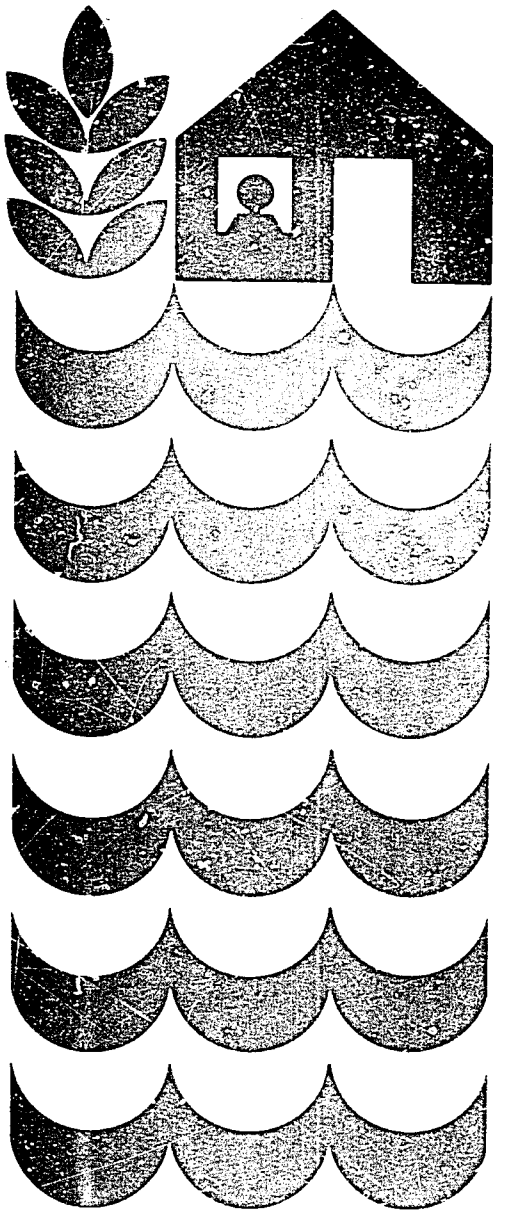
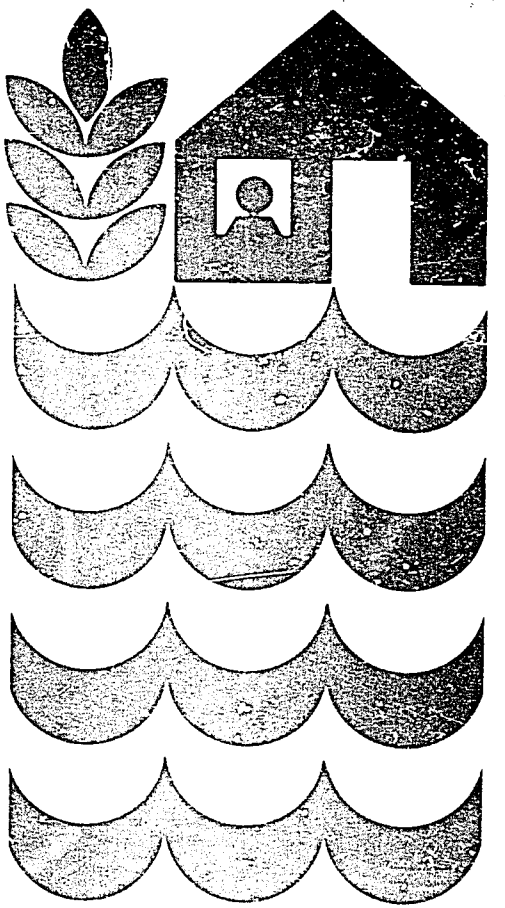
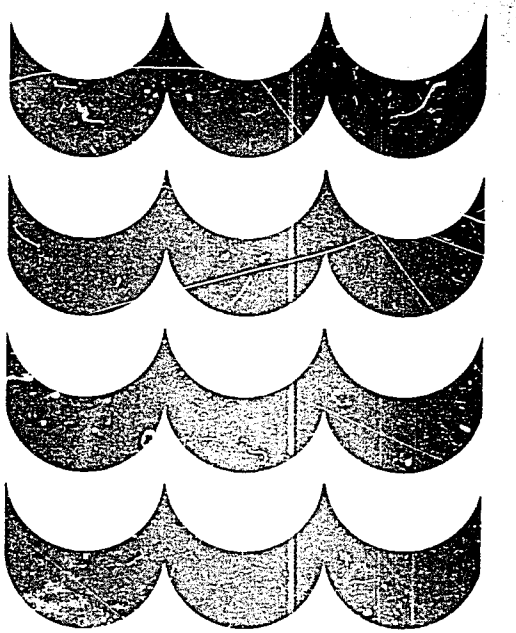
PN-AAQ-429

Water Management on Small Farms:

A Training Manual for Farmers in Hill Areas







Water Management Synthesis Project

PREFACE

This booklet is an expanded version of a bulletin entitled *El Riego en la Sierra* which was developed as a training aid for use in irrigation workshops conducted for small farmers and technicians in the Peruvian highlands through USAID, contract 527-T-059. Much of the agriculture there takes place on steep slopes, shallow soils and small farm plots (1000 square meters). Irrigation extension personnel found the bulletin to be useful in training literate and semi-literate farmers and technicians.

The irrigation workshops conducted in Peru consisted of

1. an audiovisual series that interpreted pertinent parts of the bulletin;

2. an extensive, practical, hands-on course following the audiovisual part, in which the farmers learned to use the material presented;

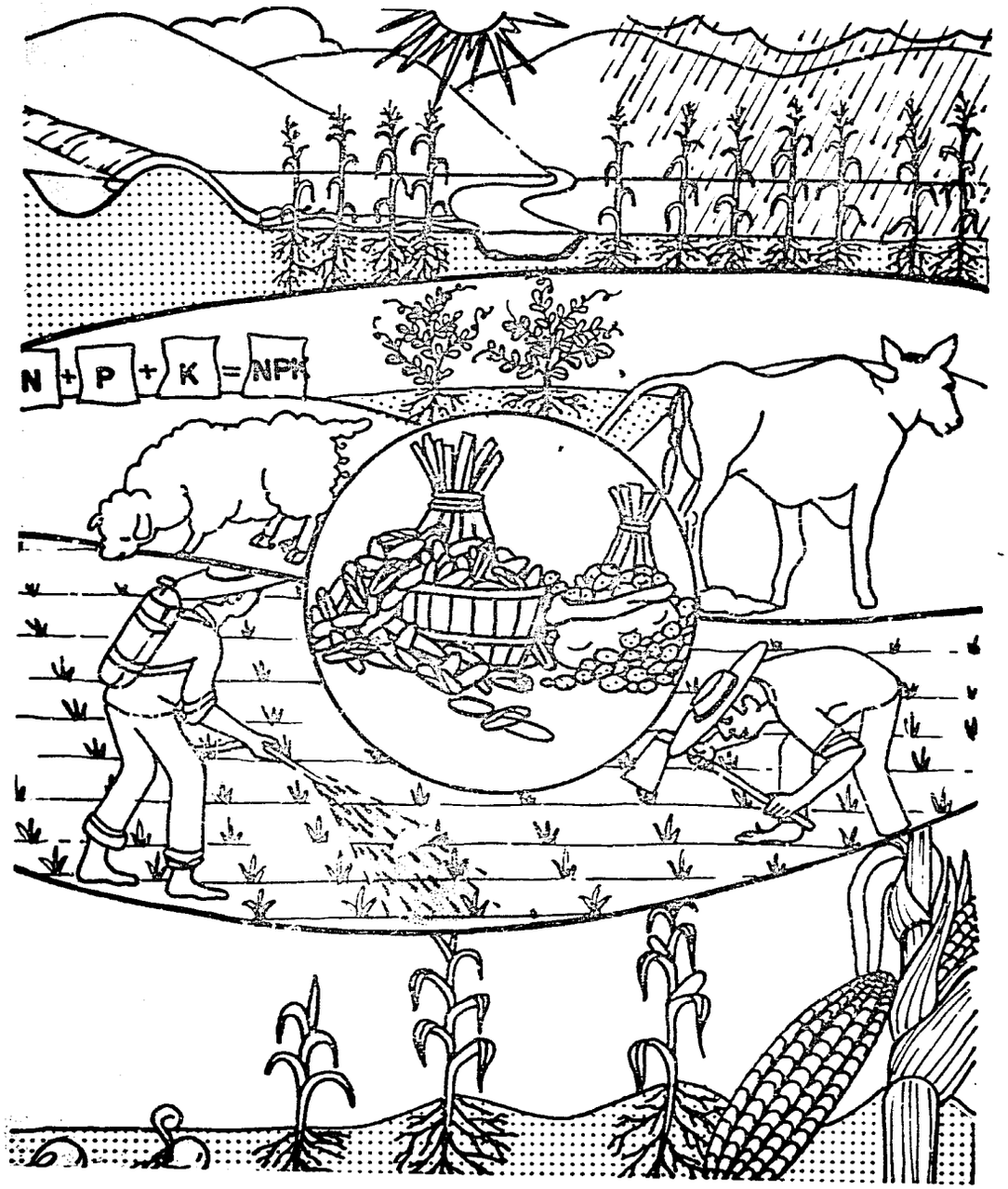
3. a field day during which farmers could observe the techniques taught to them "in action" on a demonstration farm;

