting vegetation, the rainfall impact and the loss of soil particles, dissolved nutrients, and water are all increased. The rest of this guide focuses on techniques for reducing the soil erosion and water runoff associated with agricultural activities, techniques of maintaining or increasing the soil fertility necessary for permanent cultivation of the same plots, and extension methods useful in promoting the adoption of these different farming techniques.

III. SOIL CONSERVATION STRATEGIES

There are two types of strategies which may be followed in attempts to reduce the detrimental environmental effects of the agricultural activity. The most effective is to avoid the damage due to rainfall impact by minimizing soil disturbance and promoting practices which maintain a ground cover. The second, less effective, but easier to integrate into traditional land use practices, is to continue many of the typical agricultural techniques which result in rainfall impact, but minimizing soil loss and water runoff by crop rotations or by the placement of structures (barriers, ditches, terraces) to reduce the movement of soil and water along the soil surface. These two types of strategies make up the basis of all the conservation schemes discussed here. They are discussed as separate techniques, but the best control of soil erosion, water runoff, and maintenance of soil fertility results from combining all of the complementary techniques appropriate for a particular cultivation system.

A. CONSERVATION STRATEGIES AIMED AT MINIMIZING SOIL DISTURBANCE

1. Protecting Native Vegetation

Ideally, the environmental damages associated with agricultural activities could be avoided by protecting the native vegetation, which keeps the problem from arising. This method, however, ignores man's dependence on traditional agricultural techniques to support himself and is difficult to promote, especially as human populations increase. This strategy does however, provide other valuable benefits such as maintaining a clean, reliable supply of drinking water, and reserves for native fauna and flora, which also become increasingly important as the human population increases.

2. Replanting Native Vegetation

In view of the benefits of native vegetation, replanting of previously cleared land can be an effective method for protecting land, water supplies, and native wildlife. (Fig.5)

Reforestation (or replanting of grasses or shrubs, depending on natural vegetation type) can be carried out using native species or introduced species adapted to the local conditions, having some desirable characteristic (fast growth rate, the ability to fix nitrogen, forage or wood value, etc.), and which will facilitate the return of a protective vegetative canopy. A description of some species is given in Firewood Crops: Shrub and Tree Species for Energy Production (N.A.S., 1983).

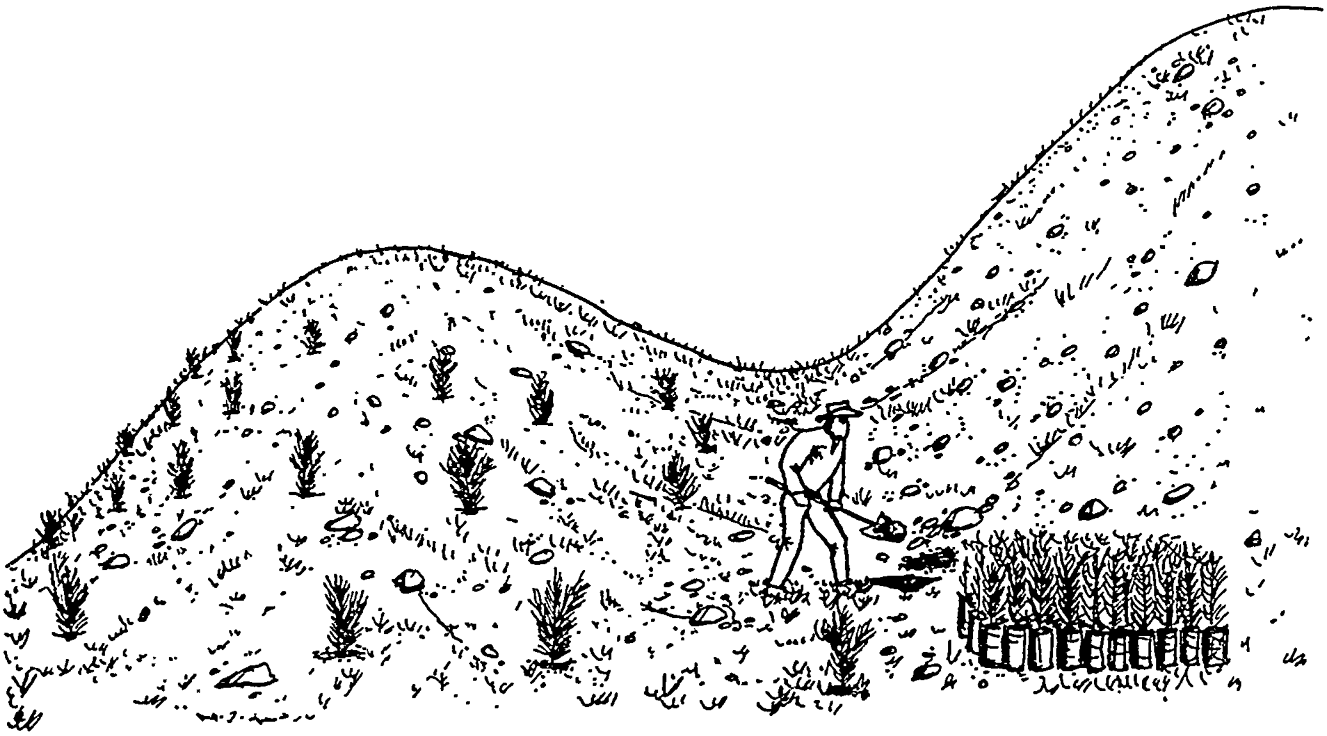


Fig. 5. Reforestation

3. Perennial Crop Cultivation Systems

Another technique which results in a minimized soil disturbance is the planting of perennial crops, such as fruit trees or pasture grasses, rather than annual crops such as corn or beans. In this manner, after the initial disruptive clearing and planting of the land a permanent ground cover is attained and the environmental damages associated with the raindrop impact are lessened. (Fig.6).

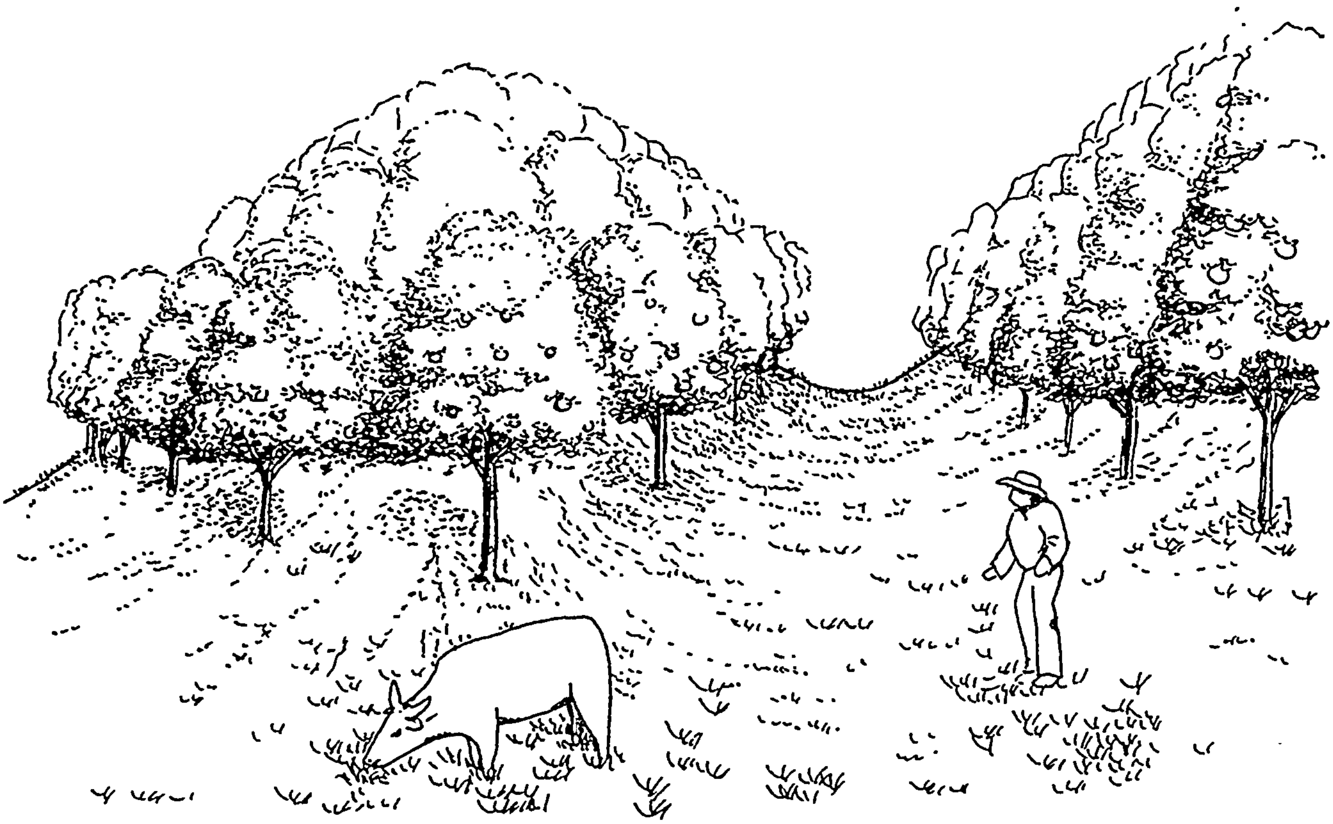


Fig. 6. Perennial Crops - Fruit trees and pasture grasses

4. Use of Ground Cover while Cultivating Annual Crops

There are techniques for maintaining a protective ground cover even while cultivating annual crops. These include minimum tillage and mulching systems. In minimum tillage systems, only the narrow row where the seeds are planted is tilled and the remaining ground surface is left intact. Because these intact areas are more compacted and have a low weed covering, they are more erosion resistant. (Fig.7) Mulching is the use of dead material or the planting of a ground cover which results in a covering of the bare soil areas in a field. As in the other techniques, the covered soil is less susceptible to erosion than bare soil. In the section on "Green Manure Crops" some suggestions for using legume cover crops are presented.

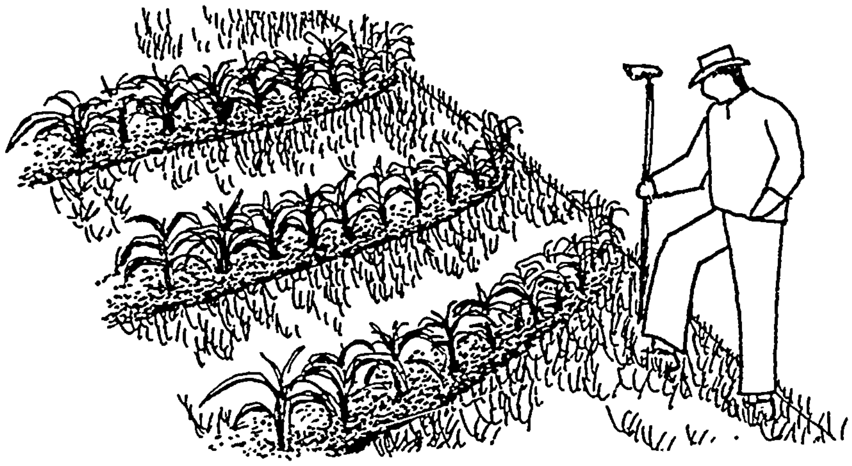


Fig. 7. Minimum tillage cultivation system

B. CONSERVATION STRATEGIES AIMED AT MINIMIZING SOIL LOSS AND INCREASING WATER INFILTRATION IN CULTIVATION SYSTEMS WHERE THERE IS EXTENSIVE SOIL DISTURBANCE.

Even though the techniques described in the previous section are more effective in reducing the environmental damages associated with man's agricultural activity, the techniques described in this section are much easier to promote because they are much easier to integrate into the traditional cultivation systems.

1. Crop Rotation

The use of a crop rotation sequence, rather than continual successive plantings of the same crop can play a role in reducing soil erosion as well as provide other benefits (vary the rooting depth and thereby moisture and nutrient uptake, restore soil structure, break pest and disease cycles, help maintain soil fertility; Hudson 1981). When land is used repeatedly for cultivating relatively open row crops (i.e. corn, beans, tobacco, etc.), a rotation with a denser green manure or forage crop can reduce erosion because of the ground cover provided. Also the maintenance of soil fertility and structure will allow the next planting of the more open crop to grow more vigorously and develop better root systems, thereby helping reduce some soil loss. Generally, however, on sloping lands (5-10% +), crop rotations alone will have little effect on erosion, and should be used in combination with other techniques.

2. Contour Barriers

Contour barriers are contour strips which intercept downslope flowing water and soil particles. These barriers slow down the water movement and reduce its erosive force. They also filter out and trap many of the suspended soil particles, keeping them from being washed out of the field. A long term advantage of barriers is that soil tends to build up behind them, creating a terrace effect. Barriers can be classified as live (strips of living plants), dead (rocks, crop residues), or mixed (a combination of the previous two).

Live barriers are strips of vegetation planted along the contour which serve to anchor the soil in place with their roots and to slow down the movement of water downslope with their stems and leaves (Fig. 8). They are planted above hillside ditches to prevent them from filling with soil and also by themselves to prevent hillside erosion. The most common types of live barriers are plants of the grass family because of the dense foliage and root mats produced. As soil builds up behind them, a bench terrace with a grass protected riser (sloping bank) is formed (see section on bench terraces). In addition the grasses are valuable as forage for animals, or for human consumption in the case of sugar cane or lemmon grass. Many species of plants have great potential as useful live barriers, some possibilities are listed in Table 1. The table is by no means all inclusive, the possibilities are almost limitless, especially when considering agroforestry systems where contour strips of nitrogen-fixing and/or wood or fruit producing trees may be used as barriers. An effort should be made to discuss the available barrier plants in the area with farmers so that each one can select the ones most suited to their needs.

As a management practice it is advisable to cut forage barrier plants and carry them to livestock rather than letting livestock graze them. If the barriers are not well established, the animals may uproot or overgraze them, thus wiping out the barrier. If farmers use the practice of opening their fields to grazing after the harvest, then an unpalatable barrier or planting early in the year to ensure a well established barrier is necessary. Maintenance of the live barriers is extremely important. Open spaces should be replanted so that the barrier forms an effective soil filter. Barriers should be cut or pruned to avoid excessive shading or root competition with the crops.

TABLE 1

SOME SUGGESTED LIVE BARRIER PLANTS

COMMON NAME	SCIENTIFIC NAME	CHARACTERISTICS
Sugar Cane (Caña de Azucar)	Saccharum officinarum	Establishes vegetatively from rhizome or stems, forms thick barrier, may also serve as windbreak, useful for forage or human consumption, may cause excessive shading
Guatemala Grass (Zacate o Caña Guatemala)	Tripsacum laxum	Establishes vegetatively from rhizome or stems, excellent forage, susceptible to overgrazing smaller plant than sugar cane
King Grass (Zacate Rey, Taiwan o Elefante)	Pennisetum purpureum	Establishes vegetatively from rhizome or stems, excellent forage grass, tall plants, may cause excessive shading or competition if not cut
Merker Grass (Merkeron, Napier)	Pennisetum purpureum	Establishes vegetatively from rhizome or stems, smaller and less succulent than King Grass, may be problem weed spreading vegetatively and by seed if not cut
Guinea Grass (Zacate Guinea)	Panicum maximum	Establishes easily from rootstock or seed, exce-llent forage grass, relatively short, forms thick bunches
Bermuda Grass, Star Grass (Zacate Bermuda, Estre-lla)	Cynodon spp.	Establishes by stolons, may be a problem weed because of its vigorous spreading, suitable for stabilizing drainages, not for contour barriers, good forage
Lemmon Grass (Zacate Limón)	Andropogon citratus	Establishes well from rootstock, unpalatable to cattle, used in making tea, forms short, thick bunches
Maicillo	Sorghum sp.	Establishes by seed, if planted closely forms excellent barrier, good forage, produces grain, grows well in arid zones, tall plant and may cause excessive shading, short-lived (2-3 years), may be alternate host for certain corn diseases

TABLE 1 (Continued)

COMMON NAME	SCIENTIFIC NAME	CHARACTERISTICS
Jaragüa	*Hyparrhenia rufa*	Establishes by seed, forms thick closely spaced bunches, grows well in arid zones, good forage, problem weed if not cut before flowering
Valeriana	*Vetiveria* sp.	Establishes from rootstock, forms low thick bunches unpalatable to cattle, medicinal value
Cardamine (Cardamomo)	*Elettaria cardamomum*	Establishes as vegetative bulb or transplanted from seedbed, forms thick bunches up to 3m tall, valuable seed crop. shade tolerant, only in cool moist climates, may cause excessive shading or competition
Gladiola [1] (Varsovia)	*Gladiolus* sp.	Establishes easily from bulbs, value as ornamental
Pineapple [1] (Piña)	*Ananas mosus*	Establishes easily from vegetative buds, grows well in poor sandy soils, edible fruits
Motate [1] (Piñuela)	*Bromelia* sp.	Establishes easily from vegetative buds, grows well in wide variety of climates and soils, edible fruits
Leucaena [2]	*Leucaena* spp.	Establishes from seeds, leaves useful as nitrogen-containing forage or mulch, grows rapidly, produces firewood, best at low elevations (less than 1000m)
Madriago [2] (Madre de Cacao)	*Gliricidia sepium*	Establishes from branches planted in post form, also from seeds, leaves useful as nitrogen-containing forage or mulch, produces firewood
Yucca [2] (Joshua tree, izote)	*Yucca elephantipes*	Establishes from stakes, edible flowers, used in live fences or as an ornamental

(1) These plants must be planted closely spaced in 2 or 3 rows in order to form effective barriers.

(2) These plants are most effective as barriers when the rows are reinforced with crop residues or rocks to form a mixed barrier. (See Fig. 8)

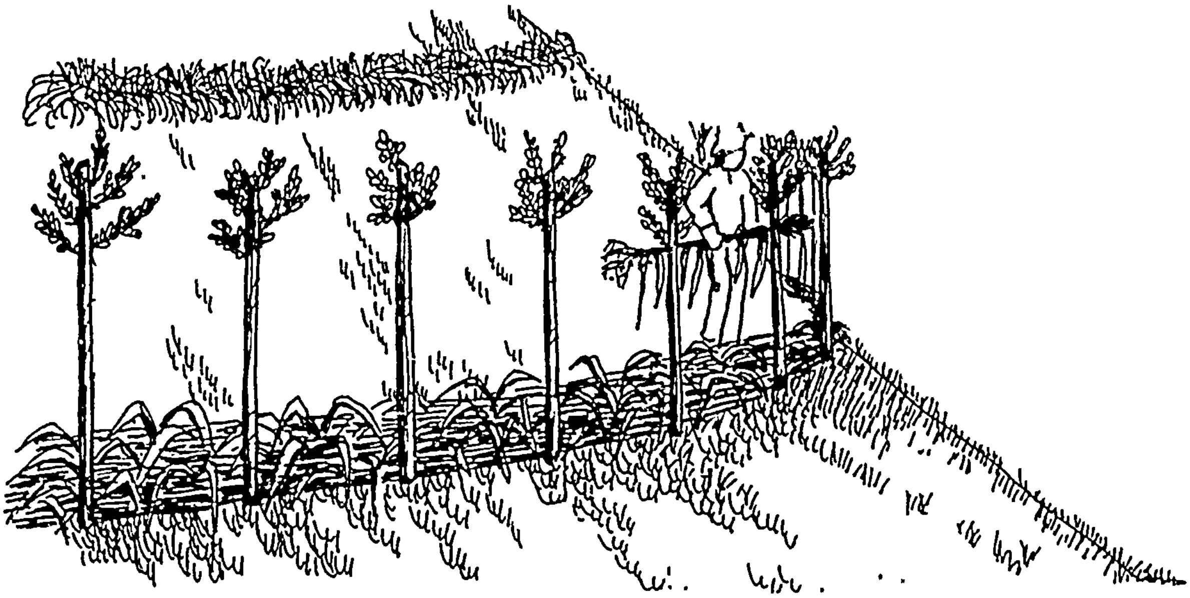


Fig. 8. Contour live barriers

In planting contour barriers, the spacing from one barrier to the next depends on the slope of the land, with barriers spaced closer together on steep slopes and farther apart on gentler slopes. (Table 2)

TABLE 2

SPACING OF CONTOUR BARRIERS ACCORDING TO THE SLOPE

SLOPE (%)	ANNUAL CROPS Distance (m)	PERENNIAL CROPS Distance (m)
5	20.0	25.0
10	15.1	20.1
15	10.1	18.2
20	9.2	15.3
25	8.2	15.5
30	6.8	12.5
35	6.4	12.7
40	6.5	9.7
60		7.0

From Suarez Castro 1980, modified to show distance along ground surface rather than horizontal distance.

Contour planting of a crop and contour strip cropping are also techniques which may be considered functionally as live barriers since they are contour plantings which serve to control hillside erosion. The planting of windbreaks is also a use of live barriers (trees or tall grasses) in this case to avoid erosion or crop damage due to wind rather than water.

Dead barriers function similar to live barriers, the difference being that they are composed of rocks, plant residues, or other non-living materials. (Fig.9). If rocks are present in a field, it is useful to construct these and in the process make the soil easier to work. Another advantage is that they can be completed during the dry season, meaning that they are in place and functioning at the start of the rainy season. If enough rocks are present, the barriers can be constructed as rock walls of sufficient height so that bench terraces are formed as the soil fills in behind each wall. If sufficient rocks are not present, the barriers lose their effectiveness as the soil fills in behind them, and they should be supplemented with the planting of live barriers.

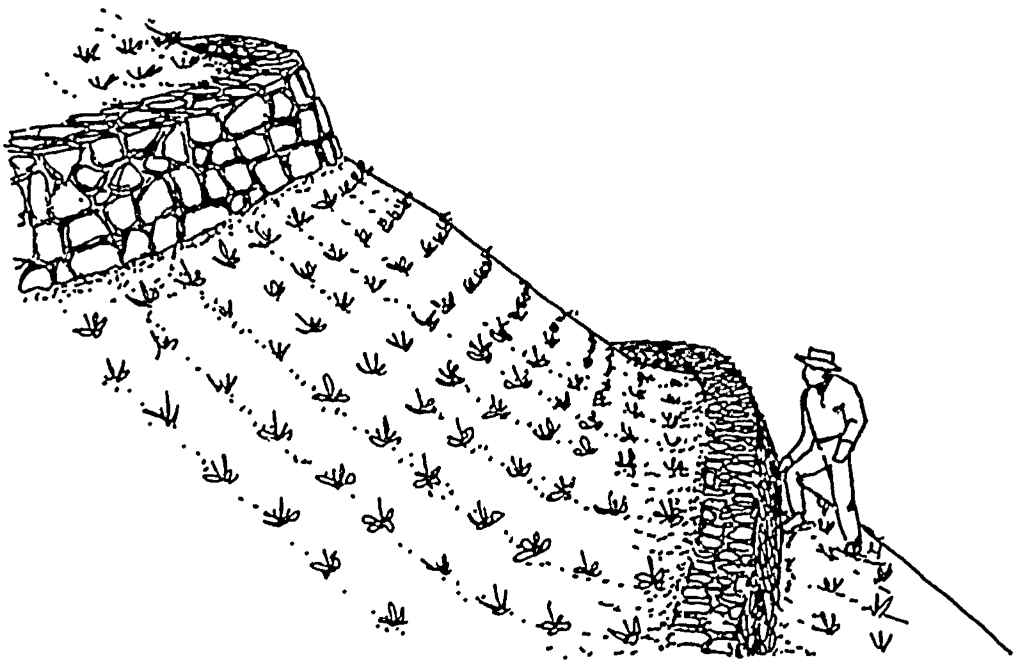


Fig. 9. Contour dead barriers

The construction of dead barriers is simple, but requires a lot of manual labor. Once contour lines are marked out according to the spacings giving in Table 2, a hoe is used to form a furrow which serves to anchor the barrier (~ 20 cm deep). Then the materials are laid out to form walls along the contour lines. In some cases, mixed barriers are used, a combination of live and non-living materials. This can consist of strips of trees with the intervening spaces filled with rocks or crop residues. (Fig. 8), or combinations of grass and rock barriers. If using plant residues, be aware that as they decompose they lose their effectiveness as barriers and will erode away, needing to be supplemented.

Contour furrows or raised planting beds may also be considered functionally as contour barriers. (Fig. 10). These techniques are useful in the cultivation of vegetables, basic grains, or any row crops in which the soil is to be intensively cultivated. The contour furrows or beds serve various purposes: reducing water movement and therefore soil erosion down the slope, permitting drainage of excess soil moisture from the planting bed, providing for a more even distribution of irrigation or rainwater, and avoiding compaction of the planting bed surface by providing walkways. The construction is simple. The furrows are plowed if possible, along measured contour lines, then cleaned out with a hoe or shovel, spreading the soil in the space between the furrows. The width between furrows is variable and depends on the crop and any irrigation requirements.

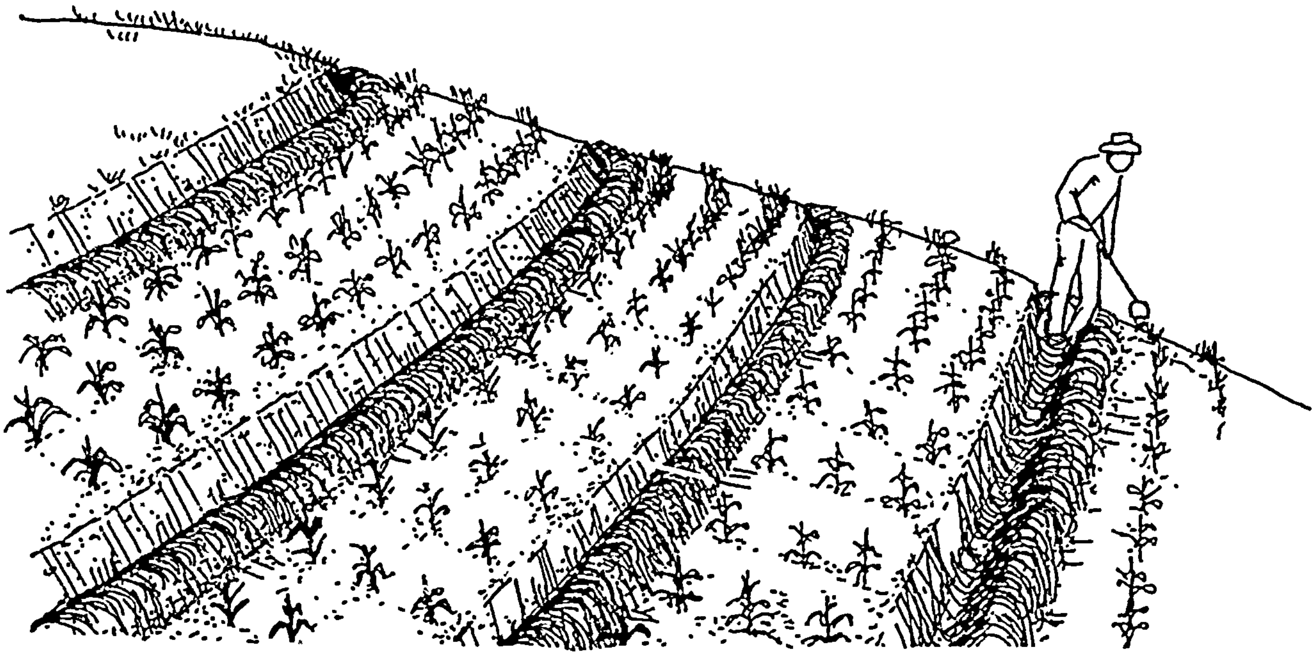


Fig. 10. Contour planting beds

3. Contour Ditches

Contour ditches serve many of the same purposes as contour barriers, in addition they completely stop downslope water movement as the water falls into the ditch. These structures are some of the most useful for small-scale hillside farming since they require less work than terraces, are simple to build, and can be used to either divert or to retain water. If constructed at a 1% slope*, they divert excess water to protected drainageways, reducing soil erosion and leaching of nutrients. (Fig. 11). The uppermost ditch, called stormwater drain by Hudson 1981, is very important if a great deal of water enters from above the field.

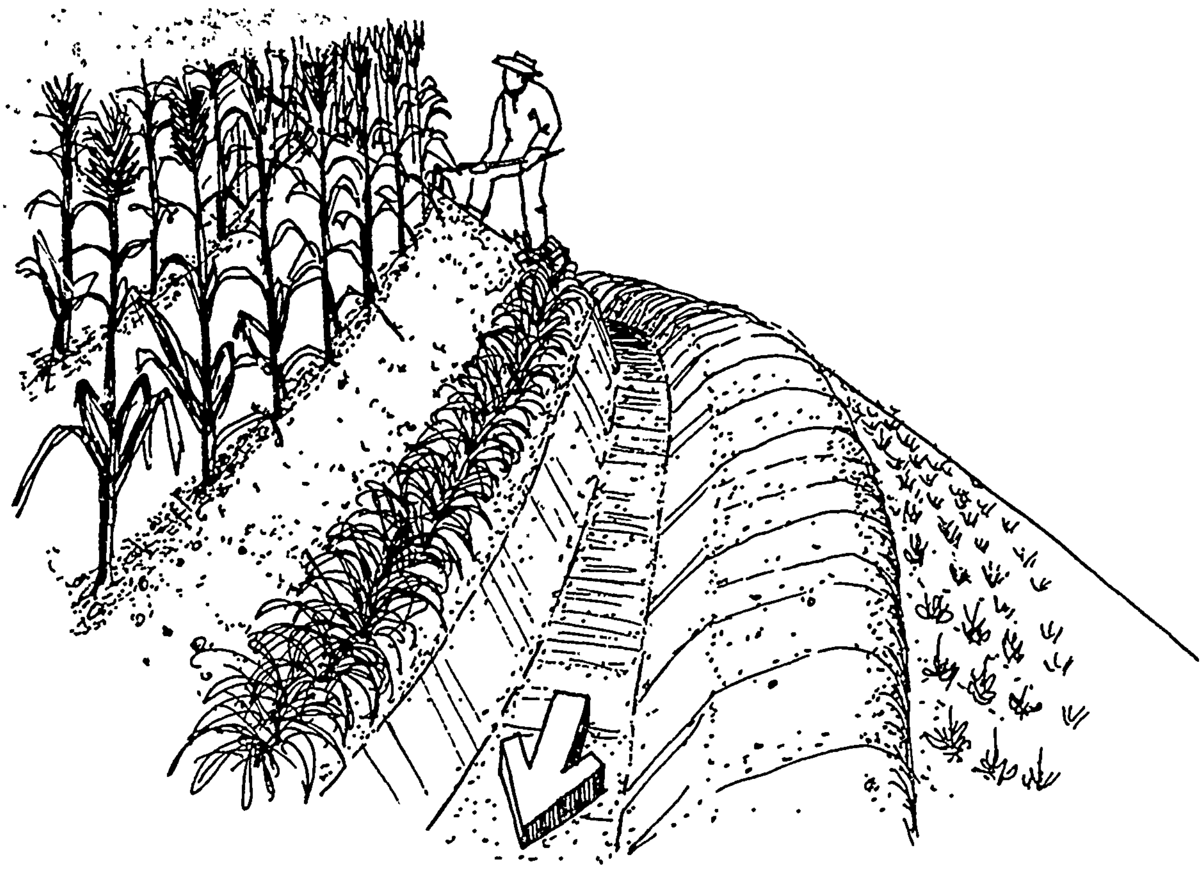


Fig. 11. Contour drainage ditch

*Hudson (1981) recommends a 0.25% slope for contour ditches (channel terraces). Due to the relative inaccuracy of the rustic levels often used (See Apendix 4), a 1% slope is recommended here to insure water flow in the proper direction.

If it is desirable to retain as much water as possible, earthen dikes can be left in the ditches or the ditches can be constructed at a 0% slope so that water infiltrates into the soil and is not diverted outside the field. (Fig.12)

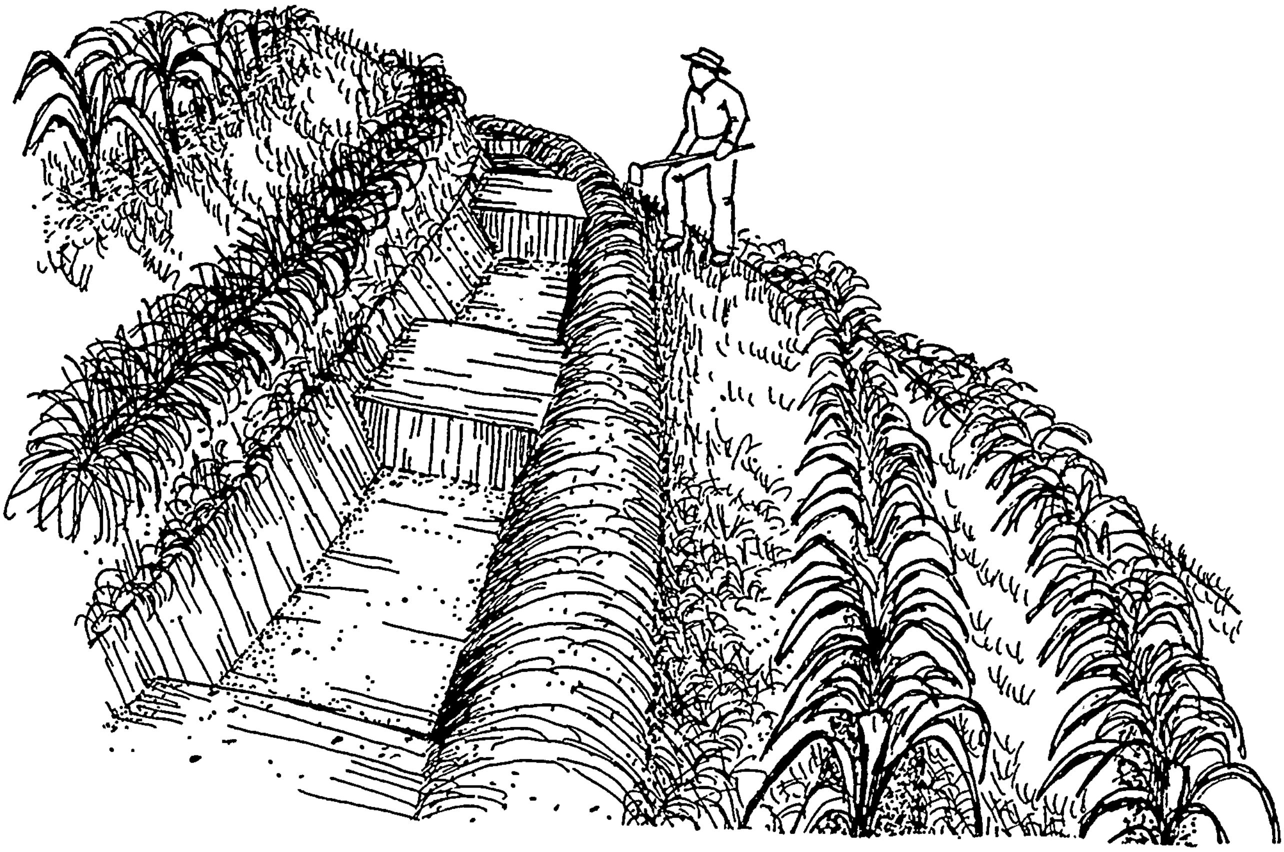


Fig. 12. Contour infiltration ditch

The ditches are constructed using pickaxes and shovels. If possible, plowing the contour line makes the construction much easier. The first stage in the construction is to excavate a 12 inch wide by 12 inch deep ditch (ditches can be constructed of any size, if desired). Then the banks are formed by cutting a slanted wall at each side. The removed earth is placed in a mound 6 - 9 inches below the lower lip of the ditch. A live barrier is necessary above the upper edge to prevent filling with soil. Especially on steeper slopes, it is often advantageous to plant the live barrier first, several months or one season in advance, so that the ditch will be adequately protected once built.

Table 3 should be consulted for the appropriate distance between ditches on hillsides of a given slope. If the ditches are to be dug with a 1% slope to drain excess water, the 1 or 2 meters before emptying into a protected drainageway should have a slightly steeper slope, (1-2%) to facilitate drainage. Care should also be taken not to drain excess water into neighboring fields, houses, or other areas which may result in problems. (See "Waterways for draining excess water from fields").

TABLE 3

SPACING OF CONTOUR HILLSIDE DITCHES

SLOPE (%)	ANNUAL CROP		PERENNIAL CROP OR PASTURE	
	Distance (m)	Maximum Length (m)	Distance (m)	Maximum Length (m)
2	42.0	90		
4	25.0	120		
6	19.3	160		
8	16.6	200		
10	14.9	260	40.2	140
12	13.8	280	33.5	140
14	13.0	300	28.9	140
16	11.4	340	25.3	160
18	10.2	380	25.0	180
20	9.2	420	24.0	200
22	8.4	470	23.2	200
24	7.7	500	21.4	210
26	7.2	500	19.8	220
28	6.6	500	19.5	220
30	6.3	500	18.9	220
32			18.7	220
34			18.6	230
36			17.7	230
38			16.9	230
40			16.2	230

From: Suarez Castro 1980 (modified to show distance along ground surface rather than horizontal distance)

4. Terraces

Terraces serve the functions of stopping downslope soil and water movement and also give the advantage of providing a flat surface for the planting of crops, thereby further reducing the possibility of erosion.

Some important points should be noted before deciding to build terraces. Since the formation of terraces requires a maximum of soil disturbance and rearrangement, they are extremely susceptible to erosion if not properly measured, compacted, and maintained with risers (sloping banks) protected by vegetation. Also when considering terracing a steep slope (25-30% +) it should be noted that a much deeper cut and fill will be needed, much more land space will be lost in the sloping terrace walls, and the useful planting space is likely to be extremely narrow unless a very deep soil is present.

Individual terraces are constructed to provide a level platform for the growth of an individual tree. They are always used in combination with another type of conservation structure, such as contour ditches, since the small platforms by themselves do not appreciably control surface water movement. (Fig. 13). When planting a hillside with individual terraces, the layout should be in an equilateral triangular or hexagonal pattern, with the distances varying according to the variety of tree being planted. The terraces generally have a diameter of 1 to 1.5 meters and should be throughly compacted to prevent collapsing.

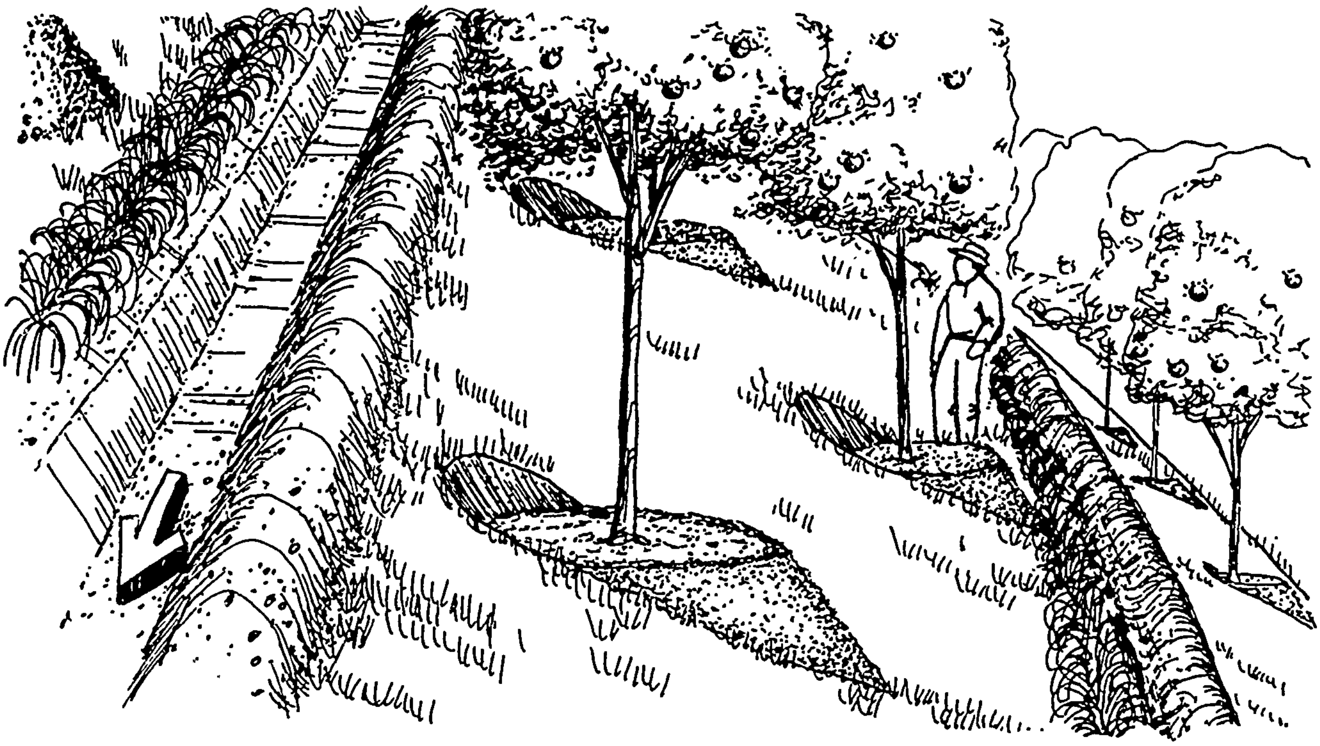


Fig. 13. Individual terraces.

Discontinouous narrow terraces (orchard terraces) provide both a flat platform for planting crops and an inverse slope which allows it to serve as a drainage or infiltration ditch. (Figs. 14, 15).

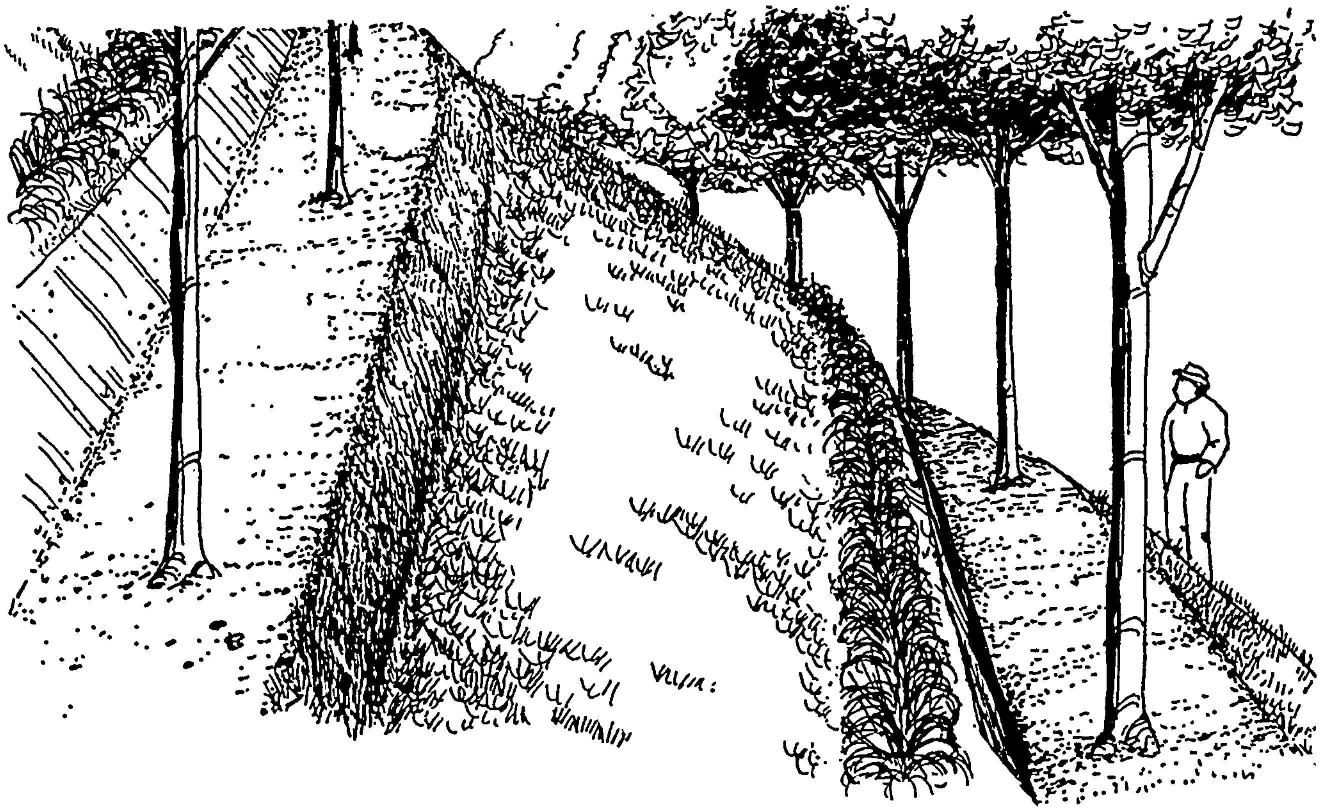
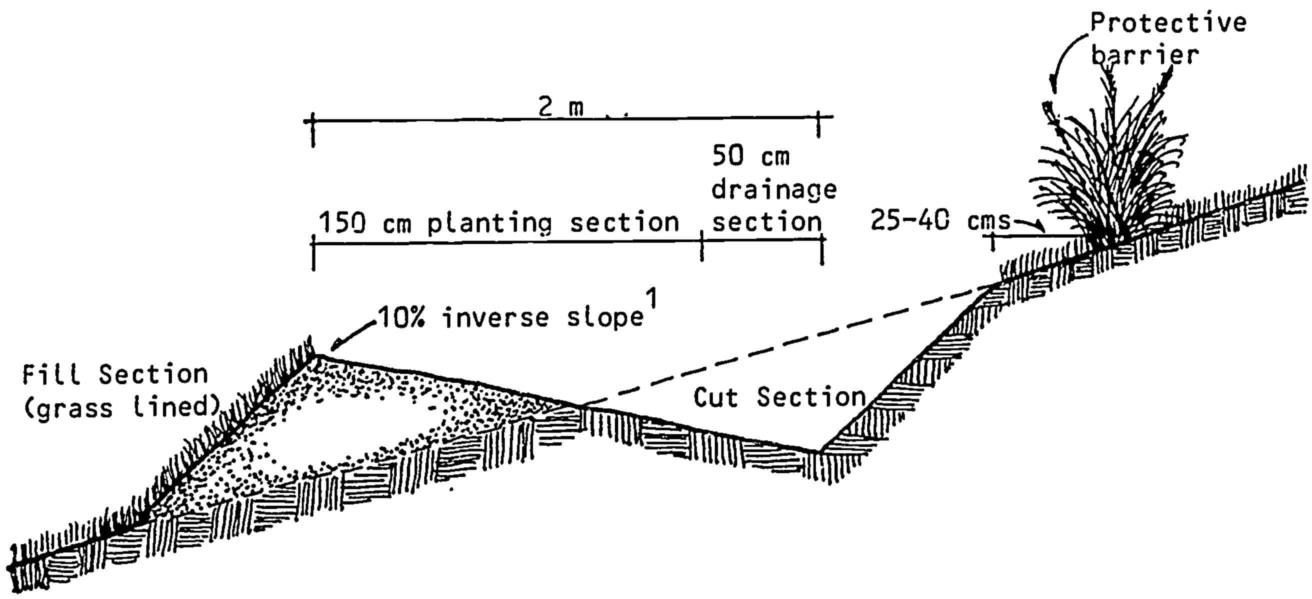


Fig. 14. Discontinuous narrow terrace (orchard terrace)



[1] If initially constructed with an inverse slope of 15-20%, some self-compaction occurs resulting in a slope of approximately 10%.

Fig. 15. Discontinuous narrow terrace (X.S.)

Construction is done, after plowing if possible, with pickaxes and rakes or hoes. Some design information is given in Table 4. Construction is most rapid in soft, deep soils.

In these cases the earth from the cut section is merely moved to the fill section, compacted, and raked smooth. If it is judged necessary to remove the topsoil and redistribute it later, then a construction sequence such as sequence "B" given for the bench terraces is recommended (Fig.18). In order to keep the risers from eroding, grass should be planted on them. The drainageway for this type of structure should be constructed similar to that of the hill-side ditch, slightly steeper right before emptying into the protected drainage area. (See "Waterways for draining excess water from fields").

TABLE 4

DISCONTINUOUS NARROW TERRACE CONSTRUCTION GUIDE

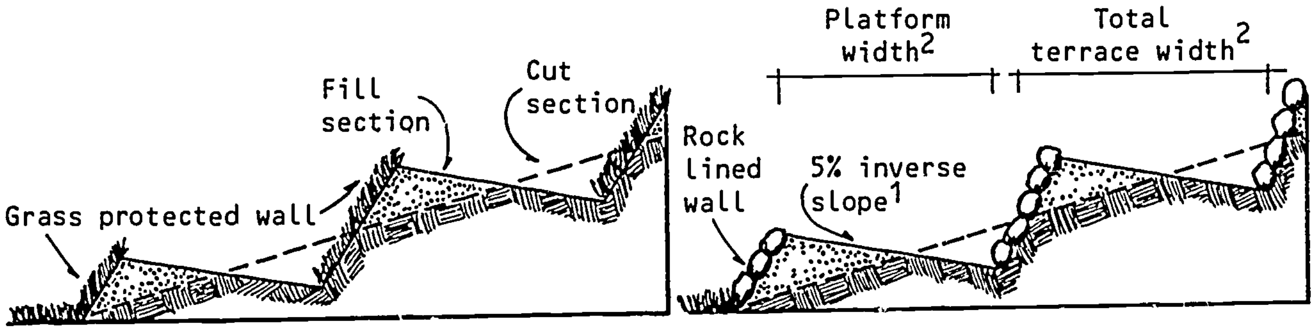
SLOPE (%)	DISTANCE BETWEEN CANALS (meters)	TOTAL CANAL WIDTH* (Platform Plus Walls) (meters)
5	18	2.22
10	14	2.32
15	13	2.40
20	12	2.52
30	12	2.71
40	12	3.00

From Michaelsen, 1980

*Based on 2m platform width, 1.5 wide platforms are also used, especially on steeper slopes with thin soils.

Continuous bench terraces are staircase-like structures which diminish erosion because the reshaping of the land surface results in the planting of all crops on gently inversely sloping platforms (Fig.16). The most feasible application is in intensively worked vegetable plots where each planting bed may be a separate terrace.