4. an evaluation of the farmers' new skills with such tools as simple levels and siphons, and their proficiency in evaluating and improving management practices; and

5. the bulletin which was given to the farmers for reference.

It is hoped that this booklet will serve as a source from which basic concepts can be taken and applied to specific situations such as those encountered in developing countries. In addition to this training manual, several slide shows and an instructor's guide have been produced to teach farmers the techniques contained in this manual.

For crops to grow well, they need soil sunlight, nutrients and water. However, in this booklet, we are only concerned about irrigation water and its proper management.



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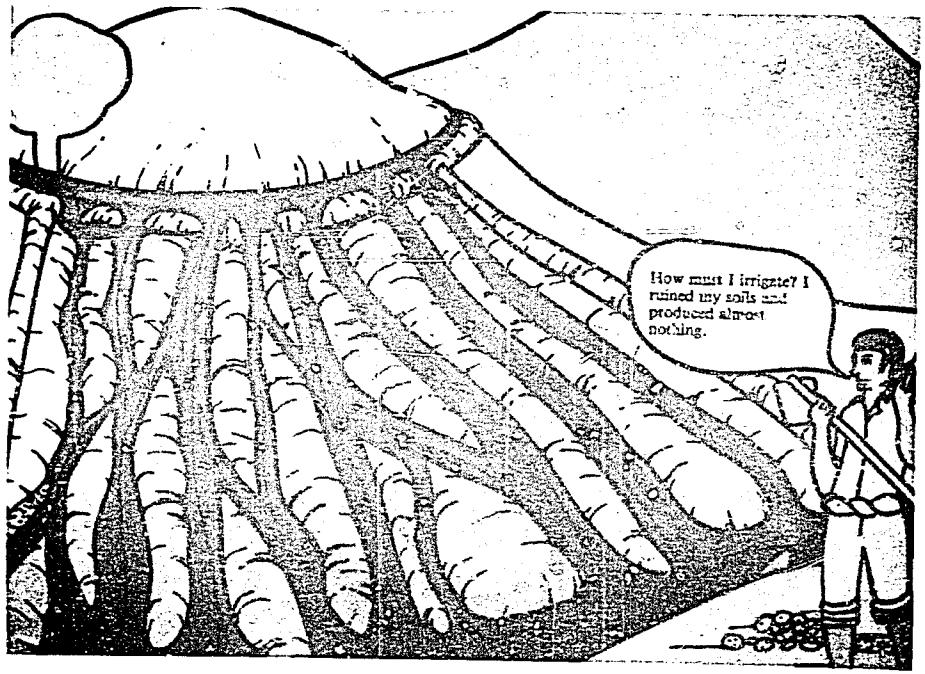
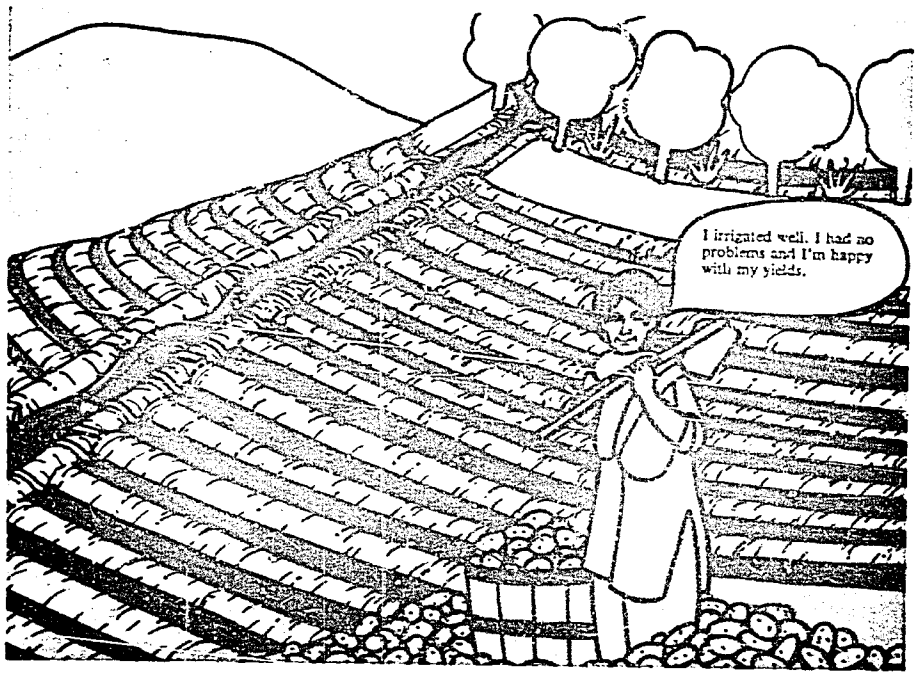
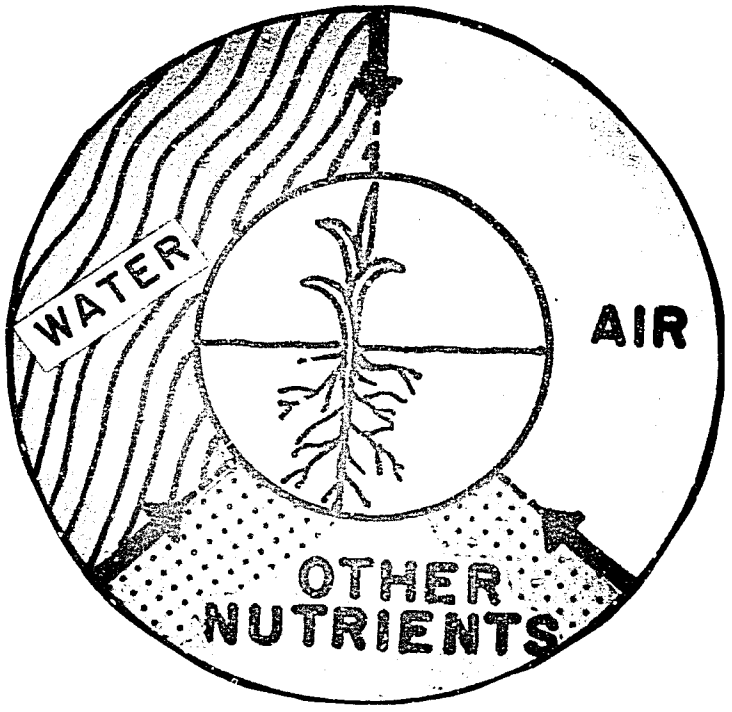
THE IMPORTANCE OF IRRIGATION WATER AND ITS MANAGEMENT IN CROP PRODUCTION AND SOIL CONSERVATION