Bench terraces can be designed level (0% slope) for water retention or with a slight slope (0-1%) to facilitate water drainage or distribution of irrigation water. (See "Waterways for Draining Excess Water From Fields")



[1] If initially constructed with an inverse slope of 10%, some self compaction occurs, resulting in a slope of approximately 5%.

[2] Platform width and terrace width vary according to slope and depth of soil. (See TABLE 5)

Fig. 16. Continuous bench terraces (X.S.)

There are many different terrace design specifications published in soil conservation books, but only the basic features are described here. Table 5 may be used as a general guide for designing terraces with the total terrace width dependent upon the slope of the hillside and the depth of fertile or tillable soil.

TABLE 5

BENCH TERRACE CONSTRUCTION GUIDE

SLOPE (%)	SOIL DEPTH* (Meters)	TOTAL TERRACE WIDTH (Meters)	PLATFORM WIDTH (Meters)
20	.2	1.68	1.30
	.3	2.5	1.94
	.4	3.34	2.60
	.5	4.26	3.30
	.6	5.02	3.90
30	.2	1.16	.80
	.3	1.72	1.20
	.4	2.3	1.60
	.5	2.98	2.10
	.6	3.46	2.40
40	.2	.90	.56
	.3	1.32	.82
	.4	1.78	1.10
	.5	2.25	1.40
	.6	2.68	1.66
50	.2	.74	.40
	.3	1.10	.60
	.4	1.46	.80
	.5	1.84	1.00
	.6	2.20	1.20

*"Depth of A Horizon" in original changed to permit use in eroded areas where horizons are often indistinct.

From Suarez Castro, 1980

Bench terraces are constructed using pickaxes, hoes, and rakes. In some areas, large, specially designed hoes are available. Construction is much easier if the section of earth to be removed (cut section) is plowed beforehand to loosen the soil. If construction is being undertaken during the rainy season, it is advisable to begin construction near the drainage area and with the uppermost terrace. In this way, any rainwater will drain off without damaging the terraces.

There are several ideas as to the best method of constructing a series of terraces. One, which may require several years for completion, is the planting of a live barrier grass or the construction of rock walls along the contour. Over time terraces are formed as soil fills in behind them. Two other construction sequences are presented here. (Figs. 17,18)

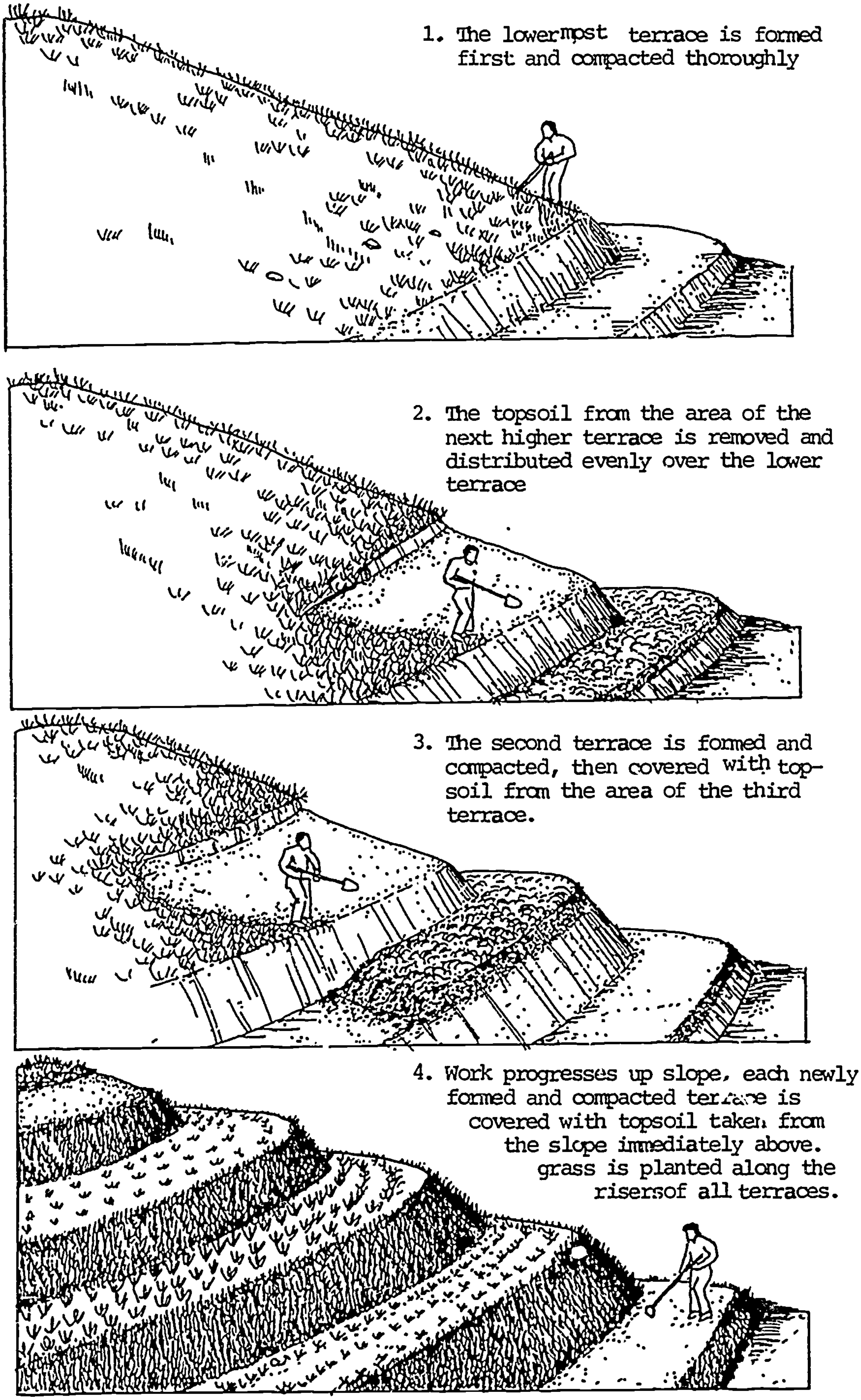
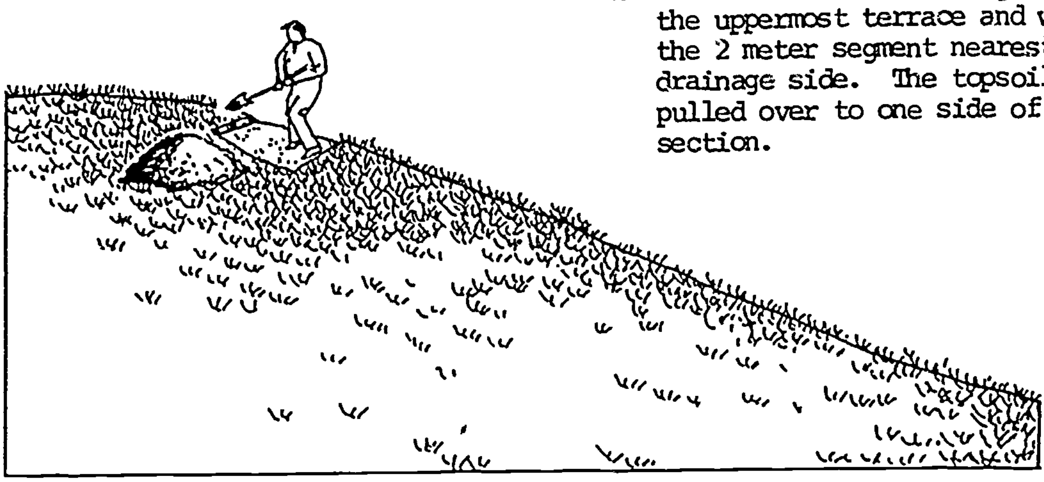
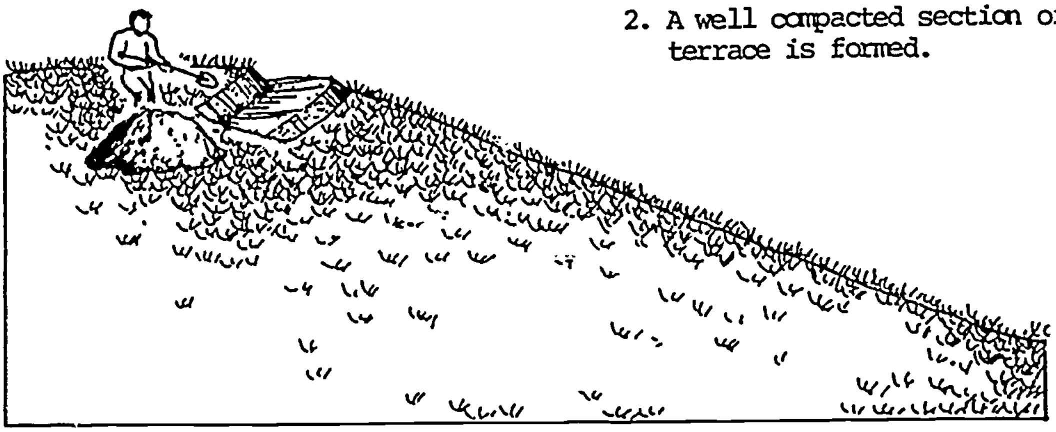


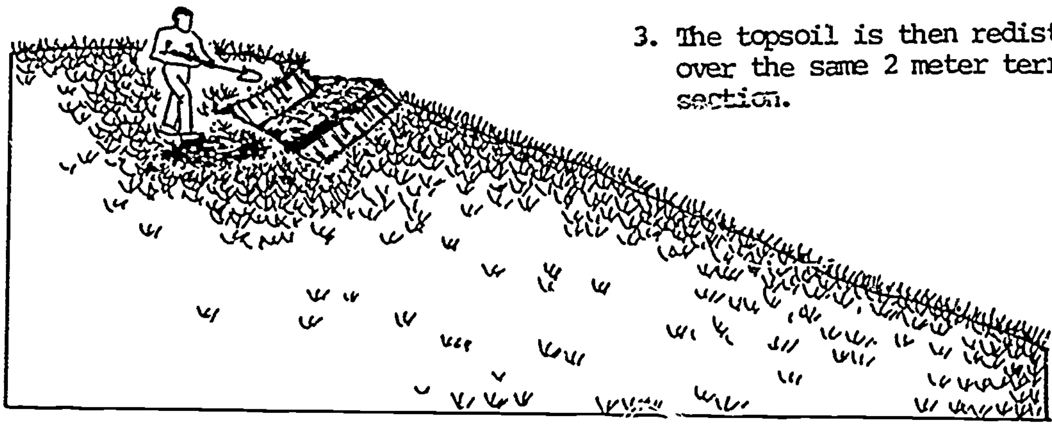
Fig. 17. Bench terrace construction sequence "A"



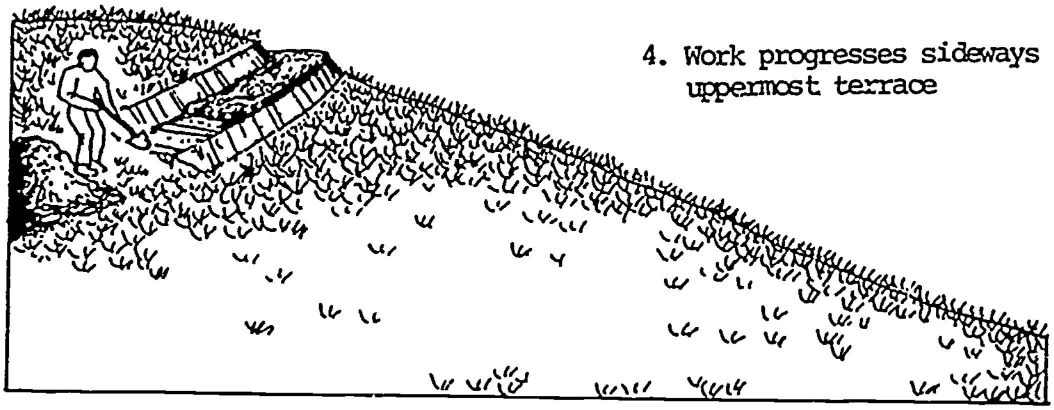
1. Terrace construction begins with the uppermost terrace and with the 2 meter segment nearest the drainage side. The topsoil is pulled over to one side of the section.



2. A well compacted section of the terrace is formed.

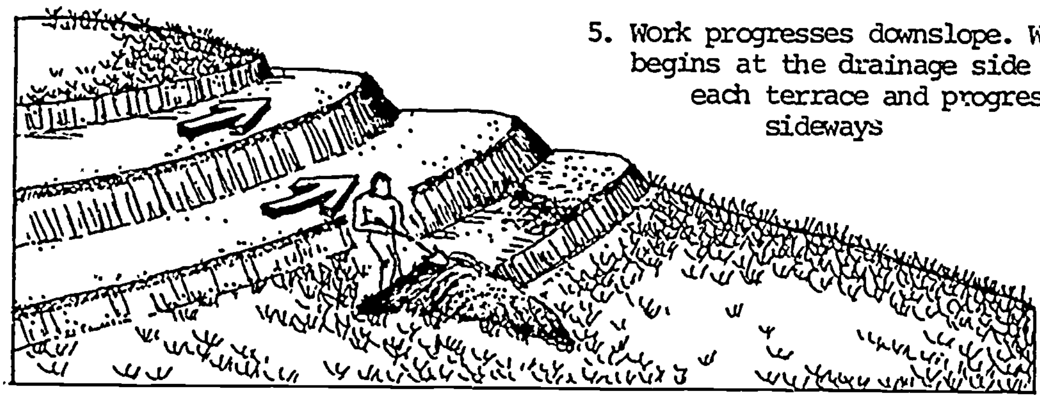


3. The topsoil is then redistributed over the same 2 meter terrace section.

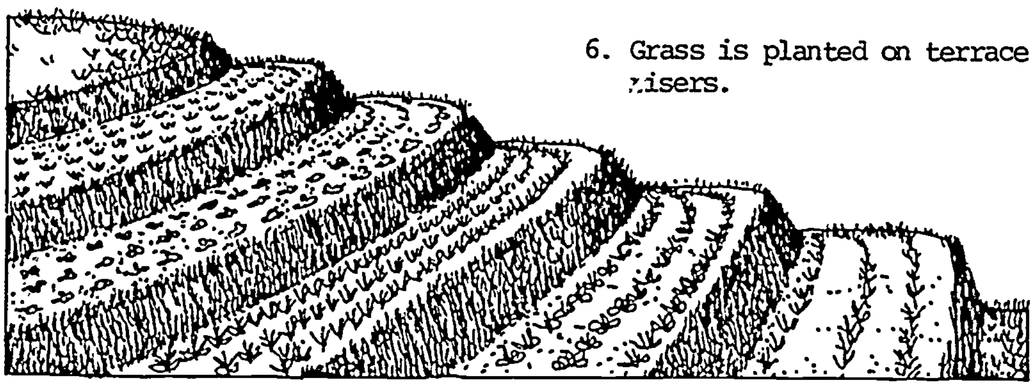


4. Work progresses sideways along the uppermost terrace

Fig.18. Bench terrace construction sequence "B"



5. Work progresses downslope. Work begins at the drainage side of each terrace and progresses sideways



6. Grass is planted on terrace risers.

Fig. 18. Bench terrace construction sequence "B"

5. Waterways from draining excess water for fields

In order to avoid problems of erosion at the site of emptying and to reduce the speed of watershed runoff following rains; soil conservation structures should be designed for water retention and infiltration whenever possible. If it is judged necessary to drain water from a field, special care should be taken in selecting areas in which to deposit all the diverted drainage water.

Possible drainage areas include pasture areas with a thick ground cover, orchards, or forested areas; where infiltration of the diverted water can probably occur with a minimum of erosion, especially if the water is spread over a large area. Existing waterways may also be used as drainage sites, although one should avoid exaggerating erosion problems by diverting water into areas of active gully formation. In all of these cases, if erosion problems are noted upon diverting runoff water, then a permanent, protected site for receiving runoff should be designed and constructed as soon as possible.

Protected drainageways can be formed by reshaping natural drainageways or digging artificial drainageways of a low, broad shape, protecting them from erosion by lining with rocks, planting grass, and/or placing drop structures or check dams periodically. (Fig. 19).

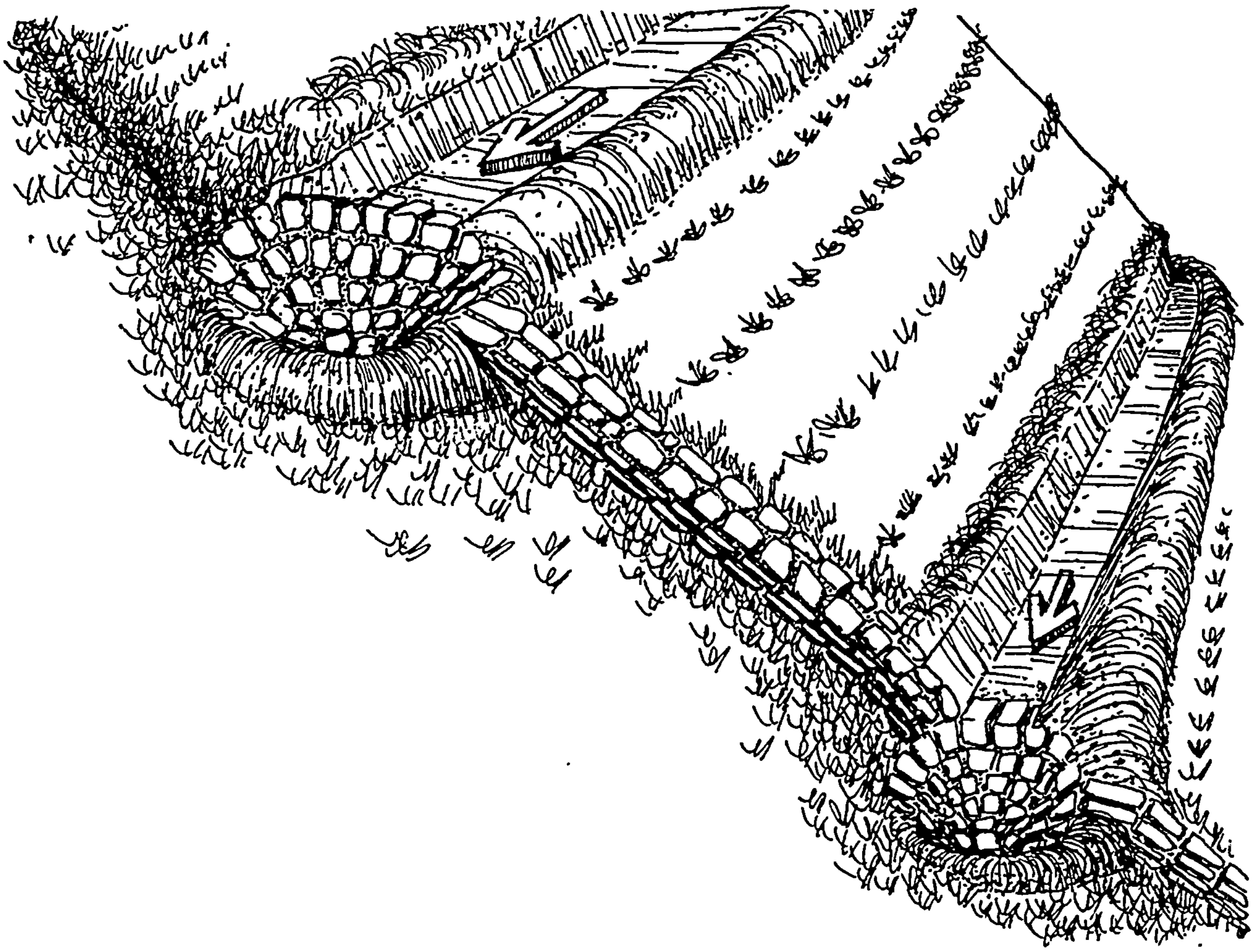


Fig. 19. Water drainageway protected against erosion by rock lining.

Waterway design specifications are given in more complete soil conservation guides (Hudson, 1981; Suarez Castro, 1980), allowing the construction of waterways of an adequate size and the selection of an adequate lining method based on local metereological conditions, soil properties, the area of land involved, land slope, and the type of protecting lining to be used. If sufficient data is available for the work area, such information can be useful in designing a drainageway of sufficient capacity, without over-designing it and involving excess work. If however, insufficient local data is available, or it is desired to teach farmers the conservation techniques without discouraging them with complicated tables or formulas, then the appropriate size can be estimated. Hudson (1981) mentions an extremely simplified method ignoring local climatic or edaphic factors: construction of a shallow (30 cm) drainageway measuring one meter wide for every hectare of land area in the drainage basin. While this is probably oversimplified, it does allow one to design drainages of probably adequate dimensions without having to deal with complicated methods.

When no appropriate drainage area is available around a field, then retention wells can be dug and water diverted into, and stored in them while it gradually enters the soil or evaporates. (Fig. 20)

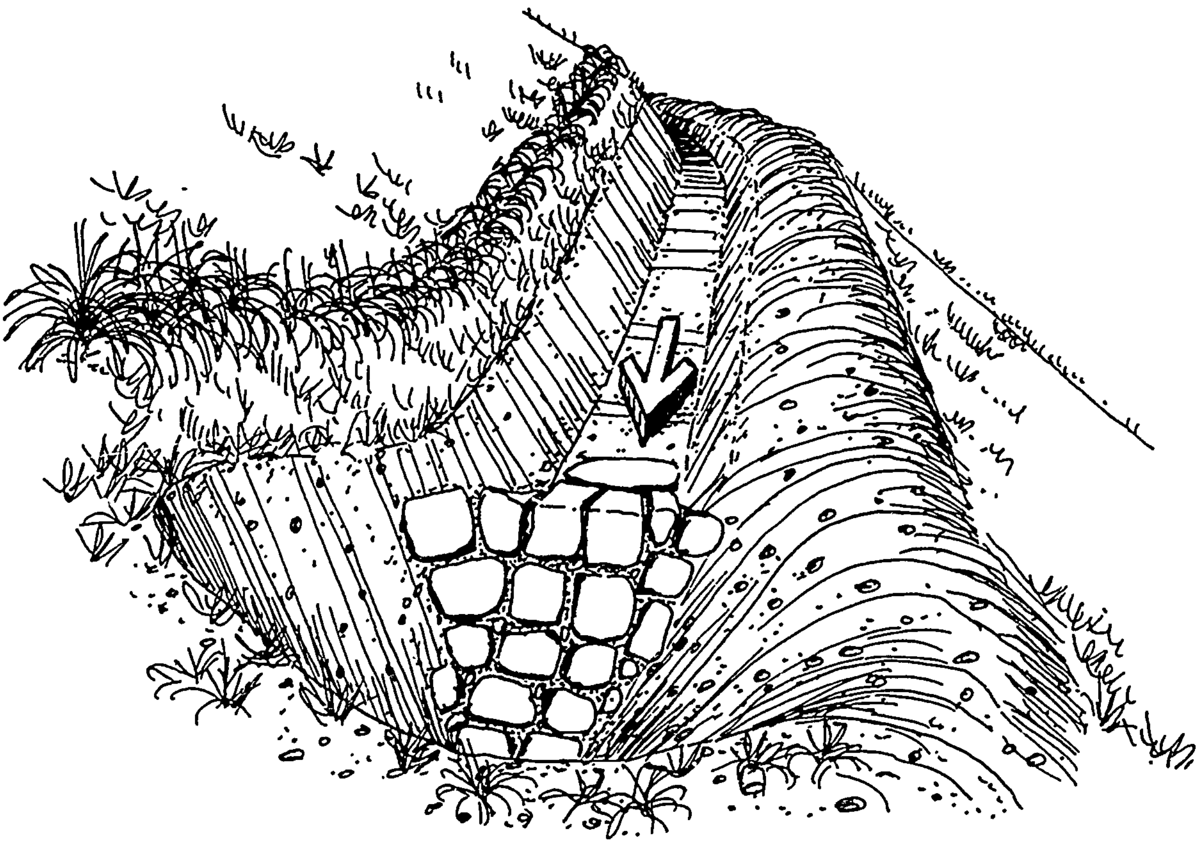


Fig. 20. Retention well as site for diverting runoff water.

Special care should be taken to have the waterways and retention wells completely constructed and well vegetated, if grass-lined, before diverting drainage water into them. This can be done by preparing them a season or two ahead of time or by preparing a temporary drainage site until the permanent one is ready.

6. Gully prevention and control

Gullies form whenever enough water flows in a concentrated area to remove the protecting vegetation and start digging in and carrying topsoil and eventually subsoil. Some gullies form naturally, others are the result of man's activity, such as redirecting water drainage patterns to protect roads, buildings, or fields. If not controlled, gullies tend to enlarge both in length and width. Both the soil destabilization and the large amounts of water running through them can eventually ruin fields, roads, or buildings located nearby. When using contour ditching or terracing techniques described in this guide, or carrying out other construction activities requiring the altering of drainage patterns, gully formation can result if the drainageway is not properly protected with rock or grass lining, with retention wells, or with a well vegetated area capable of absorbing the water safely (see previous section on "Waterways for draining excess water from fields").

Whatever the cause of gully formation, control measures should be undertaken as soon as possible to prevent further expansion, more damages, and an even more costly control due to the larger size in the future. The most effective control technique is to capture and redirect the source of water responsible. This can be done by means of a gently sloped (1%) contour ditch (Fig. 21). This is appropriate only when a suitable adjacent area is available for drainage or if retention wells can be dug to receive the water. Sometimes large livestock watering tanks are filled with water diverted from gullies.

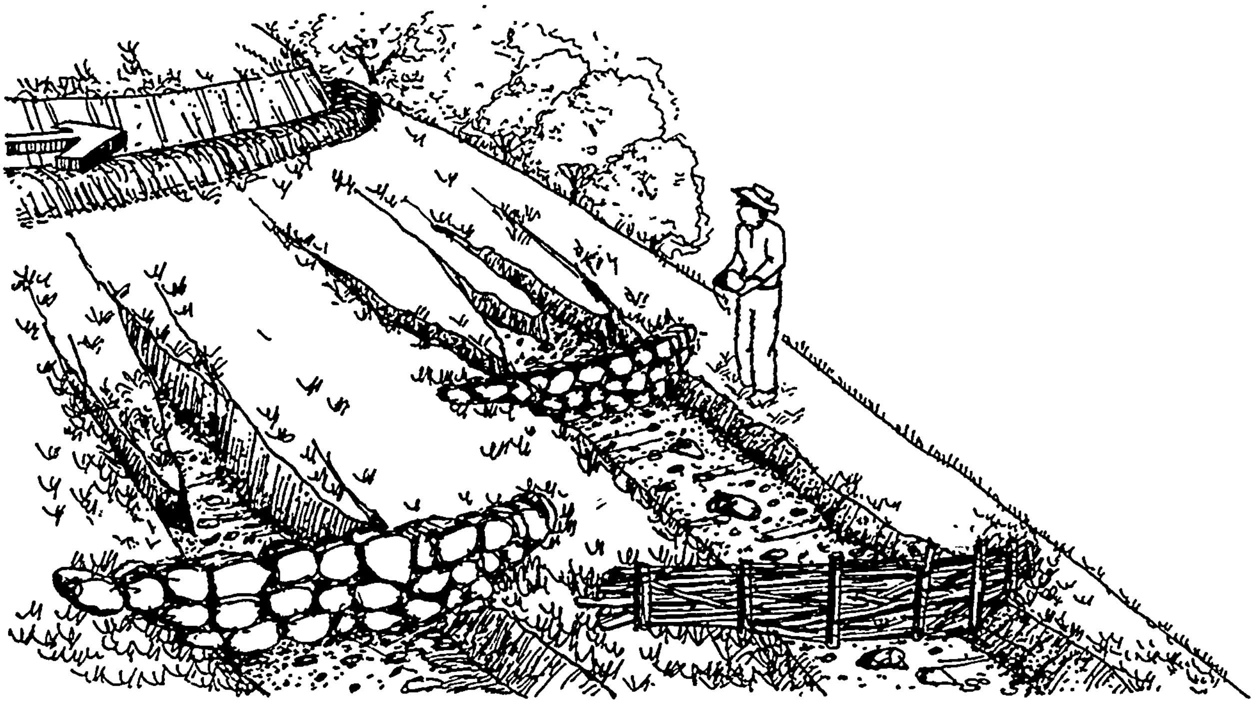


Fig. 21. Contour diversion ditch and check dams for use in gully control

Once water no longer enters the gully from above, the soil is often stabilized enough so that revegetation and filling in occur naturally without any further care. The gully, should however be protected from further damage due to cattle trampling and overgrazing, or cultivation.

When it is not appropriate to divert the incoming water by use of a contour ditch; if the gully soils, steep surfaces or climate do not permit natural recovery; or if a more rapid revegetation and refilling is desired, then check dams can be placed across the gully at frequent intervals (Fig.21). These can be made of rocks, wood, wire mesh, etc., and serve to reduce the velocity of any water still flowing and to trap soil particles helping to stabilize the gully so that revegetation can occur. The gully can also be more rapidly revegetated by planting trees, shrubs, or grasses, rather than waiting for natural colonization to take place.

C. STEPS TO FOLLOW IN DESIGNING A CONSERVATION PLAN

As in the implementation of any technology, the best results are usually obtained when each situation and pertinent details are carefully examined. The following list of steps has been found useful in both designing conservation plans and in teaching students about soil conservation.

a. Select lot, subdivide if necessary

b. Study lot, find out problems with respect to erosion, drainage, drought.

c. Select suitable drainage site if necessary

d. Decide on position of "linea madre"

e. Calculate slope

f. Select conservation strategy

g. Decide on appropriate distance between structures

h. Place marker stakes along the "linea madre" at the appropriate intervals

i. Survey and mark contour lines

j. Realign stakes along contour lines if necessary

k. Carry out conservation practice

l. Plant protective barriers if necessary

m. Plant desired crop(s) along the contour

n. Periodically review structures and carry out any needed maintenance practices.

a. Select lot, subdivide if necessary. (Fig. 22)

This step includes chosing the parcel of land to work on, noting if it should be subdivided into separate management units, each of which should be conserved separately following the rest of the steps. Subdividing the lot into separate units, each of which has a relatively uniform slope, allows the design of a conservation plan for each of the simpler units separately, rather than the difficult task of designing a single plan for a complicated, convoluted area. It should be noted here that most soil conservation techniques are only practical if maintained over a long period of time. Therefore the lot selected should be owned by or permanently available to the involved farmer.

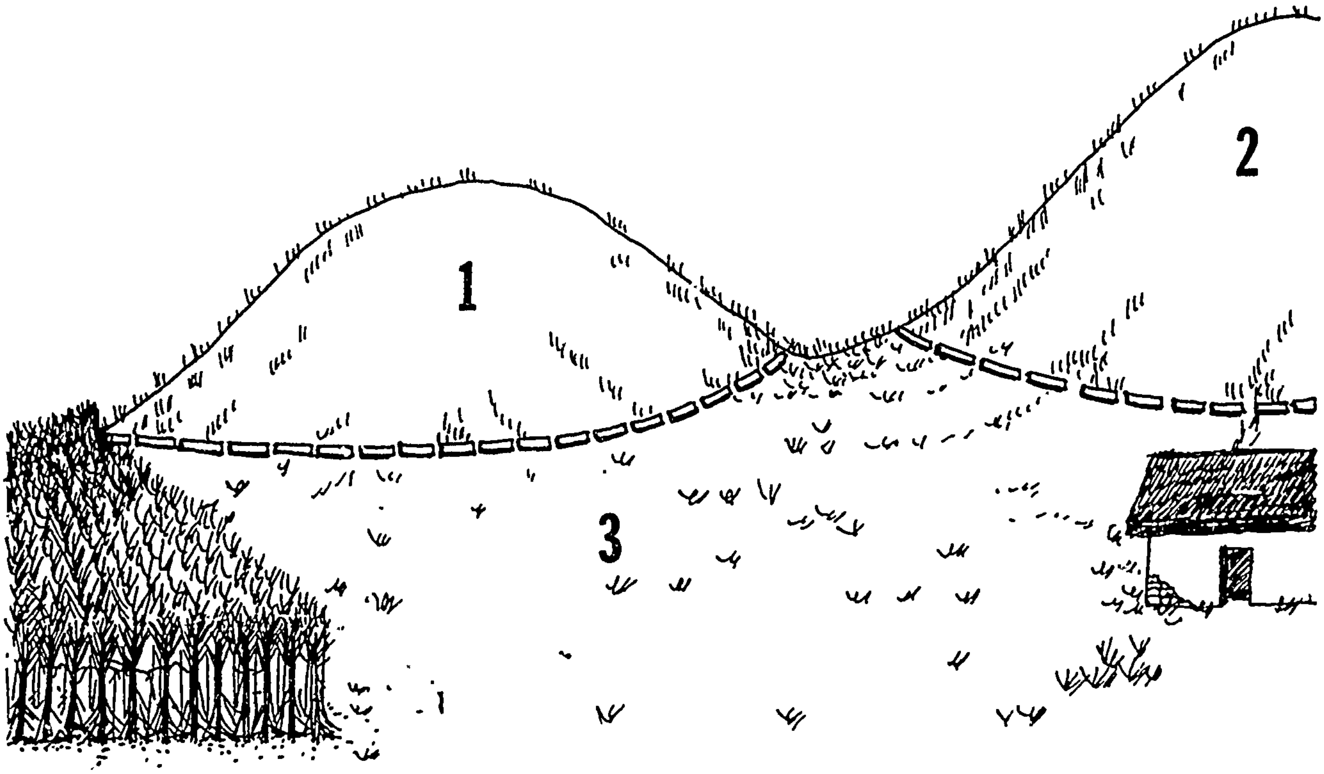


Fig. 22. Select and subdivide lot

b. Study lot, find out problems with respect to erosion, drainage, and drought. (Fig.23)

This involves asking the farmer about previous years problems; whether flooding or drought are serious problems, the point of entry of runoff water from upper slopes, and sites of serious erosion or drainage problems. It should also include investigating the types of crops, cultivation method used, fallow periods, pests or diseases, etc.

Example: In this cornfield, sections 1 and 2 are characterized by rapid rainfall runoff, causing small gullies to form. This is followed by excessive soil drying between rains. Section 3 on the other hand, is relatively level, but experiences flooding due to poor soil drainage and the runoff received from Sections 1 + 2.

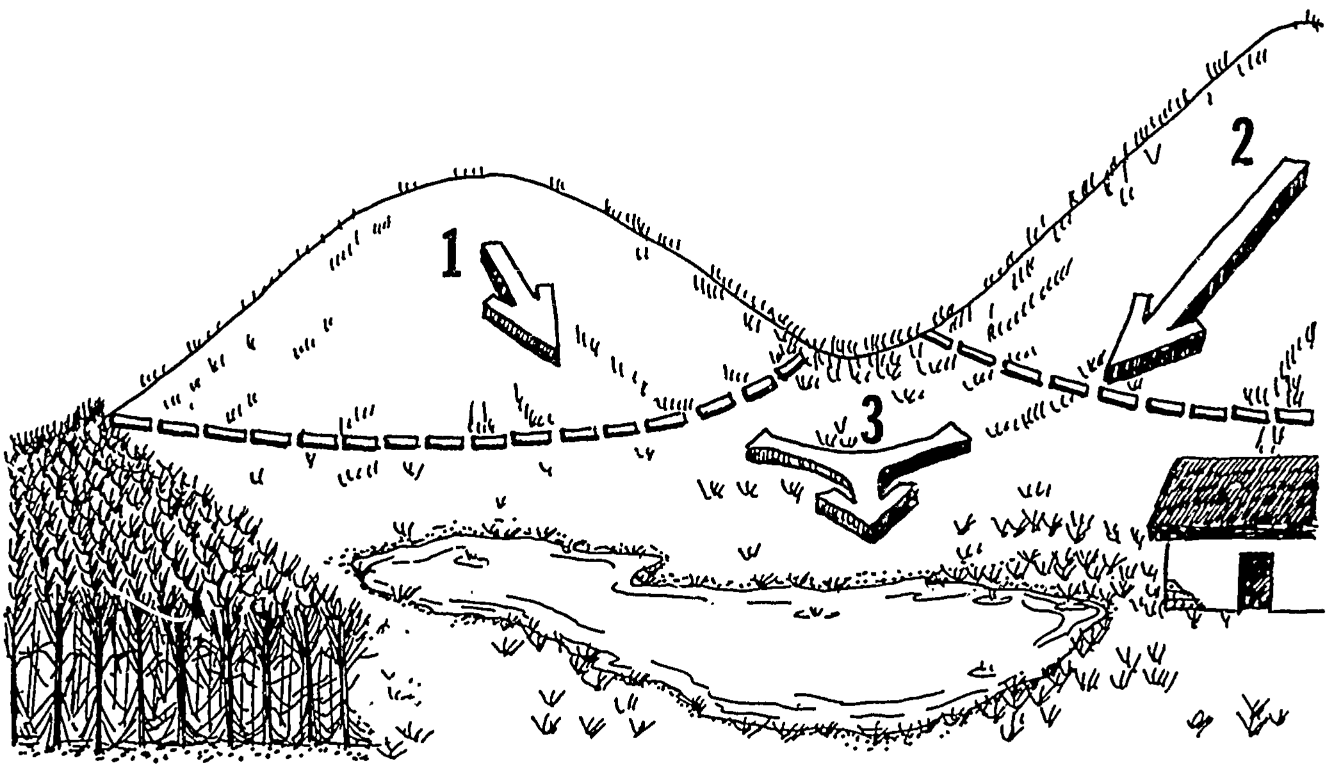


Fig. 23. Investigate erosion, drainage, and/or drought problems

c. Select suitable drainage site if necessary. (Fig. 24)

This is an often neglected step which can result in serious problems such as gully formation, flooded roads, or angry neighbors if not considered carefully. If ditches will be constructed to divert excesses of water from a lot, care must be taken to divert the water to a well-vegetated area, a retention well, or to a grass or rock lined waterway. In deciding where to divert excess water, one should also consider the postitions of neighboring fields, roads, or houses in order to avoid flooding these areas. If necessary, the construction of drainage ditches or terraces should be delayed until an adequate site for runoff water can be constructed and throughly protected against erosion. (See section on "Waterways for draining excess water from fields") Meanwhile, other conservation practices which do not result in concentrations of runoff water, such as the use of contour barriers, maintaining a dense ground cover, etc., can be employed.

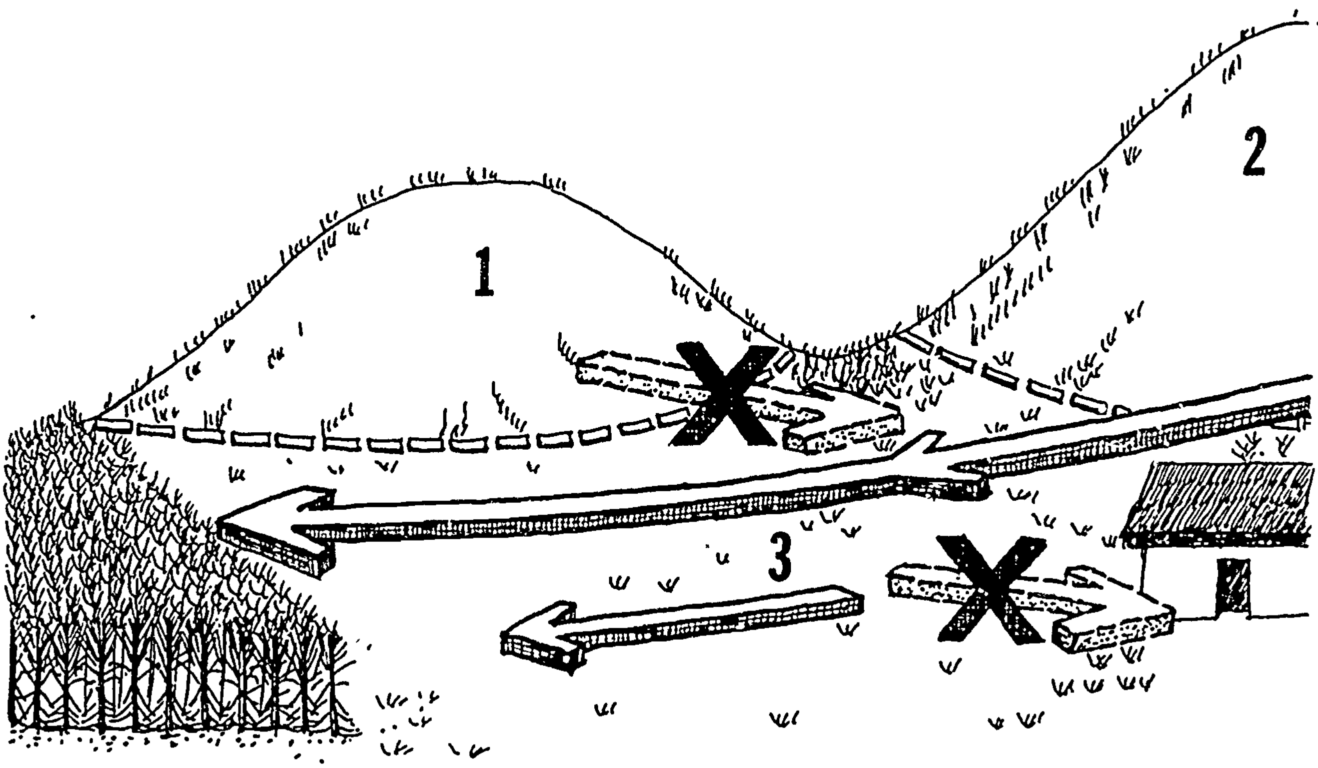


Fig. 24. Select suitable drainage site if necessary.

d. Decide on position of "linea madre". (Fig. 25)

This is the imaginary line which best represents the average slope on a unit of land. It will be used as the reference line from which to measure the distance between successive soil conservation structures. It should be positioned so that contour lines will be perpendicular to it.

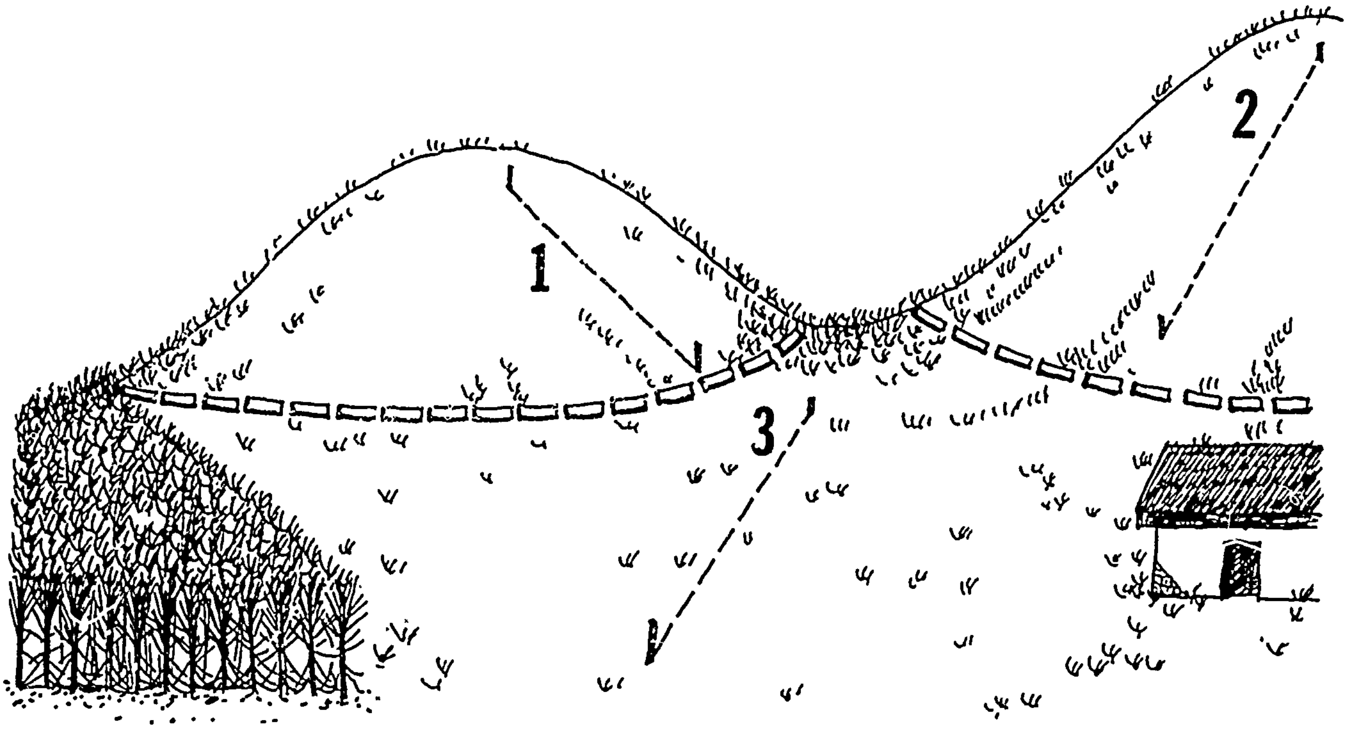
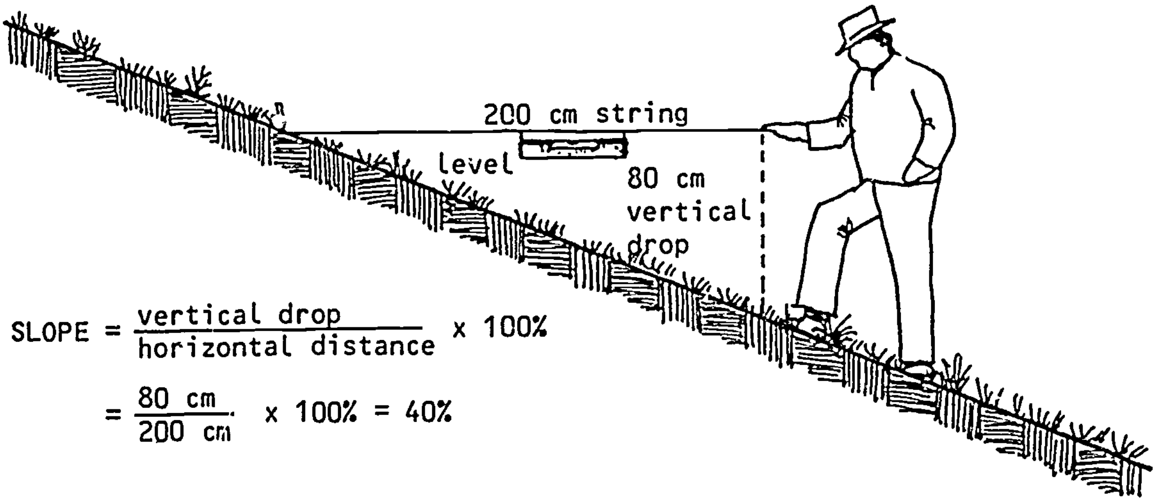


Fig. 25. Decide on position of "linea madre"

e. Calculate Slope. (Fig. 26)

The slope of the terrain should be measured at 5-10 randomly selected sites per hectare and then averaged. The slope can be measured using a string and a small line-level as illustrated, or by using an A-frame level. The slope of the terrain is important in planning soil conservation strategies. Ideally, flat or gently sloping areas should be used for the production of annual crops, while more steeply sloping areas (35% or more) should be used for perennial crops such as fruit trees or forage, and in very steeply sloping areas (50% or more) the natural vegetation should be maintained. The slope of the terrain is also used when deciding on the distance between successive contour structures, as described in other sections.



$$\text{SLOPE} = \frac{\text{vertical drop}}{\text{horizontal distance}} \times 100\%$$

$$= \frac{80\text{ cm}}{200\text{ cm}} \times 100\% = 40\%$$

Fig. 26. Calculate slope

f. Select conservation strategy

No strict guidelines are presented here for selecting soil conservation techniques due to the tremendous number of variables influencing the decision. However, the following points should be considered as the extensionist and the farmer(s) work out the most appropriate design for an area.

1. Identify resources and constraints which will affect the process. These include the availability of labor, rocks, and live barrier plants; presence of water sources for irrigation; the acceptability of a more long-term investment (perennial crop); the presence of cattle during the fallow period; etc.

2. Select as many complementary soil conservation techniques as possible which are appropriate to the desired cultivation system.

   EXAMPLE 1: Plant fruit trees on individual terraces protected by contour infiltration ditches and live barriers of king grass. Plant a green manure crop inbetween the trees and mulch around the tree bases.

   EXAMPLE 2: Intercrop corn and beans to form a dense ground cover. Construct contour discontinuous narrow terraces with a live barrier of Guatemala grass. Plant a green manure crop such as Velvet bean, during the fallow season. Plant fruit trees on the terraces.

3. Design all structures along carefully measured contour lines (Usually 0%-1% slope).

4. Carefully maintain all contour structures, protective barrier plantings, and drainageways to ensure proper functioning.

5. Review Table 6, "Advantages and disadvantages of different soil conservation techniques", and Appendix 2, "Dichotomous key to the selection of soil conservation practices".