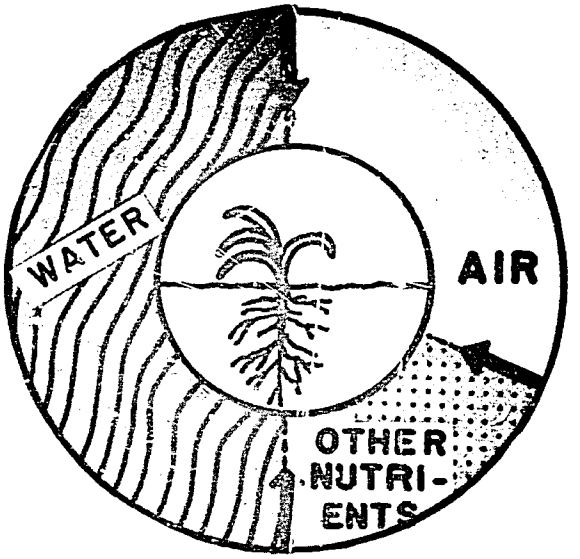
The Role of Water in Plant Development

Growing plants need water, sun, air and nutrients to form roots, stems, leaves, fruits and seeds.

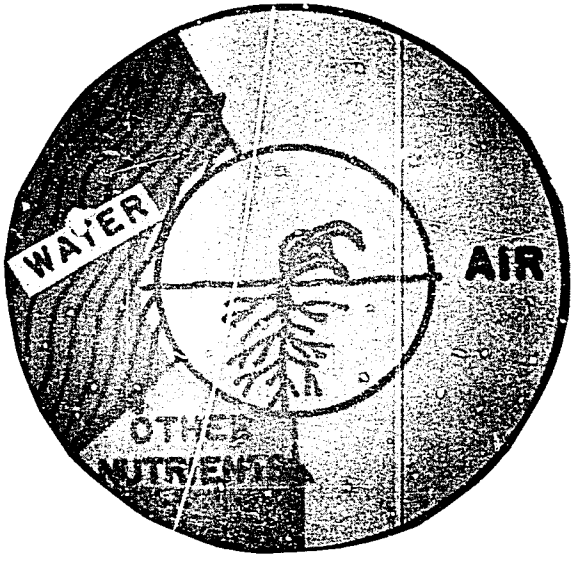


Water is a large part of the plant's structure. It carries food through the plant and it cools the crop during hot weather.

Roots can't get enough air if there is an excess of water.



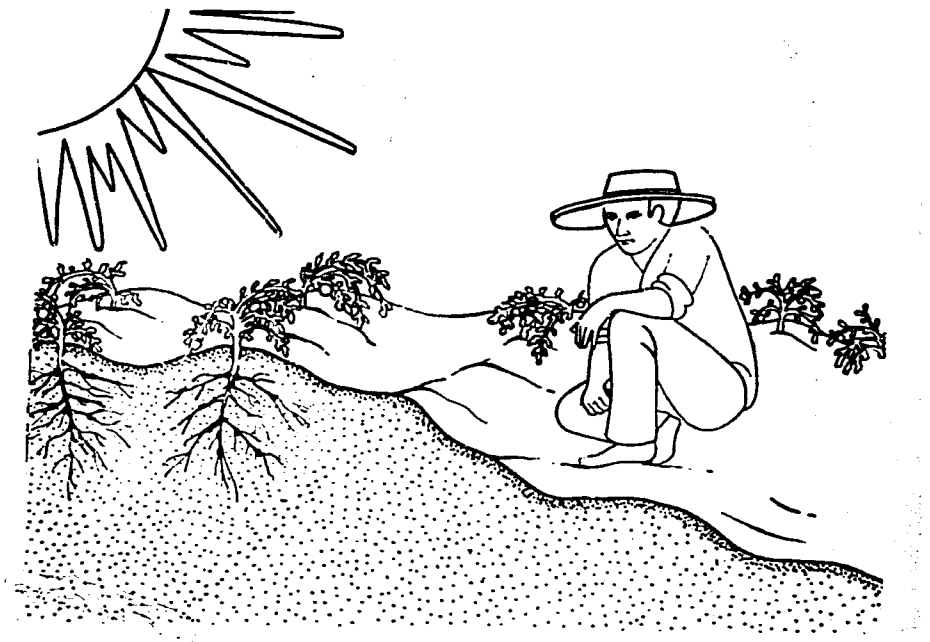
A lack of water makes plants unable to draw needed nutrients (food) from the soil.



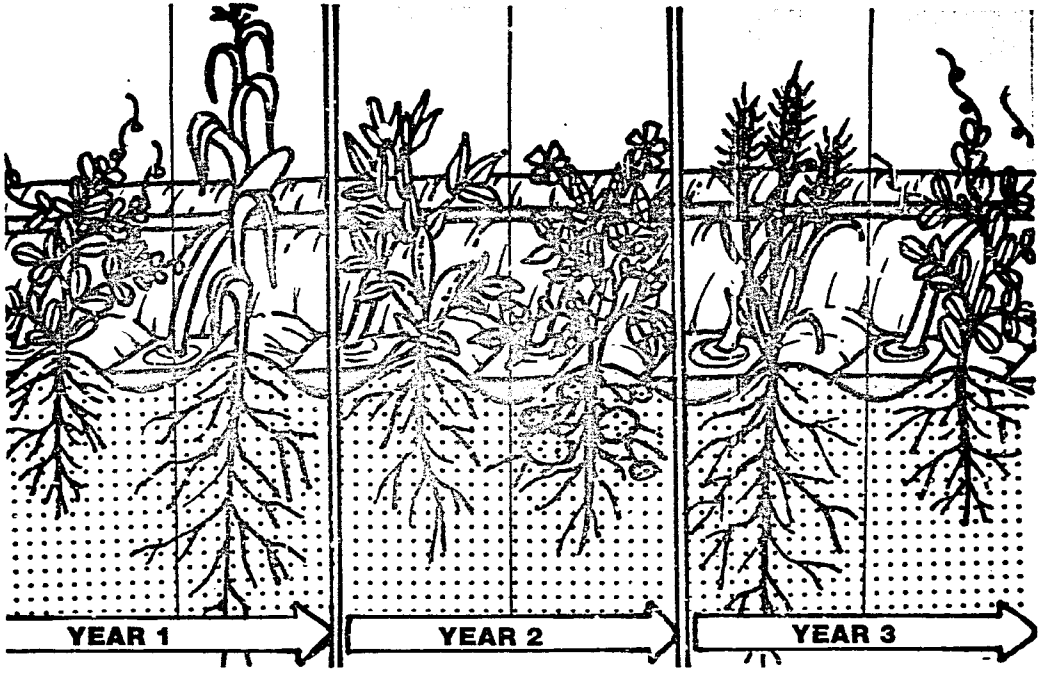
Too much or too little water results in lower yields.

For good production, crops need the right amount of water throughout their development.

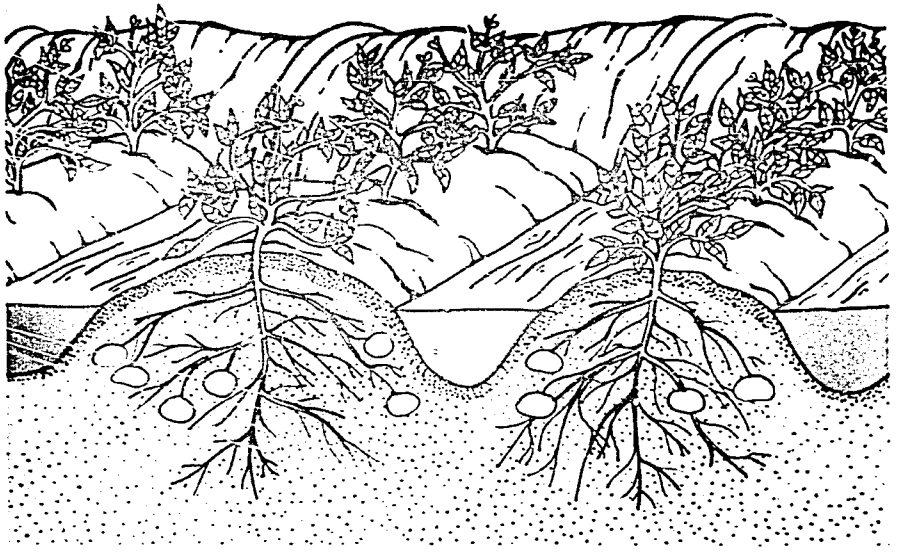
Irrigation can insure a good yield even during drought if we have provided the crop with its other needs.



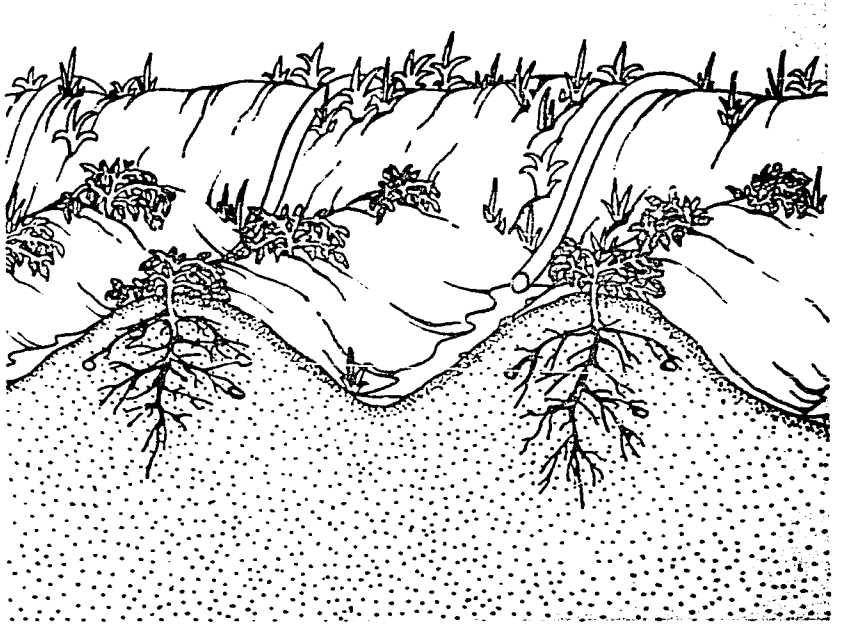
In many parts of the world irrigation allows the harvest of two or more crops each year.



Sufficient water throughout the growing season helps insure healthy crops, thus enabling the plants to resist insects and disease better.