TABLE 6

Advantages and Disadvantages of Different Soil Conservation Techniques

Technique	Advantages	Disadvantages
1. Protecting Native Vegetation	-avoids erosion and desertification -reserve for native flora and fauna	-often inapplicable due to previous land disturbance -unavailable for crop production
2. Reestablishing Native vegetation	-reestablishes vegetative canopy protecting soil and water resources -restores wildlife habitant -provides useful natural products: wood forage, medicines, etc.	-labor cost to plant and maintain, unless reestablishes naturally -unavailable for traditional crop production
3. Perennial Crop Cultivation Systems (Pasture, Fruit trees, Agroforestry systems)	-avoids annual soil disturbance -once established, low maintenance requirement to produce crop	-unavailable for annual crop production
4. Minimum tillage or mulching in annual crop cultivation systems	-protective ground cover reduces erosion -avoids some pest problems -mulching decreases weed growth -maintenance of soil fertility, structure and organic matter content	-possible pest refuges -possible weed competition -labor intensive -by itself does not control water runoff on sloped land
5. Crop rotation	-maintenance of soil fertility, structure, and organic matter content -breaks pest and disease cycles	-By itself does not control water runoff on sloped land -acceptable alternative crops must be available
6. Contour live barriers	-useful product (forage, fruit, wood) -decrease water velocity and trap soil particles -gradually form terraces behind barriers -little labor and only slight soil disturbance	-appropriate plant must be available -possible shading or root competition -do not stop flow of water -if incomplete germination, ineffective soil traps -may require fencing out of cattle -after planting, ineffective during first rains
7. Contour dead barriers (Rock walls)	-removing rocks makes tillage easier -decrease water velocity and trap soil particles -if sufficient height, form bench terraces as soil fills in	-labor cost -only where sufficient rocks -ineffective if soil fills in level with top -do not stop flow of water

TABLE 6. (Continued)

Techniques	Advantages	Disadvantages
7. Contour dead barriers (Continued)	-very little soil disturbance -if planned and constructed during fallow period, function for first rains of growing season	-may require fencing out of cattle
8. Contour planting beds and furrows	-series of barriers stop water flow -can be designed to drain or retain water or for furrow irrigation -avoid compaction of planting surface	-labor cost -extensive soil disturbance, susceptible to erosion on slopes unless protected by other structures
9. Contour ditches with protective barriers	-stop flow of water and soil particles -can drain or retain water -simple to design and build -barrier provides useful product	-labor cost to dig and maintain -disturb soil and drainage patterns, may lead to erosion if improperly designed or constructed, especially if draining water -may fill in if barrier not well established -require fencing out of cattle
10. Discontinuous Narrow terraces with protective barriers	-stop flow of water and soil particles -level platform for planting -can drain or retain water -barrier provides useful product -when well constructed require less maintenance than ditches	-labor cost -steeper slopes require deeper "cut", increasing labor -more complicated to build than ditches -disturb soil and drainage patterns, may lead to erosion if improperly designed or constructed, especially if draining water -may fill in if barrier not well established -riser may erode if not well compacted and covered with vegetation -require fencing out of cattle
11. Individual terraces with contour ditches or discontinuous narrow terraces	-level platforms for planting -stop flow of water and soil particles -barrier provides useful product	-labor cost -ditches or terraces must be well maintained to control water movement -may lead to erosion if not well compacted -only applicable for tree crops or agroforestry systems -require fencing out of cattle
12. Continuous bench terraces	-stop flow of water and soil particles -planting of all crops on level platforms -can drain or retain water or carry irrigation water -grass on risers useful as forage	-high construction cost -only practical where year round cultivation possible or where high value crop grown -on steep slopes or shallow soils, terrace width and useful planting space are very small -extensive soil disturbance, highly susceptible to erosion if not properly designed and constructed (must be well compacted with risers protected by vegetation) -require fencing out of cattle

g. Guidelines in determining the distance between soil conservation structures

The most simple rule to follow when placing a series of barriers or ditches in a field is that of locating one structure with every vertical drop of approximately 1.5 m. By standing at the site of one structure and sighting along an extended arm, one can determine the position of the next highest structure. (Fig.27)

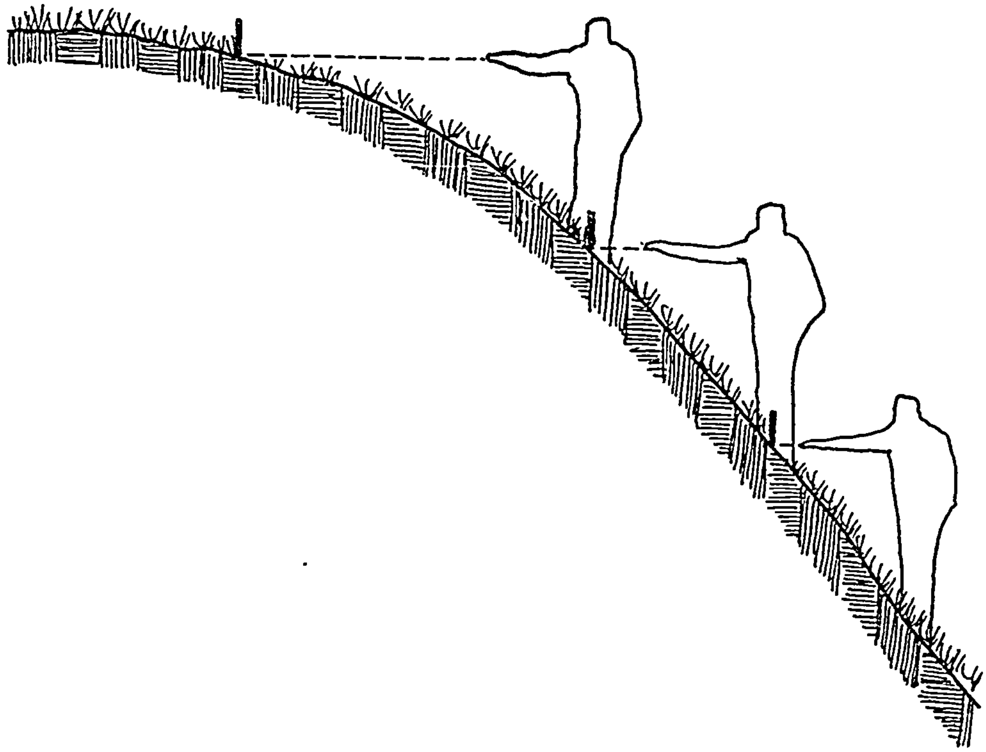


Fig. 27. Visual method for determining the distance between successive contour structures.

Technical tables prescribing distances based on the slope of the terrain should be used whenever possible to insure an optimum placement of structures. Simple tables are included in the section on "Soil Conservation and Water Management Practices" (Tables 2-5). Soil texture, soil structure, and rainfall intensity may also affect the optimum placement distance of structures, but for simplicity these affects are usually ignored. If the farmer(s) considers the amount of work required to place these structures excessive, then it may be necessary to limit the first seasons work to the placement of every other structure, planning to finish the work at a later date.

h. Place marker stakes along the "linea madre" at the appropriate intervals. (Fig. 28)

The first stake should be placed along the upper edge of the lot or at the highest convenient place where a structure will be located, subsequent stakes are placed below.

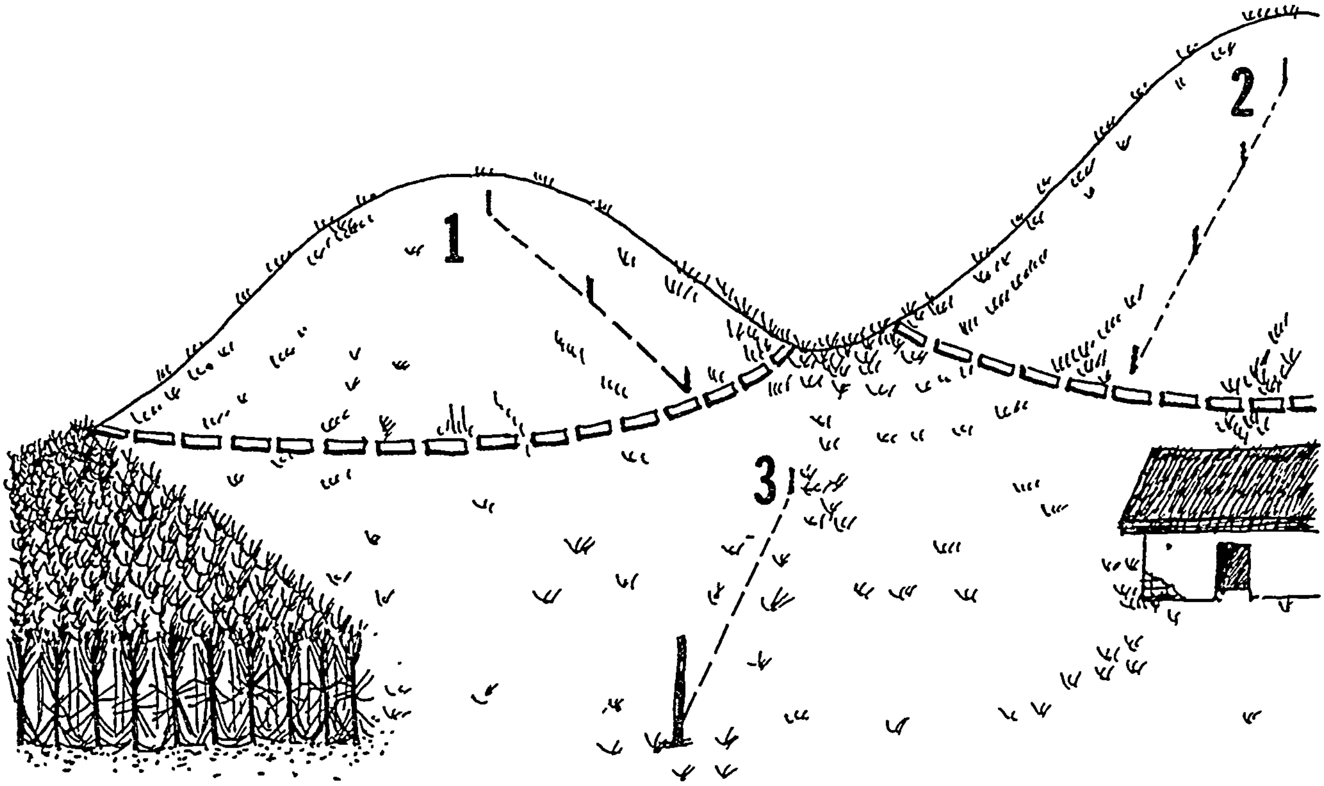


Fig. 28. Place marker stakes alcng the "linea madre" at the appropriate intervals.

i. Survey and Mark contour lines. (Fig. 29)

This can be done using an A-frame or other type of level. The construction of two types of levels is described in Appendix 4. Care should be taken to carefully calibrate the level and to orient it in the proper direction if surveying lines for drainage ditches.

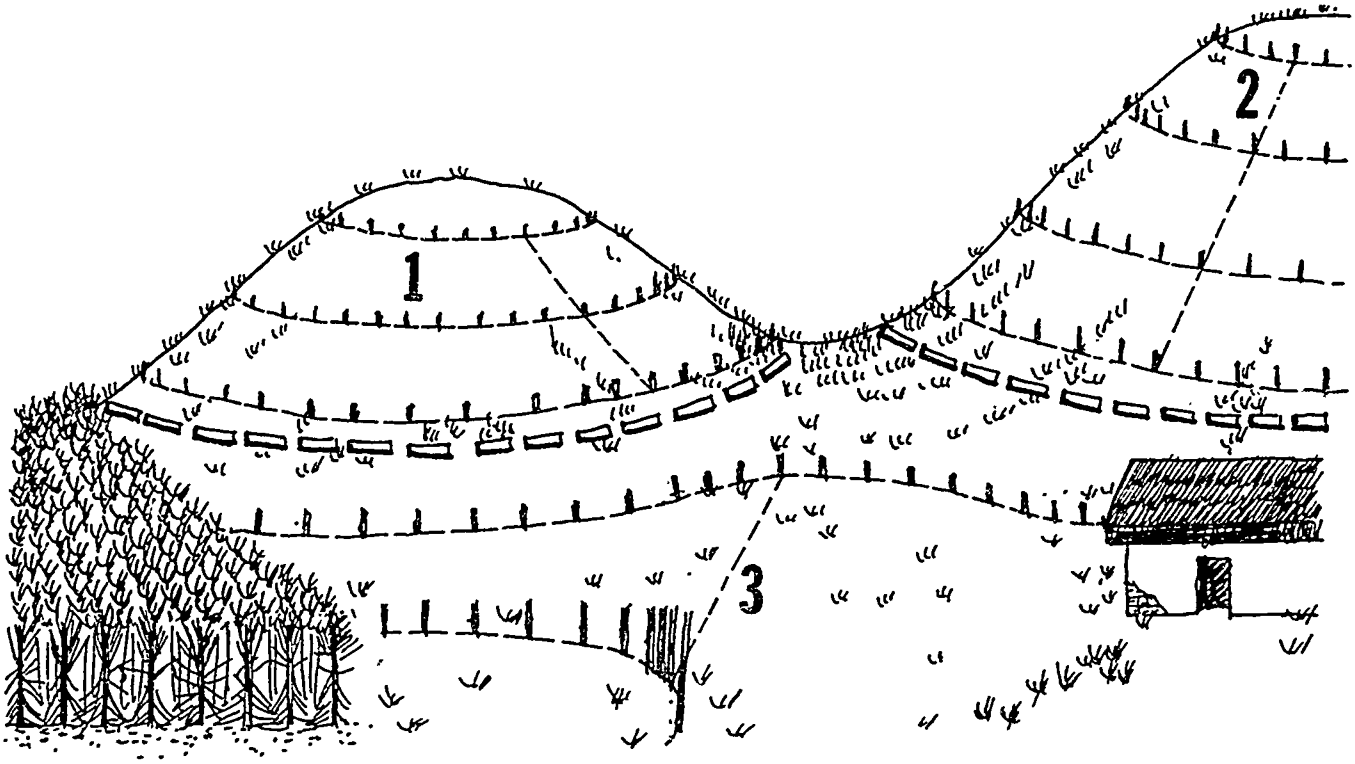


Fig. 29. Survey and Mark contour lines

j. Realign stakes along contour lines if necessary.

If the contour lines result in an extreme zig-zag pattern which may cause difficulties, for example, in plowing a plot, the lines may be straightened somewhat by slightly moving some of the stakes. It should be noted that realigning stakes means that they no longer lie along measured contour lines and that this will have to be corrected for if digging any sort of ditches todrain or retain water.

k. Carry out conservation practice(s). (Fig.30)

These are described in detail in the Section on "Soil Conservation Strategies" .

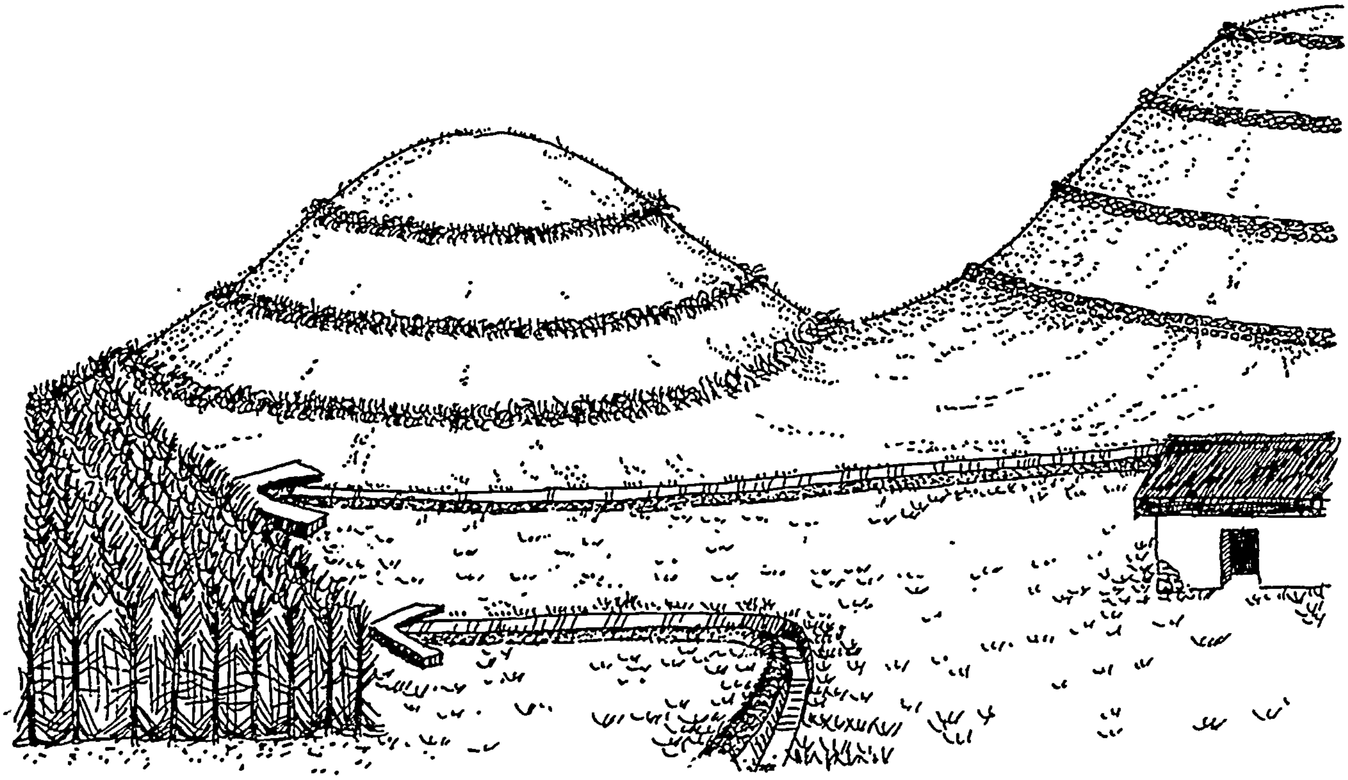


Fig. 30. Carry out conservation practices.

1. Plant protective barriers if necessary (Fig. 31)

If not protected by barriers; terraces, ditches, and drainages tend to fill in and cease to fulfill their function as conservation structures. A live barrier planted above these structures acts as a filter to keep soil particles from filling them in and lessens their maintenance requirements.

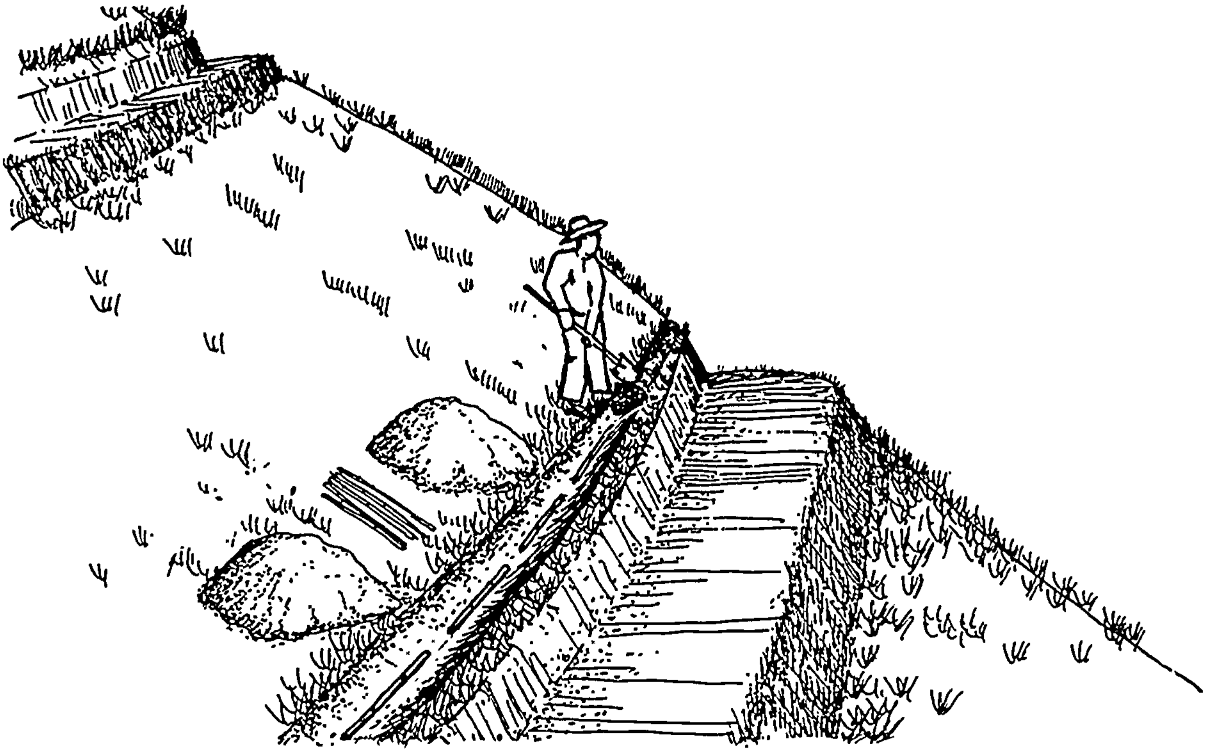


Fig. 31. Plant protective barriers

m. Plant desired crop(s) along the contour (Figs. 32,33)

Planting along the contour with closer spacing within rows and more distance between rows forms a partial live barrier with each crop furrow. Care should be taken to plant well selected seeds in order to ensure a more complete germination, and ultimately a more protective ground cover.

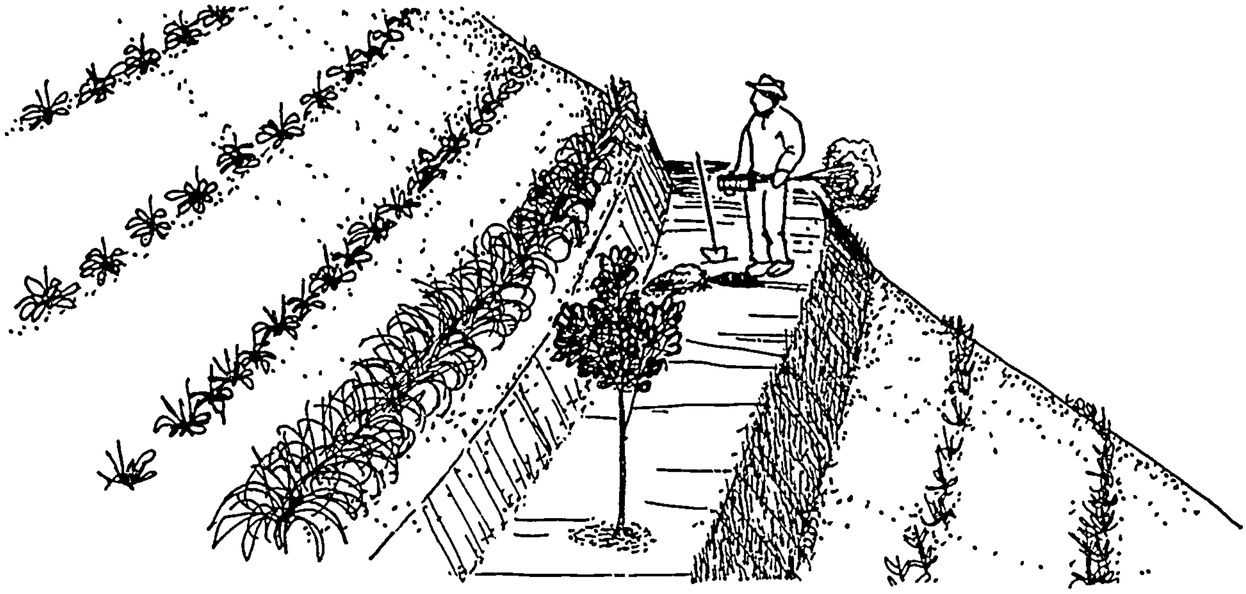


Fig. 32. Plant desired crop(s) along the contour

On irregular terrain with varying slope, successive contour lines will not be parallel. Point rows are used in the wider intervals in order to fill up the land space and still maintain contour oriented furrows. (Fig.33)

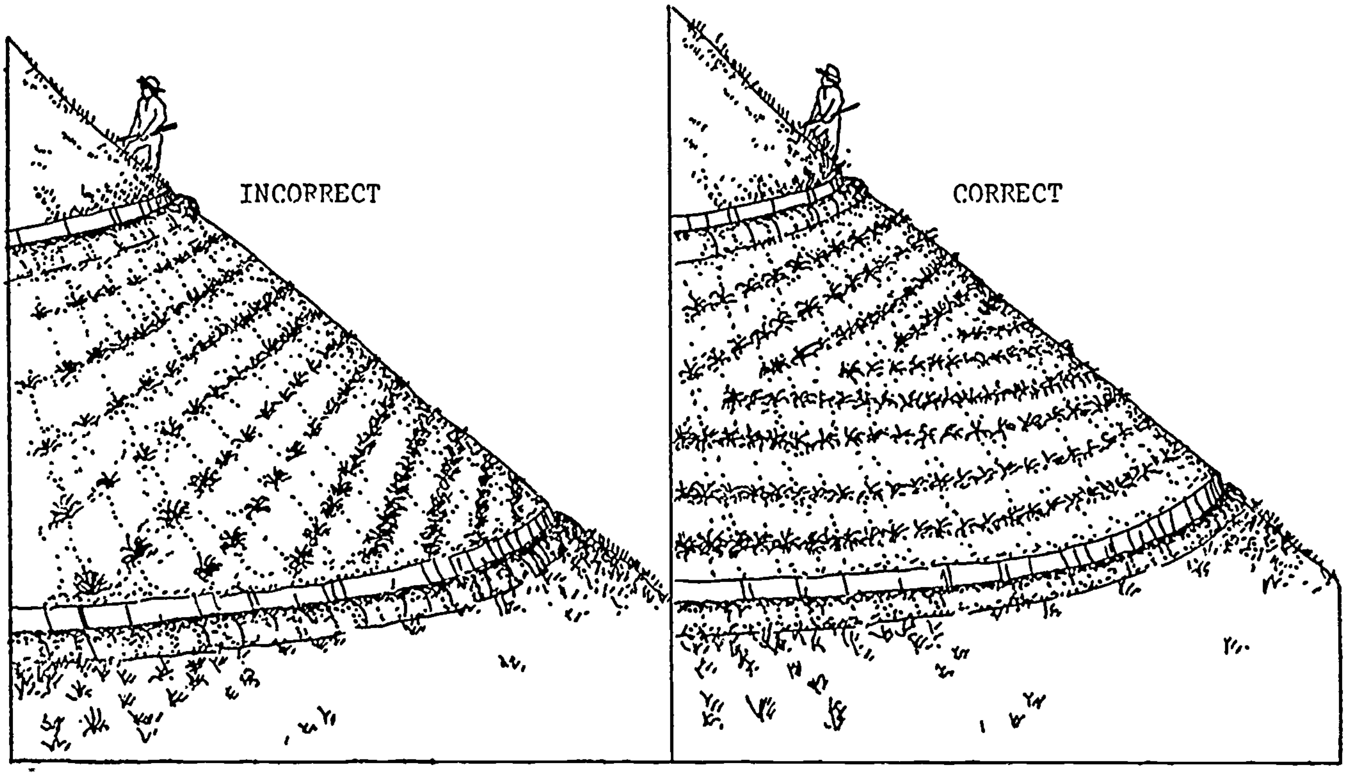


Fig. 33. Use of point rows to maintain contour furrow orientation on irregular terrain.

n. Periodically review structures and carry out any needed maintenance practices. (Fig.34)

Common maintenance practices include replanting of open spaces in live barriers, restacking or adding rocks to rock wall barriers, cleaning soil from ditches, and replanting grass on terrace walls.