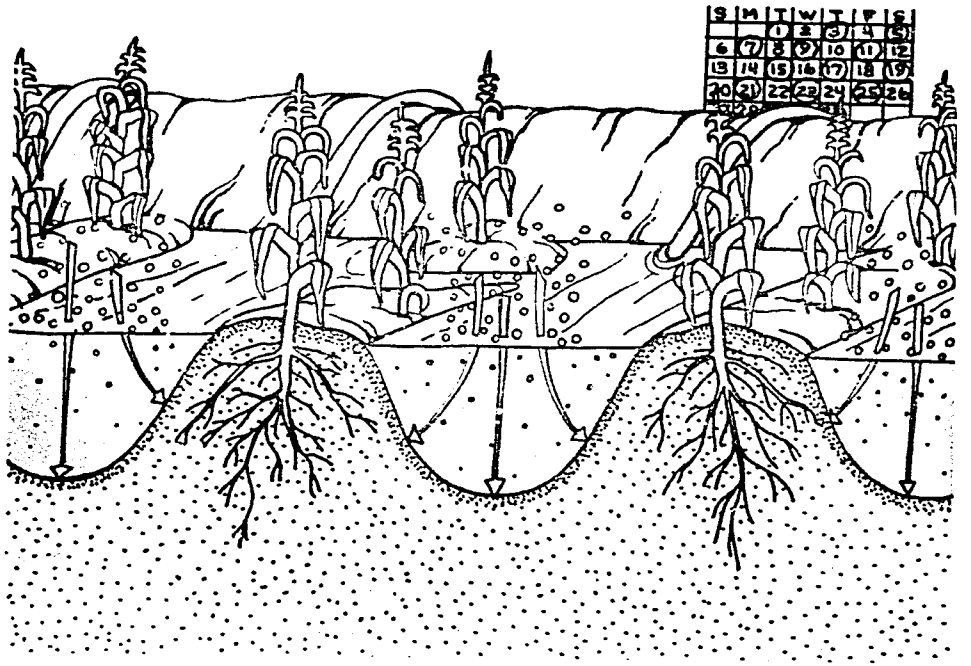
Sufficient



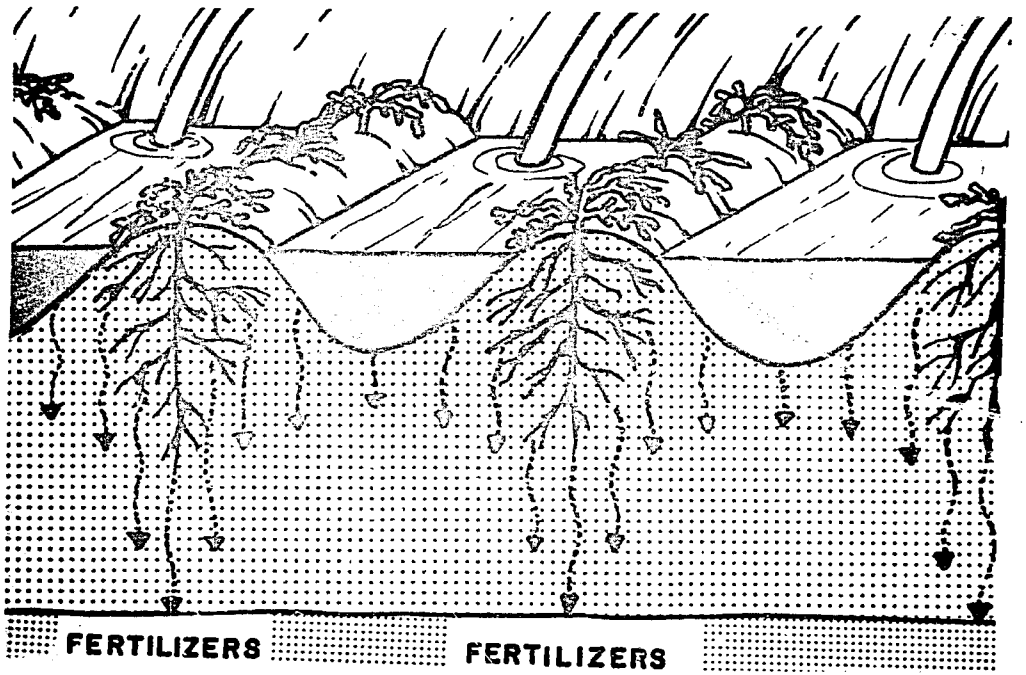
Insufficient

Irrigation Can Have Harmful Effects

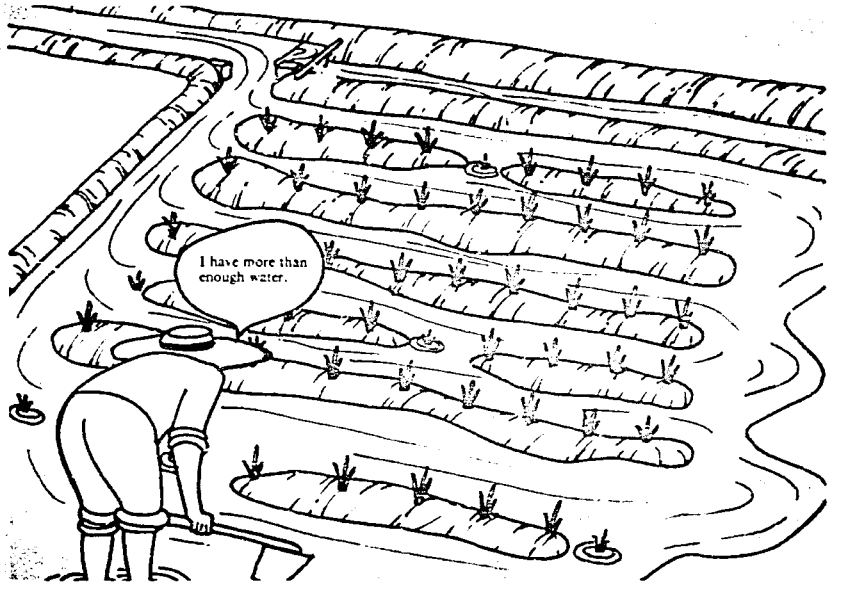
1. More frequent irrigations than necessary result in a root zone which stays too wet for too long. Insufficient aeration and root rot may result.

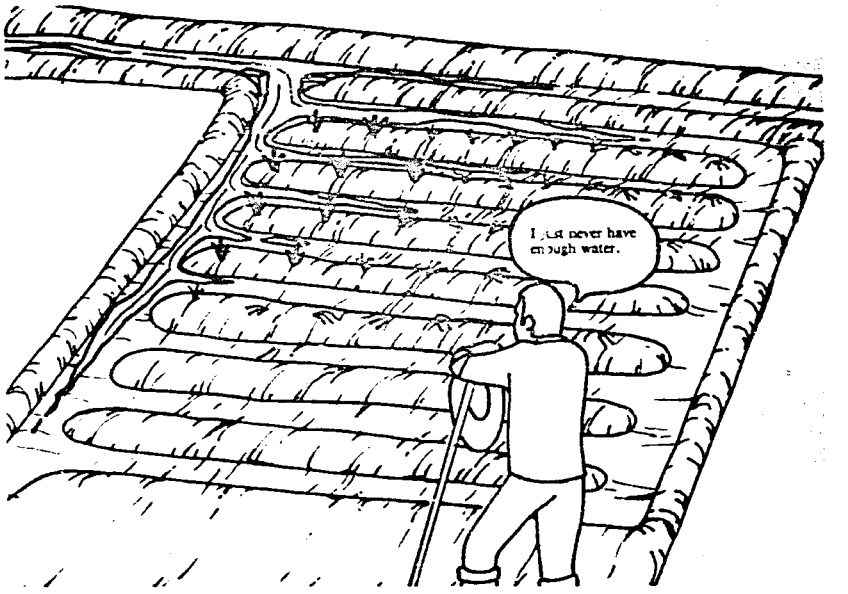


2. Excessively heavy water applications may wash fertilizers and other nutrients away from the root zone.

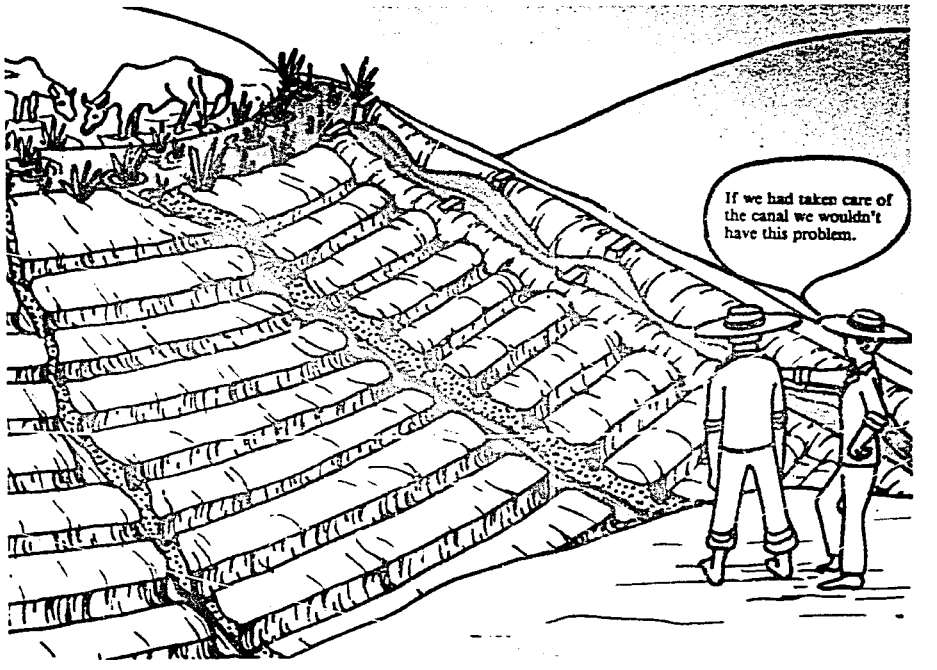


3. Some farmers waste water when they irrigate, which means that other farmers may not have enough water for their fields.

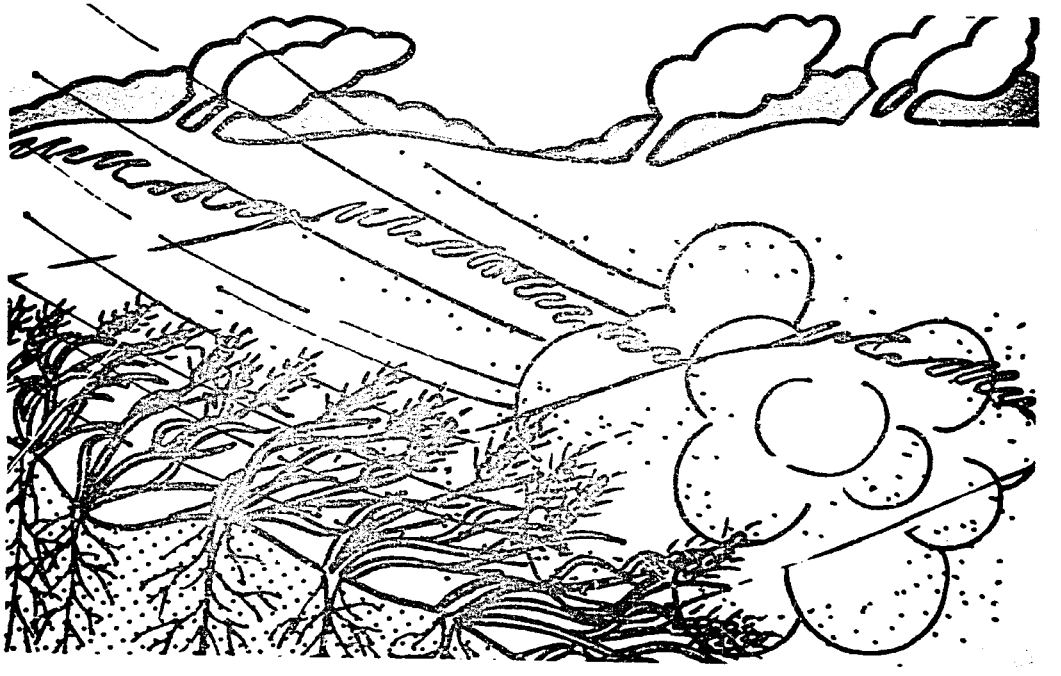




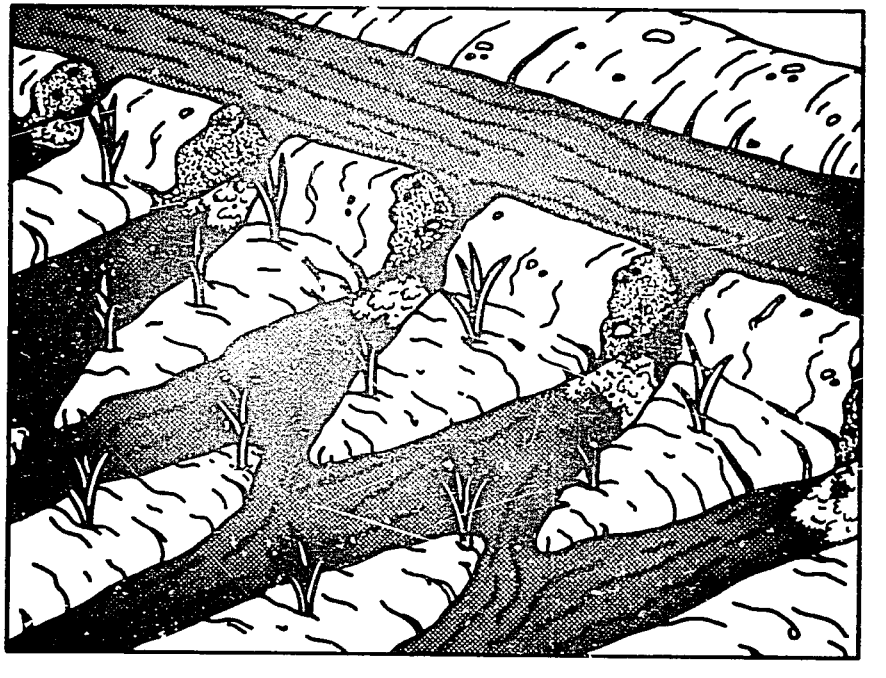
4. Careless maintenance of canals can result in weed, silt, or erosion problems, and not having water where it is needed.



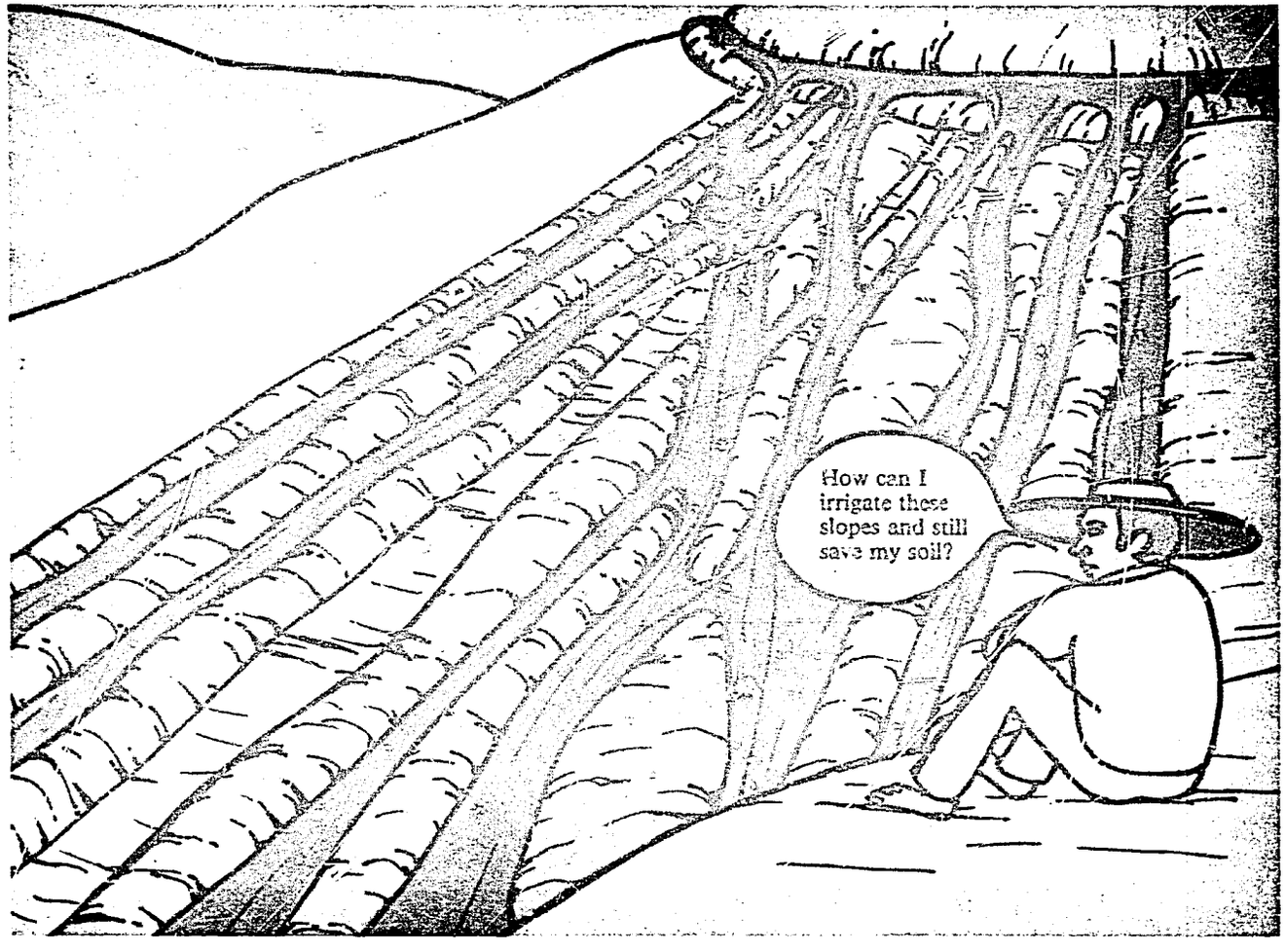
Erosion is the loss of soil through the action of water and wind.