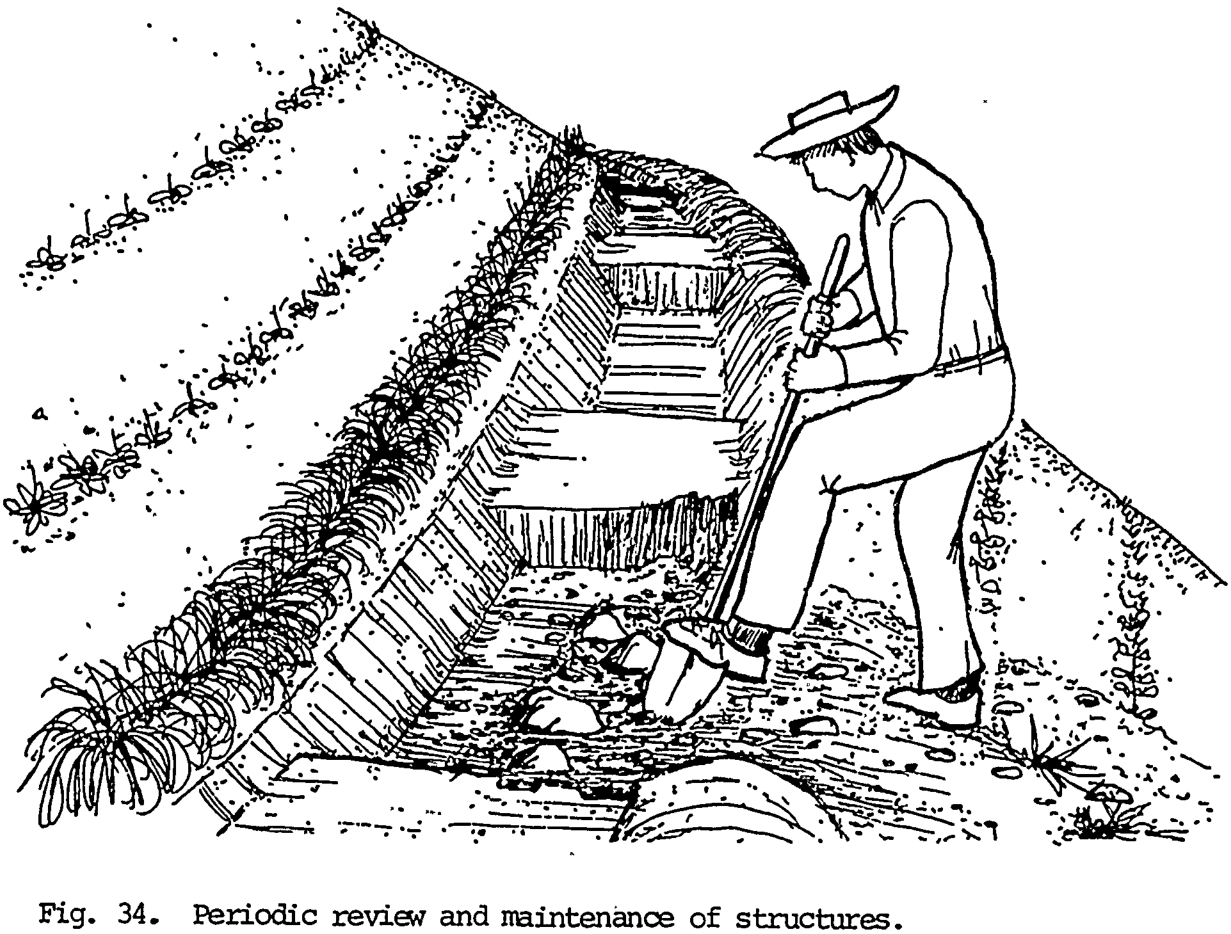


Fig. 34. Periodic review and maintenance of structures.

IV. SOIL FERTILITY AND ITS MAINTENANCE

A. INTRODUCTION TO SOIL FERTILITY

Soil fertility is a concept based on the amounts of essential nutrients available to the plants. The plant nutrients involved are classified as macronutrients such as nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S); or as micronutrients such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), and molybdenum (Mo). The amount of each of these nutrients is not the only factor in determining whether there are nutrient shortages. Soil pH (acidity) is also important because under certain pH conditions, nutrients form insoluble compounds which are unavailable to be taken up by plant roots. A shortage of any of these elements in the soil can slow crop development and reduce yields, something which extensionists should consider when working with farmers to improve crop production.

In practice, soil fertility is determined by collecting a soil sample and submitting it for chemical analysis. Since a small sample will be used to infer the characteristics of an entire field, care should be taken to ensure that the sample represents as accurately as possible the conditions present in the plot.

Sampling may be done with a soil probe or a shovel, being careful to exclude the surface litter layer and sampling at a depth of approximately 1"-8" below the surface. Subsamples should be taken from random positions throughout the entire field (10-20 per hectare) and mixed throughly in a bucket or bag. From this mix, a 1-2 lb. sample is air dried, labelled, and submitted to a laboratory for analysis. A highly variable field should be subdivided into fairly uniform sections which should each be treated separately, as they may have very different soil characteristics. Samples may be analyzed with portable field test kits, if available, but it is also advisable to familiarize farmers with the laboratory facilities available to them. In Honduras, for example, soil analyses are performed at the laboratories of Recursos Naturales in Tegucigalpa, Standard Fruit Company in La Ceiba, the Escuela de Agricultura Panamericana in El Zamorano Valley and FHIA in La Lima, Cortes. The most common soil analyses performed are those for nitrogen, phosphorous, potassium and pH, which generally are most important in limiting crop yields. If crops do not appear to respond to changes in these factors then perhaps a deficiency of another nutrient is involved and a more detailed analysis can be carried out.

B. Chemical Fertilizers

A simple way to correct some soil nutrient deficiencies is through the application of chemical fertilizers. Their expense may discourage or limit their use in many areas, but applications in small experimental plots are useful in demostrating their potential and evaluating their feasibility in a specific area.

The most commonly encountered fertilizer are in granular form and contain compouds of nitrogen, phosphorous, potassium, or a mixture of the above. The type of fertilizer and the amount to be used generally are given as recommendations accompanying soil analysis results. In applying such fertilizers, it is important to calculate from the given recommendation the quantity that must be applied in each furrow or at each plant to avoid under- or over-applications.

The timing of fertilizers applications is also important. For example in corn, a formula containing both phosphorous and nitrogen is usually recommended at planting time, while nitrogen only, in the form of urea, is usually recommended about one month after planting. Since fertilizer recommendations vary widely based on the soils and the crop to be planted, specifics concerning their use are not discussed here. A more thorough discussion of fertilizer use is given in "Soils, Crops, and Fertilizer Use: A Guide for Peace Corps Volunteers".

Extensionists should familiarize themselves with the fertilization practices in use throughout their zone in order to determine if changes in the types, amounts, and/or timing of fertilizer applications would be beneficial.

C. Organic Fertilizers

The use of organic fertilizers is another method of correcting soil nutrient deficiencies. Although it is more labor intensive than chemical fertilization, it has the advantages of being locally produced; maintaining soil humidity; improving soil organic matter content, structure and texture; adding a better balance of micronutrients, and improving the soils capacity to hold nutrients. Organic fertilizer refers to a number of types of organic matter which can be incorporated into soils or left as a mulch on the surface. This may be as simple as incorporating crop residues or manure, or as complex as planting a green manure crop, making compost, or raising earthworms to produce materials which will be incorporated into the soil at some later date.

A traditional practice in many areas is the burning of residues left when initially clearing land or after a harvest. Although some nutrients are returned to the soil in the ashes, much of the organic matter and nitrogen present are lost to the air. This loss of organic matter affects all of the just mentioned soil properties.

1. Manures and Crop Residues

The incorporation of crop residues or animal manure is a means of utilizing often wasted by products of the agricultural process. They are relatively simple operations, requiring only the labor to collect and spread manure or crop residues before carrying out the normal tillage operations.

2. Green Manure Crops

Green manure crops are nitrogen-fixing plants which can be grown for a period of time and then turned into the soil as a source of nitrogen and organic matter. If cultivated for seed production and only turned into soil after dried, they contain little nitrogen and provide mostly organic matter. Table 7 lists a variety of possible green manure crops, all different types of legumes.

In crowded areas, where there is pressure to produce as much as possible on every cleared land space, it is often difficult to convince farmers to take land out of food production in order to plant a green manure crop. Fortunately, there are alternatives which allow for the production of green manures without affecting the normal crop production cycle. Some species, such as Gandul, Rice Bean, and others (especially if planted sparsely) can be grown in intercropping systems with other crops (Fig. 35). In these cases, the green manure crop can be useful as a ground cover or living mulch which reduces rainfall impact and thereby soil erosion; in reducing weed growth; and in providing useful organic matter, seeds, or forage.

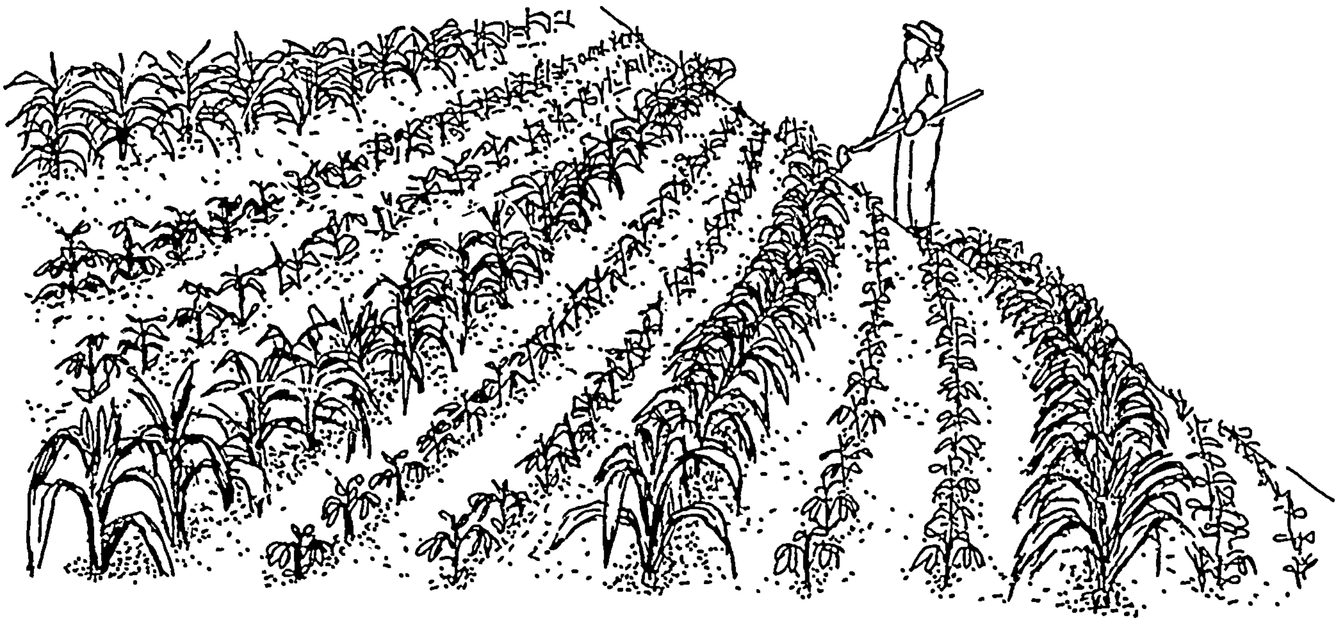


Fig. 35. Green manure used as intercropped living mulch.

Some species, such as Kudzu and Velvet Bean are such agressively climbing, densely foliaged plants, that they are best grown alone. These can be planted during fallow years and then incorporated into the soil. Velvet Bean and other drought tolerant species can even be planted near the end of the growing season, allowed to grow during the dry season, finally to be incorporated into the soil prior to the next planting season.

Fig. 36. Green manure used as fallow season ground cover.

Tree species, such as leucaena, madre de cacao and gualiqueme, can be planted along the edges or in contour strips in the middle of fields, providing a source of leaf material for green manure or forage, and also firewood. (Fig.37)

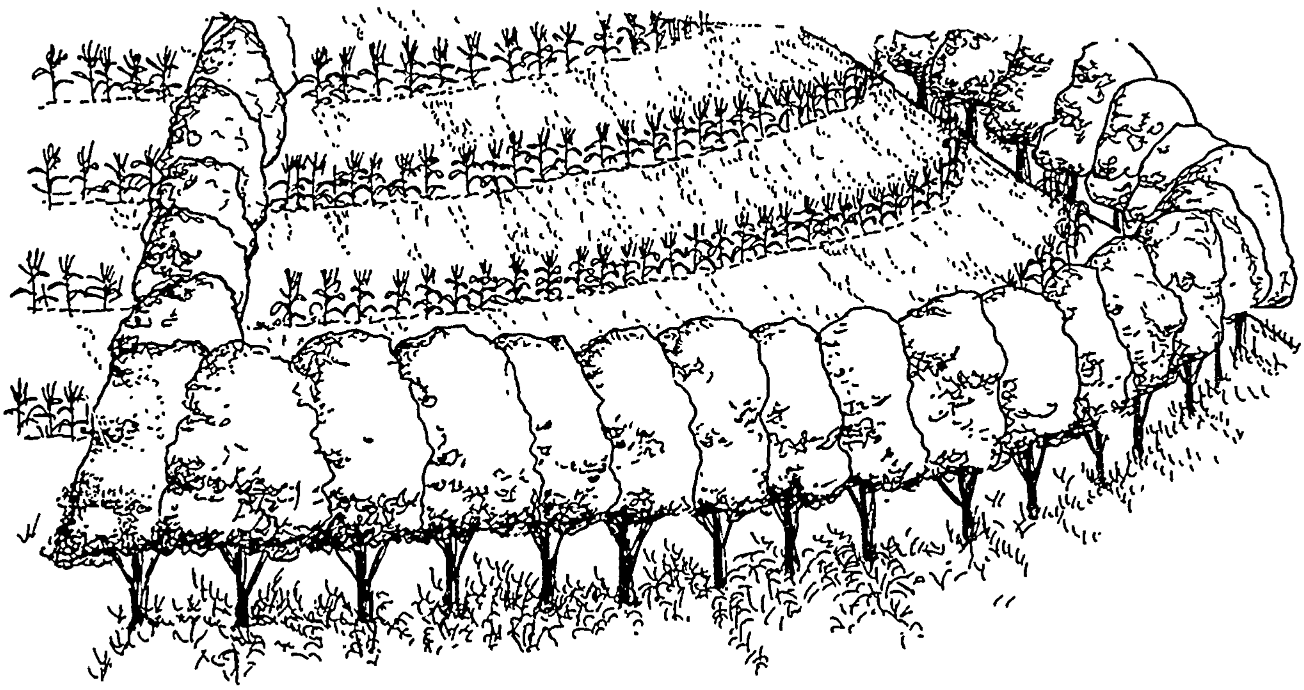


Fig.37. Green manure tree species used in agroforestry system.

TABLE 7

SOME SUGGESTED GREEN MANURE CROPS

Common Name(s)	Scientific Name	Other Uses	Cultivation	Environment	Comments
Bean, Frijol	Phaseolus Vulgaris	Food-pods, seeds	Traditional methods	Many varieties exist for almost all areas	Already commonly cultivated, but often residues not incorporated
Butterfly Pea Frijol Mariposa	Clitoria ternata	Food-young pods, forage, ornamental	2-3 seeds spaced 20-25 cm x 50-100 cm	Warm, sunny, well-drained areas, 380-4200 mm rain, wide pH tolerance 0-1600 m elev.	Perennial, often poor germination, some disease problem in humid areas
Canavalia, Jackbean Canavalia Roja, Swordbean	Canavalia ensiformis Canavalia gladiata	Food-pods, seeds, forage	1 Seed 50 cm X 50-100 cm (50-70 kg/ha)	Warm, temperate to hot tropical rainforest areas, sun or shade, 700-4200 mm rain, 0-1800 elev.	Climbing Annual; usually produces seed in 3-4 months; toxic before cooking; mature seeds must be boiled, changing water and peeling seed coat
Clover	Trifolium spp.	Forage	From seed	Developed in temperature climates, possible value in tropical areas	
Cowpea	Vigna unguiculata	Food-seeds forage	For seed: 2 seeds 10-15cm x 40cm. (25-45 kg/ha) For forage: 2 seeds 8-10cm x 30-40 cm	Warm climate, 0-900m elev.; Moderately drought tolerant, various soils	Annual, fairly erect, susceptible to insect damage
Crown vetch	Coronilla varia	Forage	From Seed	developed in temperature climates promising for cool highland tropics	

TABLE 7 (continued)

Common Name(s)	Scientific Name	Other Uses	Cultivation	Environment	Comments
Gandul, Pigeon Pea	Cajanus cajan	Food-seeds Forage Shade living fences	For Seed: 3 seeds 30 cm x 30-40 cm (15-45 kg/ha) For forage: 1 seed 5 cm x 30-40 cm	Warm climates, drought tolerant, various soils	Woody, erect perennial (5yrs.), difficult to chop when full grown, 1.5-4 m tall
Gualiqueme, Pita	Erythrina spp.	Ornamental forage, firewood	From seed		Fast growing tree, resprouts from base when cut
Kudzu	Pueraria spp.	Forage	From seed		Very aggressive climbing vine, problem weed in some areas
Lablab Bean, Dolichos	Lablab purpureus	Food-pod, seeds leaves, sprouts	2 seeds 10-15cm x 50-60 cm (50-70 kg/ha)	Many varieties exist for almost all climates all elevations	Perennial (2-3 yrs)
Leucaena	Leucaena leucocephala	Forage, firewood	From seed	Hot areas, drought tolerant, lower elev. (up to 500-1000 m)	Fast-growing tree, resprouts from base when cut
Madre de Cacao Madriago	Gliricidia sepium	Forage	From seed or stakes	Hot areas, 0-1600 m elev. 1500-2300 mm rain	Fast-growing tree resprouts from base when cut
Rice Bean, Frijol Arroz	Vigna umbellata	Food-seeds, pods, leaves, seedlings forage	3 seeds, 20 cm x 50 cm. (60-80 kg/ha)	Hot, humid areas, 0-1500 m elev.	Mature seeds in as little as 60 days
Tepary Bean	Phaseolus acutifolius	Food-seeds Forage	1-2 seeds 8cm x 50-90 cm Seed production: (11-17 kg/ha) Hay producción: (60 kg/ha)	Arid and semiarid regions	Grows poorly in humid areas, salt sensitive, susceptible to insect damage but disease-resistant, annual, semi-erect, 50 cm tall
Velvet Bean, Frijol terciopelo	Mucuna pruriens	Food-pods, leaves, seeds when toasted are like coffee Forage	2 seeds 40 cm x 50-100 cm (10-45 kg/ha)	Drought tolerant, 0-2000m elev. 380-3100mm rain, soil variable	Trailing or climbing vine, produces great amounts of foliage, can smother weeds, variable life span (up to 6-8 months to produce seed, use staking when growing for seed

FROM: Tropical Legumes, Resources for the Future, N.A.S. 1979 and Handbook of Legumes of World Economic Importance Duke, 1981

3. Composting

Composting is a very labor intensive technique which involves mixing plant residues, manure, soil, and water.

Decomposition takes place over a period of 1-4 months, reducing the mix to rich humus to be incorporated into the soil. Because of the bulkiness of the material and the labor involved, it is most practical in small, intensively worked vegetable plots, but it can also be used as a fertilizer in large fields of any crop if labor is available.

A compost pile can be composed of almost any organic materials: weeds, banana stalks, sawdust, coffee pulp, corn or bean residues,etc. Manure from cows, horses, chickens or rabbits, is usually used as a nitrogen source. Ashes, eggshells, and sometimes chemical fertilizers may also be added. Composting can be done with a careful eye on the chemical composition of the ingredients in order to provide an optimum ratio of the elements necessary for the bacterial and fungal decomposers, or by just throwing a little of everything in. Some farmers feel more confortable with the casual, less exact approach, while others may be more intrigued by a more scientific attitude towards the process.

Some of the types of compost piles are the square aboveground compost pile, the underground compost pile, the volcano compost pile, and the contour compost ditch. (Fig.38)

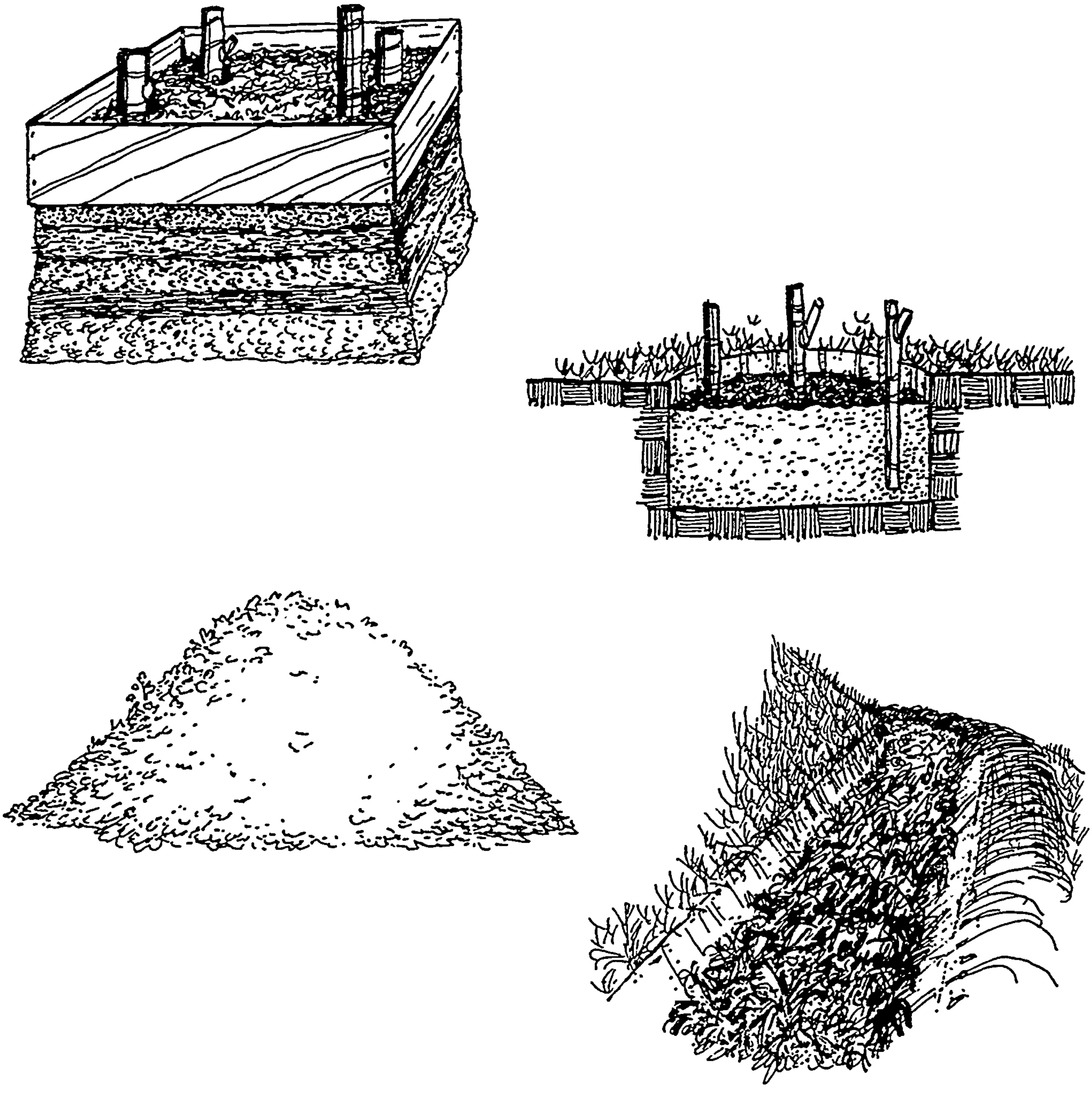


Fig. 38. Various types of compost piles

The square aboveground compost pile is tightly compacted into a wooden frame and is often composed of three 12" layers. Each of the layers is made up of 9" of plant materials (both fresh and dry), 2" of manure, and 1" of black soil. Each layer is throughly compacted and saturated with water during construction. Posts are placed vertically in the pile (one per m^2) to be removed after construction to serve as air vents. These piles are generally turned once a month and are ready to use in 3-4 monts.