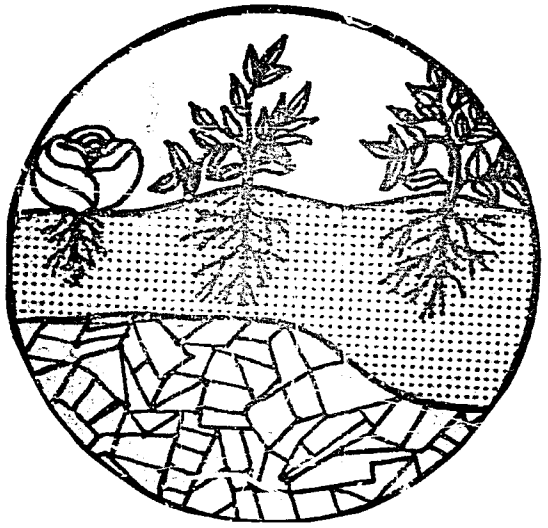
5. Uncontrolled irrigation water can be a primary cause of erosion.



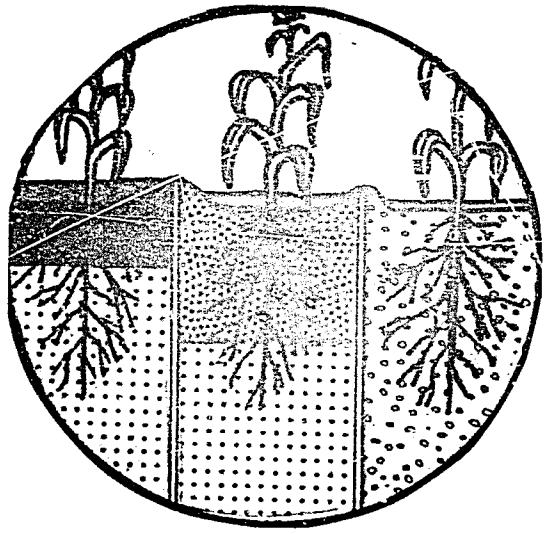
On steep slopes there is greater danger of erosion than on flat land.



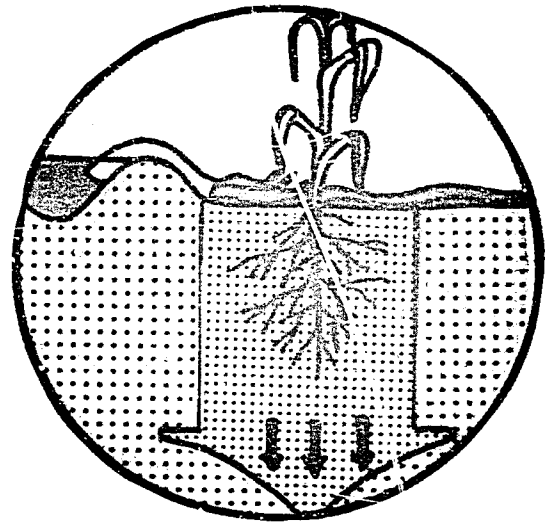
BASIC IRRIGATION CONCEPTS



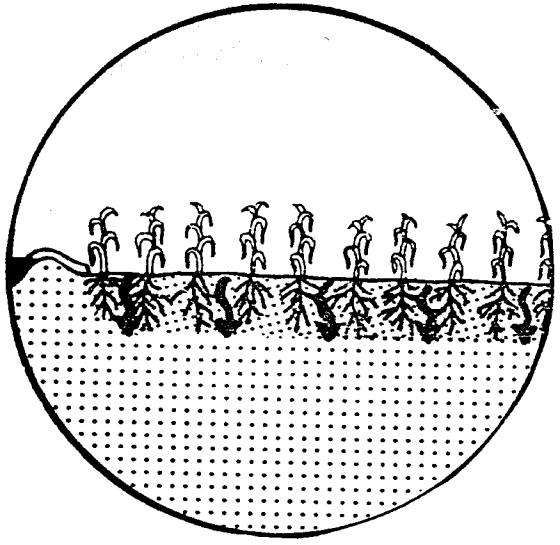
1. Water holding capacity



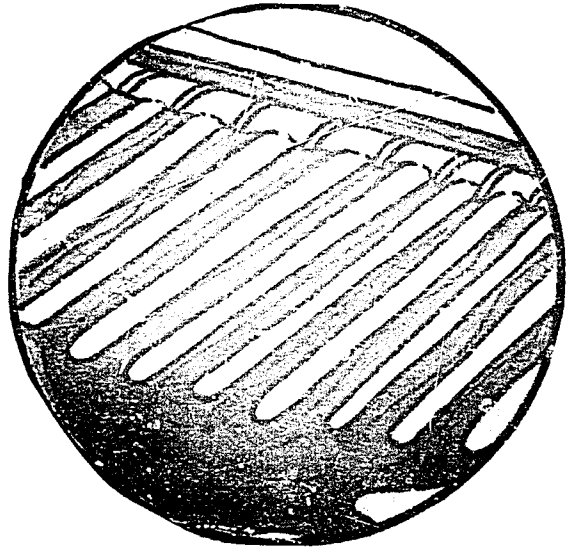
2. Water entry into soil



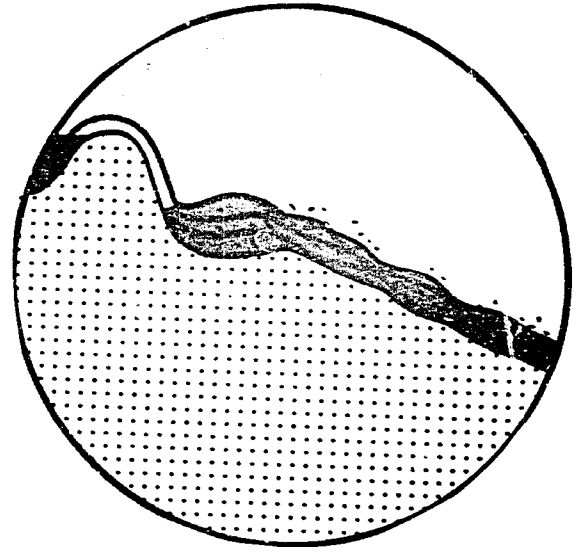
3. Deep percolation



4. Uniformity of water penetration



5. Runoff



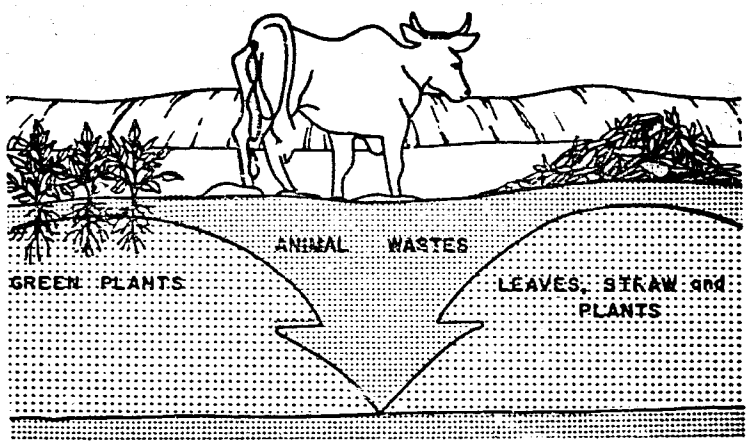
6. Erosion

Concept 1.