The underground compost pile is similar, but is constructed inside a hole dug in the ground (50-100 cm deep). This can be very effective in arid zones or during the dry season, as it reduces the amount of evaporation from the compost.

Another type of compost pile is the volcano compost pile, which is simply a mound composed of the same materials (plant matter, manure, soil and water). This type of compost pile can be used to decompose materials much more rapidly (1-2 months), if it is turned and mixed frequently (every 2-3 days).

The contour ditch compost method simply involves filling contour ditches with crop residues, manure, and soil. This method can be very effective on a large scale, leaving the materials undisturbed to gradually decompose over the course of the year. Drainage ditches, should not be filled with compost during rainy periods. Contour retention ditches can be filled however, as the piled up compost serves as a spongy retaining material. The water collected also speeds up the decomposition process.

3. Composting with Earthworms

Another method of improving soil chemical and physical properties is the raising of earthworms and the subsequent incorporation of both the worms and the rich soil they are raised in. Earthworms can be raised in a mixture of the same materials used in composting,but in this case they are not compacted. They are also often enclosed in a box or tub to prevent their escaping. If a variety such as "Red Wiggler" (Coqueta Roja) is available, it may be much more active and reproduce much faster than other native types of earthworms. The earthworms ingest organic matter, digest it, and leave behind a mineral rich feces which provides nutrients for plant growth. Also by physically passing through the soil, earthworms increase soil aeration and drainage.

For a more thorough discussion of composting and of composting with earthworms, see The Encyclopedia of Organic Gardening (Rodale, 1971).

V. EXTENSION METHODOLOGY

The technical aspects of solving problems associated with hillside farmland are much more simple and straightforward than the extension work aspects. Even though there are many variables which affect land use decisions, there are many more which affect the receptivity of farmers in an area to an individual Peace Corps Volunteer's promotional efforts. The possibilities available to a Peace Corps agricultural extensionist are almost endless. Presented here are some sample work activities, guidelines for evaluating work, motivating techniques, and types of groups with which one may be involved.

Volunteers should find this material useful in designing and carrying out a more realistic and successful work plan. For additional references on the extension process in rural areas see: Two Ears of Corn, Bunch 1985; Communication Strategies, Lionberger and Gwin, 1982; Communication Innovations, Rogers and Shoemaker, 1971; Agricultural Extension, Gibbons and Schroeder, 1983 and Helping Health Workers Learn, Werner and Bower, 1982.

A. Timetable of Events Associated with a "Typical" Two Year Peace Corps Volunteer Service.

1st. 3 - 6 months:

1) Settling in, find and fix up living quarters, meet people and make friends

2) Work on learning local customs and language

3) Get acquainted with work zone, communities, climate, topography, crops, technology, problems.

4) Identify at least three communities as target areas.

5) Plant demonstration lot perhaps in the form of a vegetable garden in each of the communities; in own yard, with interested collaborator, or as a school project. Use live barriers, contour ditches, contour planting beds, organic compost, etc.

6) Become familiar with host agency, its resources, and its policies, meet fellow extensionists.

7) Develop reputation as interested, responsible extensionist by attending host agency and community meetings, visiting farmers and keeping informed of seasonal agricultural

activities. Help out farmers in areas other than soil conservation (pest control, fertilizer applications, cooperative management, etc.).

8) Formation of ideas about best potential work strategies.

9) Look for interested collaborators to try out soil conservation techniques.

2nd 3- 6 months:

1) Maintain reputation as interested, responsible extensionist.

2) Discuss specific possibilities for soil conservation work with farmers and other extensionists,begin promotional efforts such as introductory lectures, simple demostrations (See Apendix 5), field trips, etc.

3) Select at least one collaborator from each of the communities and help them carry out some conservation practices on their own land.

4) Encourage these initial collaborators to help seek out and teach other interested farmers.

3rd. 3- 6 months:

1) Keep demonstration lots well maintained, use them to motivate and to teach others to start more demonstration lots.

2) Keep records to measure success of demonstration lots, publicize successes in the communities involved and at host agency meetings.

3) Make sure host agency extensionists, collaborators and other interested farmers understand techniques used; plan more formal courses, demonstrations, or field trips.

4) Constantly be on the lookout for new collaborators, have the initial collaborators help organize interested farmers into groups to receive visits and demonstrations at regularly scheduled times. Encourage initial collaborators to work as volunteer extensionists with other interested farmers.

4th 3- 6 months:

1) Work with larger number of collaborators

2) Organize farmers so that future extensionists will already have distinct groups to visit.

3) Make sure farmers and other host agency extensionists are well-trained to be able to continue designing and building soil conservation structures.

4) Publicize work based on records kept; publicize at agency and community meetings: local, regional or national fairs; radio, newspapers.

5) Train incoming Peace Crops Volunteers.

Depending on the area, the receptivity of the people, the number of growing seasons per year, etc., this may already be the end of the two year period. If work has proceeded rapidly, all this may have taken as little as one year. In case any time remains, it can be spent trying additional soil conservation techniques (remember that different techniques reinforce each other when combined); helping develop the farmers into more stable, better organized groups; giving more formal training courses for both farmers and extensionists; expanding the work to other communities; or working on another aspect of agricultural development, such as youth organizations, improving marketing, crop diversification, etc.

B. Guidelines for Evaluating Extension Work

1) Guidelines for evaluating soil conservation techniques used: If records are kept, then a comparison of budgets and crop yields can be made (See Appendix 3). This type of record can be very important in convincing farmers or other extensionists to try similar techniques in another area. Records can also be used to evaluate which techniques are most appropriate or which are inappropriate to the area. Remember, however, many of the benefits of using soil conservation techniques are long-term and may not show a dramatic improvement when using short-term observations to evaluate the techniques.

2) Guidelines for evaluating the extension methodology used: Again records should be kept following the growth of a program. This is often measured in terms of number of people or landarea involved in the program. Extensionists should realize that a large program is not necessarily more desirable than a slow starting, steadily growing one. Finding farmers genuinely interested in carrying out soil conservation practices is difficult (especially the first

one). It is reasonable to expect slow acceptance of the techniques at first. Each farmer adopting soil conservation techniques may lead to one or two additional farmers adopting the techniques during the next planting season. Assuming two additional highly motivated new collaborators for every current collaborator, the following growth sequence can be generated:

1	(+2) = 3	(+6) = 9	(+18)=27	(+54)+81	(+162)=243
First planting season	Second planting saason	third planting season	fourth planting season	fifth planting season	sixth planting season

This growth sequence may represent anywhere from two to six years, depending on the climate and the crops involved.

If there is only one planting season per year (an arid zone without irrigation or crops such as coffee, fruit trees), after two years the volunteer is at the point with 3 collaborators. It is important that these 3 people be well trained and highly motivated and that other local extensionists are convinced of the value of the work so that it can keep expanding in the area.

In this case, since such a small number of collaborators are involved, the volunteer should attempt to visit several communities so that each one can initiate this growth sequence of adopting soil conservation techniques at the same time. For example: if this can be carried out in four communities then 12 collaborators rather than only 3, are involved.

If there are two planting seasons per year (moderate climate where a system such as successive corn and bean plantings are practiced), after two years the volunteer may be at the point where 9 or 27 collaborators are involved. If working in 3 separate communities, 27-81 people could be involved. Any of these is enough so that time will be saved teaching in groups. These teaching groups can be the basis for organizing interested farmers into agricultural committees or cooperatives at a future time. These groups will also form a nucleus of people for future extensionists to visit, reducing much of the time spent in initially getting introduced to a community and discovering interested farmers. This larger involvement also merits bringing in outsiders for field trips to see the variety of work being done and its acceptability to the community. This helps motivate the innovative farmers, making them feel they are doing something important and worthy of respect, and also motivates the visitors to try the techniques in other areas. At this time, the program can also serve as a model for other extensionists to follow.

If there are three or four planting seasons per year (year-round cultivation possible because of climate or availability of irrigation water), after two years the volunteer may be at the point with 27, 81 or 243 collaborators, depending on the speed in getting started. Enough collaborators are now involved that the formation of groups is essential if attention is to be given to all, especially if working with more than one community. These large groups can be powerful forces, making it much easier to attract government aid in the form of courses or loans, and in meriting regional or national publicity for soil conservation techniques. The area can now serve as a good model for other agricultural extensionists or development agencies. The group oriented nature may involve changing the work strategy, focusing more on training people in management and organization to stabilize and strengthen the groups, rather than strictly focusing on training in agricultural techniques.

From this growth sequence, one can see that even though growth starts very slow, if it can be maintained at a steady rate, it is soon growing so fast that one extensionist can hardly keep up with it. Essential to the process however, is quality and success, especially in the initial period, in order for the techniques to appear acceptable and attractive to farmers.

C. Extension Techniques

A soil conservation extension program almost always faces a challenge initially to generate awareness that soil erosion is a major problem that merits dealing with. Often farmers do not perceive deforestation or environmental degradation as problems, and may attribute poor production to other factors (lack of credit to buy fertilizers, quality of seed available, lack of modern farm machinery, etc.). One of the first goals of any extensionist, therefore, should be to change some of the attitudes farmers may have and introduce some of the following ideas: The importance in an increasingly crowded society of permanently cultivating the same plots of land while maintaining others in an undisturbed state to protect water sources and wildlife, the simplicity of adopting soil conservation techniques, and the advantages of labor intensive improvements as compared to capital intensive (buying fertilizers, improved seeds, farm machinery) improvements. Only upon generating genuine interest in soil conservation techniques can an extensionist expect farmers to be willing to try out and to care for, any new types of structures or planting systems introduced.

Several methods are available to extensionists attempting to change farmers' attitudes and generate interest in new techniques. Some of the common ones are informal discussions, lectures, films or filmstrips, classroom demonstrations, demonstration lots, field trips, visits from farmers already using the techniques, financial incentives, and soil conservation courses.

Informal discussions with farmers can be one of the extensionist's most effective techniques, especially in more isolated communities and where people may be unaccustomed to receiving courses, attending meetings, or receiving visits from extensionists. Informal discussions provide an opportunity to make friends, to have people understand what to expect of the extension program, and to discuss ideas in an informal setting. Friends made in this manner, often turn out to be the first interested collaborators in an area.

More formal presentations such as lectures, films and filmstrips, and classroom demonstrations (see Appendix 5) made to a group of people, allow for the presentation of more information to more people and the use of visual aids to make some of the ideas clearer. They have the disadvantage, however, of requiring people to attend a meeting at a fixed time, something people may be unaccustomed to or very reluctant to do. These types of presentations are probably most effective when several individuals have already expressed an interest during informal discussions. In communities where people are not accustomed to receiving formal presentations, the format and content of the lecture, film, or demonstration should be designed carefully to ensure that the people attending understand how this will relate to their own farm work.

Demonstration lots are small plantings, carefully prepared and cared for, that demonstrate some or all of the techniques which are to be promoted in an area. "Seeing is believing", and that is the main advantage of this technique. People are given a concrete example, so that when an extensionist talks about digging ditches in the middle of a corn field, planting in contour curves, or using organic fertilizer, farmers will have a clearer concept of what these terms are describing. They also provide a local trial to evaluate the appropriateness of the techniques under local conditions.

Field trips to, or visits from farmers already using soil conservation techniques provide an opportunity to evaluate what is being done in other areas and to consider their appropriateness in the new area. These are especially valuable if there is a chance to discuss the new techniques directly with the farmers involved. This will permit a more thorough consideration of time and labor involved and the rewards to be expected. Agricultural extensionists should encourage their collaborators to seek out and share their experiences with other farmers in the area. Extensionists might even consider making a "moral contract" with collaborators, requiring them to teach two additional farmers, who in turn will each promise to teach two more farmers. etc. In this way the number of farmers learning and using the techniques increases more and more rapidly with time. The extensionist should be aware that if the model area or farmer has received any special attention or aid to carry out the work, this may be interpreted as a prerequisite to the success of the technique.

Financial incentives (credit, seed, fertilizer, food-for-work, etc.) are available from many national and international agencies interested in rural development projects. These often are available only for groups of farmers. They can be used to attract participants to a project designed, for example, to bring people together for formal classroom sessions where new techniques are described, followed by carrying out the practices on their own land. In this process, the involved farmers receive benefits from increased production and a longer useful life of their fields. In Appendix 3, an extension program is described in which fifty farmers were involved in such a project. If carried out throughout a region or country, these types of projects can benefit the economy because of greater self-sufficiency in production and can reduce migration to urban areas and avoid often destabilizing political pressures for rapid land reform measures. This method has the advantages of attracting a larger number of people to be trained during the extension program and the more immediate achievement of economic benefits to a larger number of people. A pos " le disadvantage of this strategy is that it may overlook t ; importance of future acceptance of soil conservation techniques by farmers not involved initially. If the same motivating benefits are not available to other farmers, they may not feel that th. soil conservation work by itself is worthwhile. Depending on the receptivity and the subsequent extension methodology followed, however, this may not present a problem. In fact, the more immediate high visibility of such a program may allow a great increase in the effectiveness of a Peace Corps Volunteer during a two year service. The high visibility of such a large project could also be important in providing a site for field trips to motivate or train other farmers and extensionists, and a basis for publicizing the sucess of soil conservation techniques on a regional, national, or international level.

Soil conservation courses allow extensionists to teach a variety of techniques to farmers, more than they may be able to learn by doing their own field work. It should be remembered however, that many people are unaccustomed to learning in a classroom format, and that the courses should involve as much practical fieldwork as possible. Courses are probably most effective in training extension workers, or once several farmers in an area have already tried some soil conservation techniques on their own fields and seem receptive to learning more.

D. Working With Groups

As an extension program gets under way in a community and starts growing, it becomes more and more necessary for the extensionists to work with groups as time may not always be available for individual visits.

If working in communities with no organized groups, extensionists are faced with the task of initiating groups with which to work. It is not unusual for community members to be resistant to the idea of joining such a group. For many reasons (a tradition of working alone, local feuds or jealousies, suspicion of unwanted economic or political committments, etc.), this may be one of the extensionists' most difficult tasks. Dealing with and overcoming this reluctance is an individual matter and every extensionist works things out uniquely. It takes time and communication to develop a relationship that both the community members and the extensionist are comfortable with. Other people, including other agricultural extensionists, nurses, or school teachers, who have had experience working with similar community groups, may have very useful suggestions in these matters.

Although presenting new information to farmers is more efficient on a group than on an individual basis, this may not be so for actual field work. The extensionist must evaluate each community to decide if it is more appropriate to carry out demonstrations on individually or group tended lots. In group cultivated lots, the work and risks are shared, lessening the burden of any individual. However, sometimes farmers are less conscientious about caring for a crop if it is not theirs individually. In such cases, it may be most appropriate for the extensionist to present new information or techniques at a central location, such as a school, a small parcel of land made available to the extensionist for this purpose, or by rotating among the individual parcels of the group members. After the group presentation, the extensionist should, whenever possible, discuss or visit each individual's parcel to ensure that the technique will be put into practice correctly.

Organized groups of farmers can also be very important in the continued spread of the introduced techniques after the extensionist leaves. They increase communication among farmers, they serve as support groups for innovative farmers, they are more likely to attract the attention of other extension programs, and in some cases they manage credit funds which make it easier for farmers to implement certain technologies. Extensionists should familiarize themselves with the different types of groups so that they have a better understanding of how groups may facilitate, or possibly inhibit, the continuance of their promotional effort.

Agriculture committees are often informal assemblages of people drawn to meetings by a common interest in agricultural innovations. These committees are very flexible and allow for the admission of new members or formation of new committes upon demand. This can be a big advantage when working in a new area as the success of the program will probably attract more and more interested persons. This flexibility also leads to the danger of dissolving rapidly if interest wanes, especially if dominated by only one or two enthusiastic members. The members of these committees can, however, be very important resources as local volunteer extensionists since very often they are attending solely based on interest and a desire to learn, without any other reward. These committees can also be a good starting point for the organization of an agricultural cooperative if desired.

Cooperatives are more formal groups, generally organized around a set of by-laws or constitution, requiring members to fulfill certain responsibilities (pay dues, attend meetings or workdays) and granting them certain priviliges (credit, buying and/or selling at favorable prices, right to farm a certain portion of land). Because of their formal nature, cooperatives are likely to be more permanent organizations than agricultural committees. Also as a result of this more formal nature, they are less flexible about admitting new members. Many times cooperatives receive preferential treatment from governmental agencies when soliciting training courses, credit, or other types of assistance.

There are several types of cooperatives, differing in the nature of the rights they grant and the responsibilities they require of the members. Production cooperatives involve the members working together in the production process, such as farming the same piece of land. Credit cooperatives manage a common fund which is used to loan members money, an alternative to more expensive and often unavailable bank loans, Buying and selling coops pool all the farmers buying orders, buying in bulk for cheaper prices, and pool the farmers' produce to sell at higher prices or lessen transportation costs.

Soil conservation extensionists may also be involved in working with other types of groups, such as schools, youth groups, housewives groups, etc. Regardless of the type of group an agricultural extensionist works with, some basic concepts must be considered. First, groups should be goal-oriented or purposeful, that is they must provide some advantage to their members; some incentive to spend their time with the group. Second, the group must have a structure, organization, plan of activities, and disciplinary code which permit the attainment of its goals. Third, care must be taken in planning, promoting, and realizing all group oriented activities to avoid disillusion among members and abandoning of the group. This may result from joining a group without understanding its stated goal or joining a group incapable of attaining its stated goal because of flaws in the design of its structure, organization, plan of activities, or disciplinary code. When these concepts are kept in mind, then the group is much more likely to serve its members in a productive, self-sustaining fashion. Once confident of the usefulness and power of their own group, community members will be much more motivated to work within the group framework to improve their own situation.

VI. CONCLUSION

This guide attempts to provide agricultural extensionists with an understanding of some techniques which have been found helpful in improving hillside farming systems. Hopefully each extensionist can find one or several techniques presented here which are appropriate for any specific work area. Clearly it is not the role of this guide, just as it is not the role of the extensionist, to dictate the techniques to be used in any given situation. Rather agricultural extensionists and farmers should realize the realm of possible techniques available to them, enabling them to formulate their own plans according to the many variables (climate, topography, labor, markets, etc.) which determine the appropriateness of any given farming practice for an area.

Furthermore it is hoped that hillside farms are not to be regarded as "things to be fixed once and for all" with a set of soil conservation techniques. Farms, like individuals and communities never reach an ideal state of development, rather they are dynamic units which must adjust over time to a changing climate of environmental, human, economic, and political factors; all of which require that new practices constantly be tested and evaluated. If agricultural extensionists can communicate to farmers the importance of testing and evaluating new techniques, such as the ones included in this guide and many others, then both will be better prepared to address the problems facing the farmers now and in the future.

The technologies described in this guide are all simple options available to small-scale hillside farmers in the use of their land. It is hoped that through the use of these practices that better yields may be sustained for more years on each cultivated plot of land. In addition to the increase in crop production, the introduction of soil conservation techniques may facilitate the promotion and realization of more long-term effects of area-wide conservation programs; such as the management of watersheds to maintain a reliable, clean, drinking water supply and the protection of undisturbed lands as reservoirs of native flora and fauna.

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APPENDIX 1

ENGLISH-SPANISH VOCABULARY LIST

A-frame level	nivel tipo "A"
bench terrace	terraza de banco
check dam	barrera
compost	abono orgánico
compost pile	abonera
contour barrier	barrera al contorno
contour furrow	surco al contorno
cover crop	cultivo de cobertura
crop residues	rastrojos, residuos
dead barrier	barrera muerta
desertification	desertificación, desertización
discontinuous narrow terrace (orchard terrace)	acequia de ladera, terraza de huerta, terraza angosta
drainage	desagua o drenaje
drop box	caja disipadora
earthworm	lombriz de tierra
earthworm house	lombricero
eroded land	tierra erosionada, tierra cansada
erosion	erosión
fertilizer	fertilizante, abono
grass lined drainage canal	canal de desague engramado
green manure	abono verde
gully	cárcava
hillside	ladera
hillside ditch (channel terrace)	zanja o acequia de ladera
individual terrace	terraza individual
infiltration	infiltración
line level	nivel de cuerda o de albañil
live barrier	barrera viva
manure	estiercol

minimum tillage .... labranza mínima
mixed barrier .... barrera mixta
mulch .... cobertura
planting bed .... cama o arriate
point row .... surco muerto
retention well .... pozo de retención
riser (terrace bank) .... talud
rock lined drainage canal............... canal de desague empedrado
rock wall .... muro de piedra
runoff .... escurrimiento, agua de escorrentia
slash and burn .... roza y quema
slope .... pendiente, desnivel
stormwater drain .... cabecera
(uppermost of series of contour ditches)
windbreak .... barrera rompeviento

APPENDIX 2

DICHOTOMOUS KEY TO THE SELECTION OF SOIL CONSERVATION PRACTICES

1.	a.	Slope less than 12% or greater than 60%	2
	b.	Slope between 12% and 60%	3
2.	a.	Slope less than 12%	Live Barriers and Agronomic Measures*
	b.	Slope greater than 60%	Reforestation
3.	a.	Slope between 12% and 50%	4
	b.	Slope between 50% and 60%	Perennial Crops Using Discontinuous Narrow terraces
4.	a.	Terrain with little or no rocks	5
	b.	Terrain with abundant rocks	Rock Wall Barriers and Agronomic Measures*
5.	a.	Annual crops (basic grains, vegetables tubers, flowers) or bananas	6
	b.	The majority of the fruit trees (citrus, coffee, cacao, etc.)	Individual Terraces with Discontinuous Narrow Terraces or Hillside Ditches
6.	a.	Deep soil (greater than 1 meter)	7
	b.	Shallow soil (less than 50 cm)	8
7.	a.	Non-irrigated	8
	b.	Irrigated	Continuous Bench Terraces and Agronomic Measures*
8.	a.	Slope between 12% and 30%, and soil depth greater than 50 cm	Discontinuous Narrow Terraces with Agronomic Measures*
	b.	Slope between 12% and 50%, or soil depth less than 50 cm	Hillside Ditches with Agronomic Measures

* Agronomic measures refer to other land management practices, such as contour plowing and planting, mulching, etc. which may be appropriate to the area.

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APPENDIX 3

RESULTS OF THE SANTA CRUZ EXTENSION PROJECT: FARM BUDGETS AND THE PROFITABILITY OF MODERN AGRICULTURAL TECHNIQUES.

Many non-traditional agricultural techniques require a greater investment in labor and/or fertilizers, seeds, pesticides, etc. than the traditional techniques they are designed to replace. The extra labor and expenses incurred discourage many farmers from changing their traditional methods.

In order to illustrate the changes which a small family farm operation might experience, data are presented here representing average expenses and earnings of 50 farmers. The data were collected in Santa Cruz, El Paraíso, Honduras, the year before (1982) and the first year (1983) in which techniques of soil conservation, fertilizer use, improved corn seed varieties, and chemical pest control were introduced to a group of local farmers by Rory William Steinke, a Peace Corps Volunteer.

The farms involved in this project were all small (1 Mz =.68 ha), with slopes ranging from 10-50%. They were planted with corn and beans, the traditional crops in this area. Because of the nature of this group, these data are probably not applicable to other cultivation systems such as vegetables or fruit trees, but they do provide insight into questions which may be important to extensionists working with other systems.

TABLE 8

RESULTS OF THE SANTA CRUZ EXTENSION PROJECT:

FARM EXPENSES AND EARNINGS PER MANZANA (0.68 hectare)

I. EXPENSES		1982		1983
A. Land preparation				
Soil Conservation practices			40 days at L.5.00	L. 200.00*
Plowing		L. 20.00		20.00
SUB TOTAL		20.00		220.00
SUB TOTAL (excluding labor provided by family)*		20.00		20.00
B. Corn Crop (1st.planting season)				
1. Cultural practices				
- Planting (1983 incl.fertil +Pesticide application)	2 days	10.00*	8 days	40.00*
- Weeding	16 days	80.00	16 days	80.00
- Fertilizing			2 days	10.00*
- Weeding	16 days	80.00*	16 days	80.00*
- Folding over mature ears	12 days	60.00*	12 days	60.00*
- Harvesting	12 days	60.00*	20 days	100.00*
- Husking	10 days	50.00*	20 days	100.00*
- Transport (field to house)	2 d. + 2 mules	30.00*	5 days + 2 mules	75.00*
- Shelling	10 days	50.00*	20 days	100.00*
2. Products				
- Seed	30 lbs.at 0.20/lb	6.00	30lbs.at 0.50/lb	15.00
- Fertilizer (18-46-0)			2qq at L.38.00qq	76.00
- Fertilizer (urea)			2qq at L.28.00qq	56.00
- Insecticide (volaton)			15 lbs.at 0.80/lb	12.00
SUB TOTAL		426.00		804.00
SUB TOTAL Excluding labor provided by family*		86.00		239.00
C. Bean Crop				
1. Cultural practices				
95 - Weeding (pre-planting)	16 days	80.00*	16 days	80.00*
- Planting	4 days	20.00*	4 days	20.00*
- Weeding	16 days	80.00*	16 days	80.00* 96
- Harvest	12 days	60.00*	12 days	60.00*
2. Products				
- Seed	40lbs.at 0.40/lb	16.00	40lbs.at 0.40/lb	16.00

T A B L E 8 (Continued)

			1982		1983
	SUB TOTAL		L. 256.00		L. 256.00
	SUB TOTAL Excluding labor provided by family*		16.00		16.00
	TOTAL		702.00		1,280.00
	TOTAL Exluding labor provided by family*		122.00		275.00
II.	EARNINGS				
	A. Corn	12qq at L.12.50-L.25.00/qq	150.00 - 300.00	27qq at L.12.50-L.25.00/qq	462.50 - 925.00
	B. Beans	10qq at L.30.00/qq	300.00	11qq at L.30.00/qq	330.00
	TOTAL		450.00 - 600.00		792.50 -1255.00
III.	NET EARNINGS		(-252.00)-(-102.00)		(-487.50)-(-25.00)
	Net Earnings excluding labor provided by family*		(+328.00)-(+478.00)		(+517.50)-(+980.00)

All values given are in Honduran currency, the Lempira (L.) The exchange rate is L.2.00 = US$1.00

The expense accounts reveal several points which should be considered by the extensionists when advising farmers:

--These farms are heavily dependent on family labor. (Note net losses when all labor costs are included). Therefore designing a conservation plan that can be carried out without hiring out additional labor is important.

--The market price available to farmers determines whether or not the extra expenses are profitable in the short run. Due to seasonal variations in grain prices, profits are much higher if grains can be stored and sold when prices rise (in this case approximately 6-8 months after time of peak harvest).

--Once the soil conservation practices are in place however, future years' labor expenses will decrease and a greater likelihood of sustained yields increases the profitability of the modern techniques in the long run.

--The use of organic fertilizers may reduce the amount of chemical fertilizer needed and avoid some expenses.

--Limiting the first year's work to a smaller plot (1/4 - 1/2 Mz) can greatly reduce the risk incurred and can be helpful in promoting the techniques in new areas.

APPENDIX 4

TWO SIMPLE LEVELS FOR USE IN SURVEYING CONTOUR LINES

In many areas, sophisticated surveying levels are not available to farmers interested in designing soil conservation structures. Even where they are available, it is often more practical for the farmer to build a cheap, simple, effective level for use in surveying contour lines. Although less accurate than more sophisticated levels, the two levels presented here, when properly constructed and used are sufficiently accurate for the work on small hillside farms requiring measurements of 0% or 1% slope described in this guide.

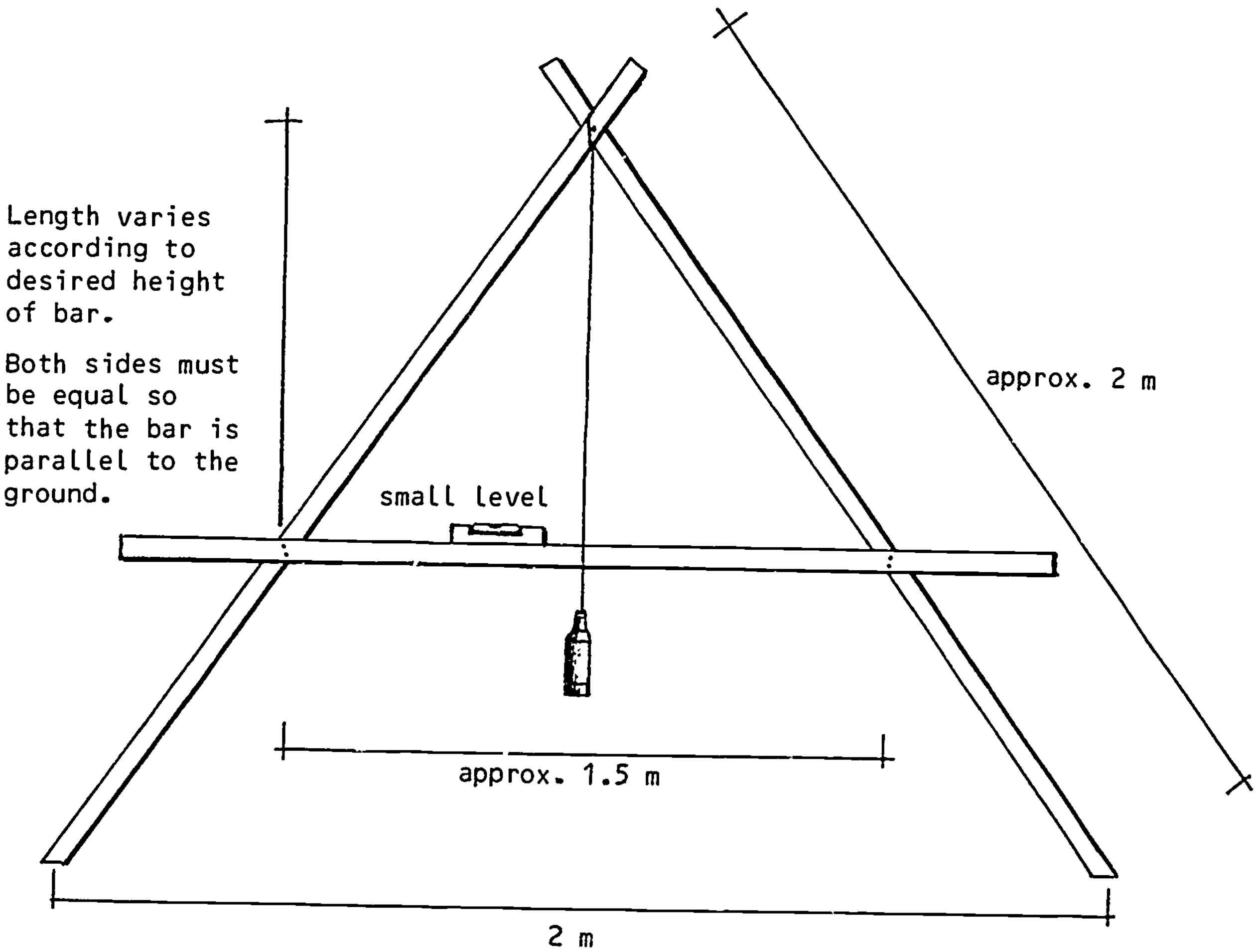

Fig. 39. A-Frame level for surveying contour lines.

A-frame level:

1. Construction:

   The materials required are 3 straight boards or sticks, 3 nails or screws, a thin string, and a screw-capped glass bottle or uniform-shaped rock. A small line level is very convenient and makes use much easier on windy days.

   Important points to consider in building the A-frame level:

   --The symmetry of the level is important (2 legs should be same length and crossbar should be positioned identically on the legs so that it is parallel to the ground.

   --The dimensions of the level are not important, but if constructed much larger than the one pictured, they should be assembled with screws so that they can be disassembled for transportation. Measuring an exact distance (i.e. 2m) between the feet makes calibrating the 1% contour position easier.

   --The plumb bob must be attached so that it does not deflect the string to either side. If a screwcap bottle is used, it should be hung by a hole made exactly in the center of the cap. If a rock is used, it is important that a very uniformly shaped rock be chosen.

2. Calibration:

   The level should be calibrated every day before use, as warping of the wood can greatly change the results.

   a. Calibration of 0%

      1. The level should be positioned with both feet on firm surfaces but with one end obviously higher than the other.

      2. The level is gently rocked, allowing the string with the plumb bob to gently strike the cross bar.

      3. When the plumb bob stops swaying side to side and the string strikes the cross bar at the same point repeatedly (5-10 times), mark this position in pencil on the cross bar.

      4. Reverse the position of the level so that the other foot is now at the higher point. Care must be taken to position the feet of the level in exactly the same points as before.

5. Repeat steps 2 and 3, obtaining a second mark on the other side of the center of the cross bar.

6. The 0% position of the level is exactly in between the two marks obtained in this trial. This position can be marked by measuring with a ruler or paper (1/2 the distance between the 2 marks). Now when the feet of the level are even the string will strike the cross bar at the 0% position which is used to survey contour lines for barriers, terraces or ditches which are to be used for retention, rather than diversion of water.

7. Once calibrated, a small carpenter's or line level can be fastened to the cross bar to facilitate use on windy days.

b. Calibration of 1%

1. Position the level so that the feet are on the same level and the string strikes the cross bar at the 0% position. The feet should be on firm surfaces.

2. Raise one foot by the distance required to position the level at a 1% slope. For example, if the distance between the feet is 2m, then a 2 cm. tall object or 2 cm. tall stack of coins should be placed under one foot.

$$\left(\frac{2 \text{ cm.}}{200 \text{ cm.}} = .01 = 1\%\right)$$

3. Rock the level gently, now the string strikes the 1% slope position. Mark this position on the crossbar.

4. Since this type of contour line will be used to construct structures to divert water, an arrow should be placed pointing toward the lower foot to indicate the direction of water flow

5. As in the previous calibration, if desired a small level can be fastened to the cross bar.

3. Use of the A-Frame level:

The A-Frame level is used to survey contour lines by placing stakes at the position of the feet when the level gives the desired reading. Stakes should all be placed on the same side of the level, all upslope or all downslope, in order to avoid errors. When not being used the level should be stored in a dry, shady place.

Line Level:

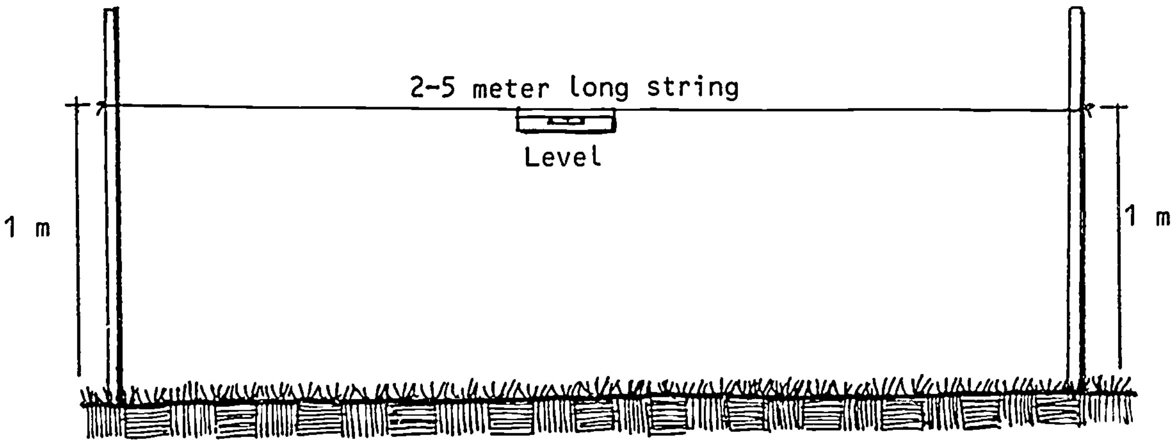

Fig. 40. Simple line level for surveying contour lines.

1. Construction:

   The materials required are 2 straight boards or sticks, a string of desired length and a line level.

2. Calibration:

   The level should be calibrated every day before using as bending of the hooks on the line level or warping or chipping of the sticks can greatly change the results.

   a. Calibration of 0%

      1. Slots are cut in each stick at the same distance from one end.

      2. The string is tied firmly to each stick so that it cannot slip out of the slots.

      3. Hook the line level on the string and find a place on firm ground which gives a level reading.

      4. Reverse the direction of the line level on the string while maintaining the position of the sticks. If the reading changes, the hooks of the line level must be adjusted slightly by bending them.

5. Repeat steps 3 and 4 until the line level gives identical readings upon reversal.

b. Calibration of 1%

1. Repeat the steps as in the calibration of 0%. However this time the slots on the sticks should be placed so that a 1% drop occurs over the distance of the string. (example: if the string measures 2m then the slot on one stick should be 2 cm higher than on the other).

2. Remember that the stick which has the slot located higher up actually represents the lower ground surface when the reading of the string is level. Remember to mark the sticks so that no confusion as to the direction of water flow will arise when surveying contour lines.

c. Use

This type of level is easiest to use with a least 3 people, two holding the sticks and the third reading the line level and placing slakes. When not in use the line level should be protected so that the glass vial and hooks are not damaged.

APPENDIX 5

SOME DEMOSTRATIONS USEFUL IN PROMOTING NEW TECHNIQUES

One of the main problems faced by agricultural extensionists is gaining credibility in a community. People are often unwilling to invest time or money to try new techniques that they do not understand, solely based on the word of an outsider. The following demonstrations can help farmers understand more about their soils and how they might benefit by changing some of their traditional agricultural practices.

Fig. 41. Demonstrating erosive power of raindrop Impact

As water is dropped on the soil next to a piece of white paper, soil particles are dislodged and splash onto the paper. This demonstration done over a mulch-protected soil results in no dislodging of soil particles. This illustrates the value of a permanent ground cover or mulch in the prevention of soil erosion.

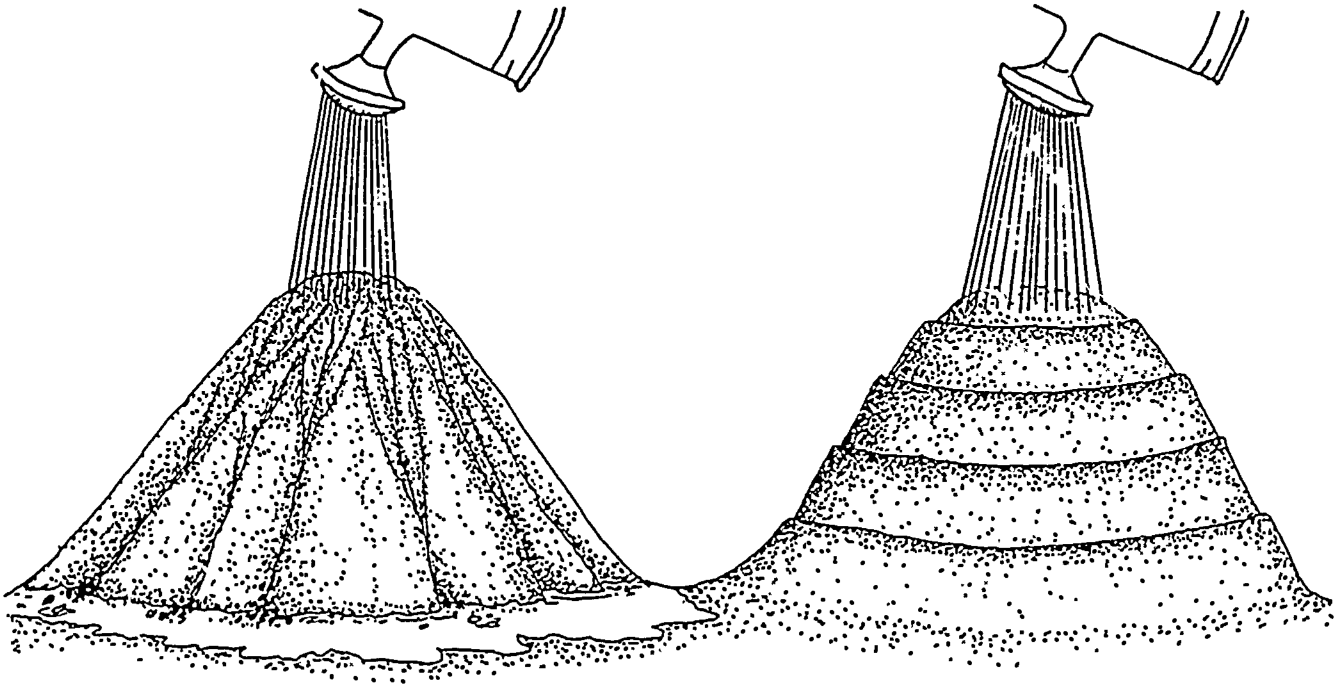

Fig. 42. Demonstrating the advantage of contour cultivation practices over tratitional agricultural methods.

Form two mounds of soil and scratch contour furrows in one and furrows straight up and down on the other. When watered, the mound with contour furrows should erode less than the other mound.

This demonstration can be used to stress the importance of working the land along the contour. A trial run should be made before the actual demonstration to determine the appropriate watering intensity.

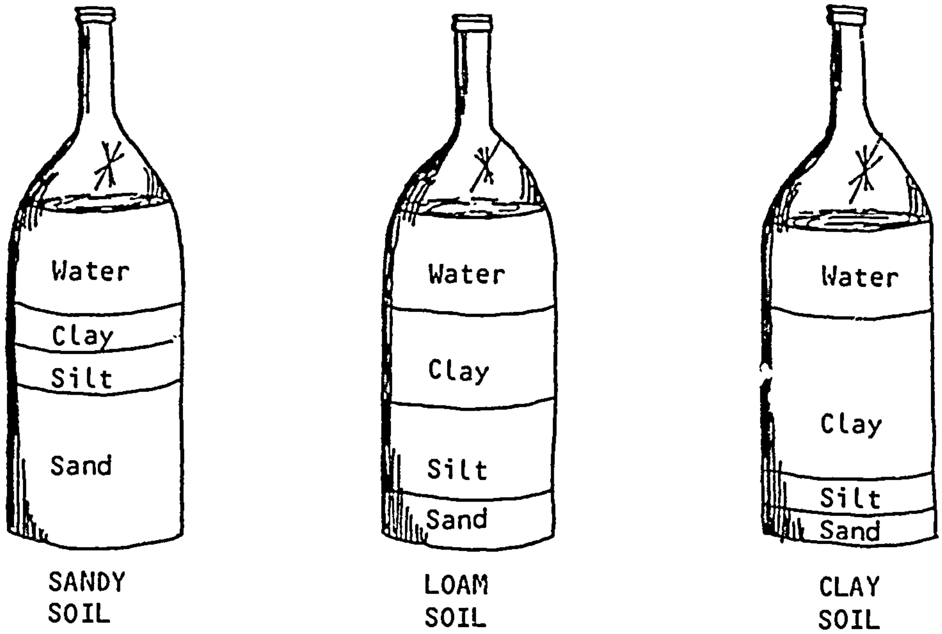

Fig. 43. Demonstrating the particulate makeup of soils

Place soil in a bottle, add water, shake, and set on a stable level surface. The heavier sand-sized particles will settle out first followed by silt-sized and then clay-sized particles. This demonstration illustrates the particulate nature of soils and can be used to help farmers understand what soil texture means and how it can be important in affecting the drainage or erodability of a soil. The bottles should be allowed to remain undisturbed for a full day in order for the finer, clay-sized particles to settle out.

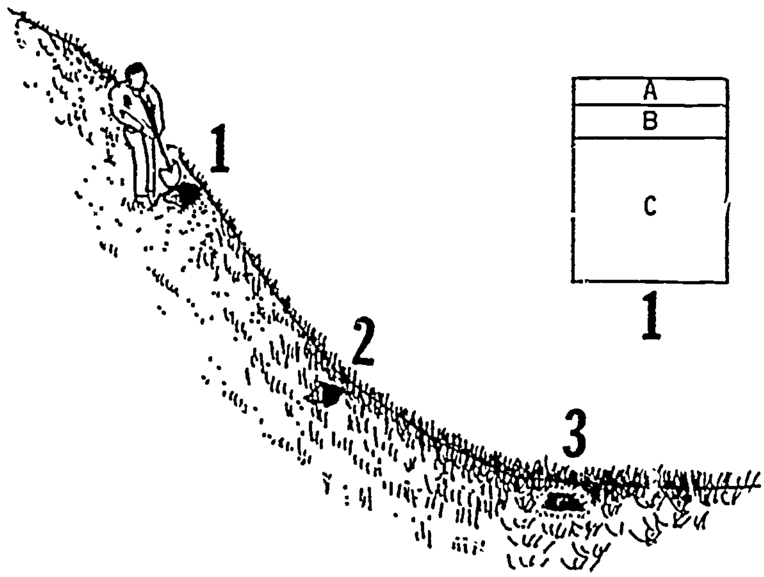

Fig. 44. Demonstrating soil profiles

By digging soil pits at the spots indicated in different parts of a field, the results of past erosion can be seen. The much thinner layers of the more fertile A and B horizons on the more steeply sloped areas can be helpful in explaining the need to introduce soil conservation measures.

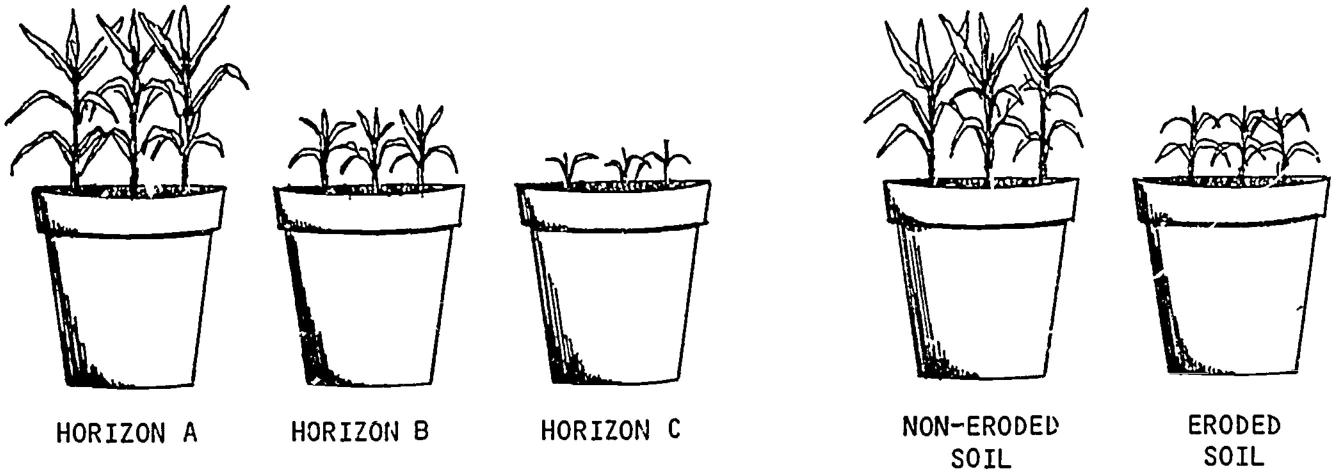

Fig. 45. Growth trials in soils of varying fertility.

Planting of 3-5 corn seeds in cans containing soils from different horizons or from eroded and non-eroded parts of the same field can demonstrate the difference in fertility between upper and lower soil horizons and the value of protecting the upper soil horizon from erosion. This demonstration requires 3-6 weeks to show best results.

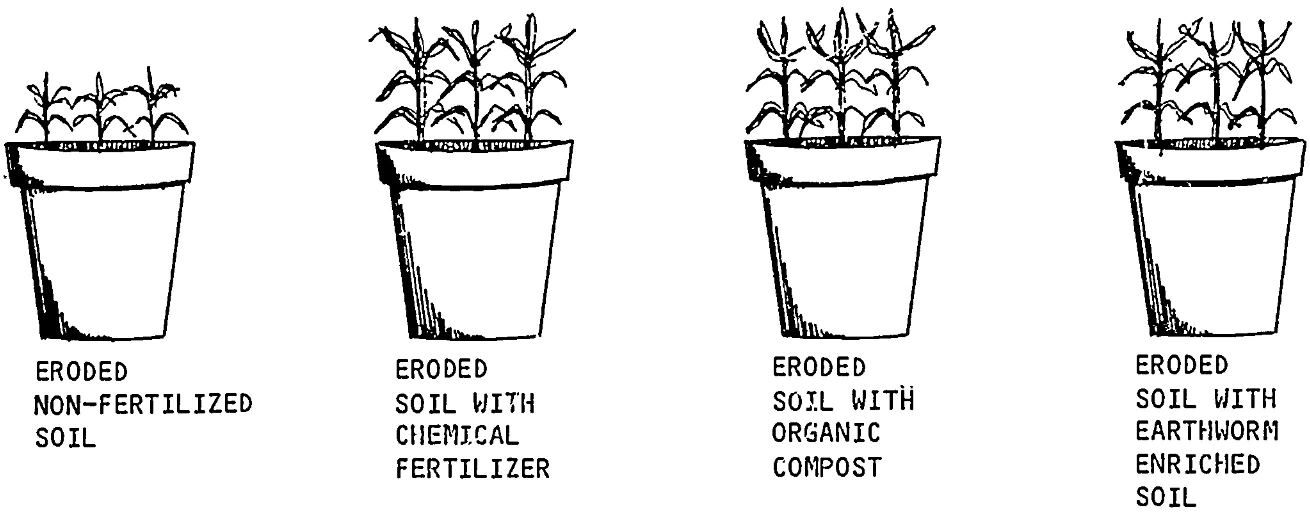

Fig. 46. Growth trails using chemical and organic fertilizers.

Similar to number 5, this demonstration can be used to show the benefits of using different techniques to maintain or increase soil fertility. Again 3-6 weeks are required for best results.

Growth trials such as the ones shown here can be carried out to show an unlimited number of comparisons. It might also be valuable to try mulched soil, repeatedly burned soil, waterlogged soil, another crop which could be grown to maturity (beans, radishes, carrots), etc.

Since 1961 when the Peace Corps was created, more than 80,000 U.S. citizens have served as Volunteers in developing countries, living and working among the people of the Third World as colleagues and co-workers. Today 6000 PCVs are involved in programs designed to help strengthen local capacity to address such fundamental concerns as food production, water supply, energy development, nutrition and health education and reforestation.

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