WATER HOLDING CAPACITY

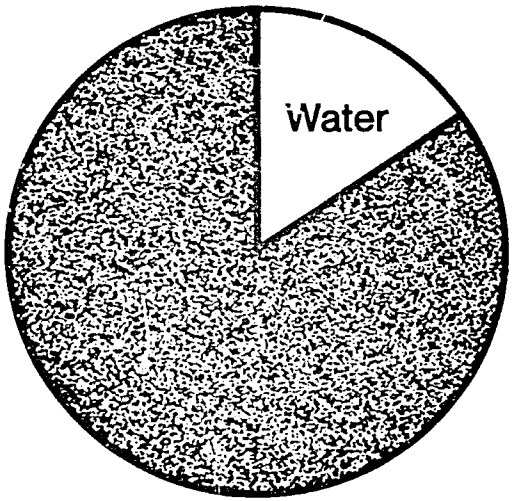
The soil in which the crop's roots grow is the reservoir from which plants can take their water. The amount of water which a soil can store within reach of the plant depends on the texture and structure of the soil and the depth to which the roots grow.

Organic matter within the soil helps increase the soil's capacity to store water. The best plants and plant residue for improving a soil are green legumes such as alfalfa, clover, peas and beans.

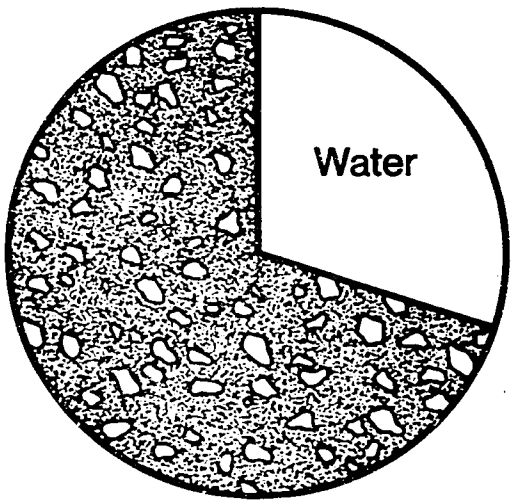


Sources of Organic Matter

WATER HOLDING CAPACITY



Soils low in organic matter



Soils high in organic matter

The Effect of Soil Texture and Structure on Water Holding Capacity

SOIL TEXTURE

Sandy or Coarse-Textured Soils

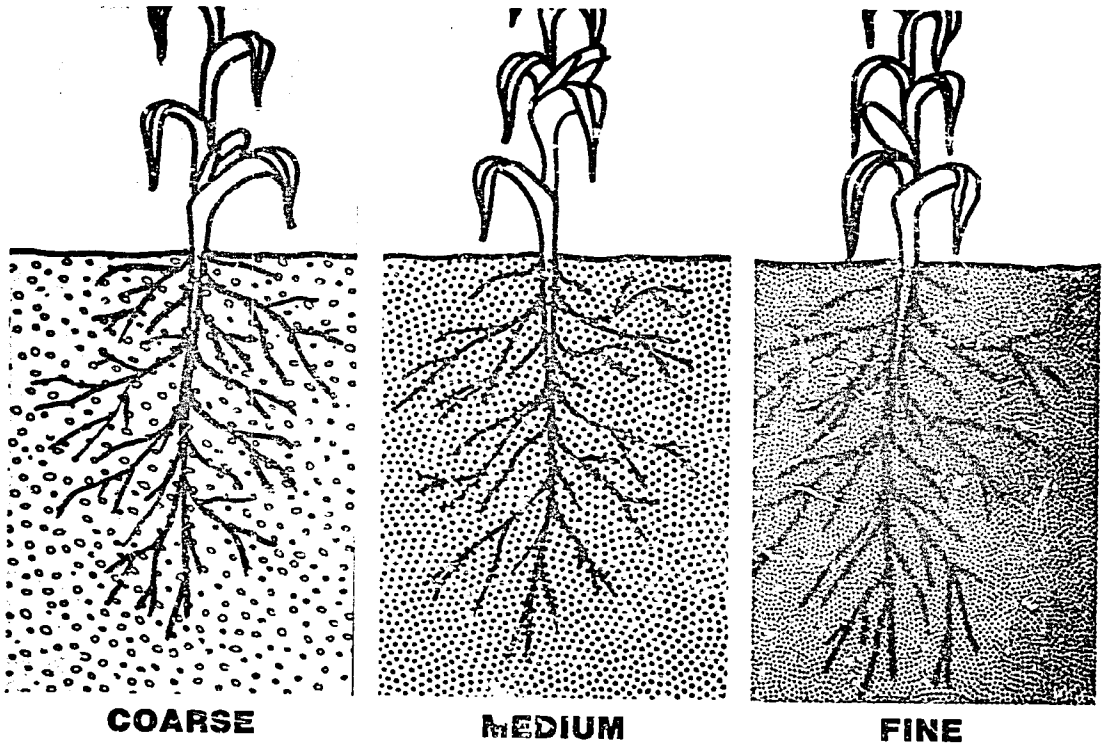
- contain much sand
- are rough when rubbed between the fingers
- are easy to plow and till
- do not form clods when dry
- generally these soils have ***low*** water holding capacity

Medium-Textured Soils

- contain coarse, medium and fine (clay) particles in almost even amounts
- form clods when dry which are easily broken with a pick, shovel, disc or other tillage equipment
- generally these soils have ***good*** water holding capacities.

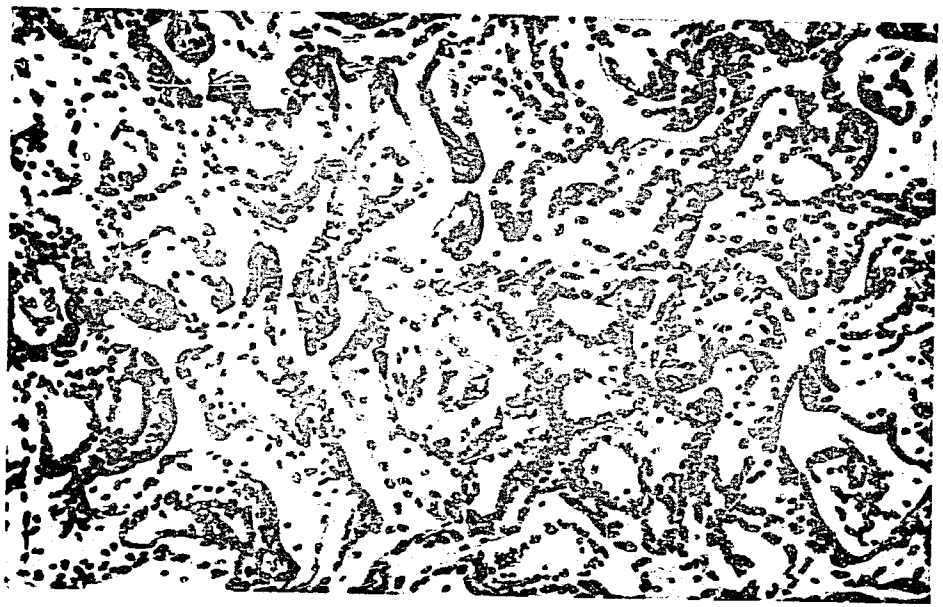
Clayey or Fine-Textured Soils

- contain many fine particles
- are hard to plow if they are not wet
- form cracks on soil surface when the soil dries
- form very hard clods when dry
- these soils have ***high*** water holding capacity



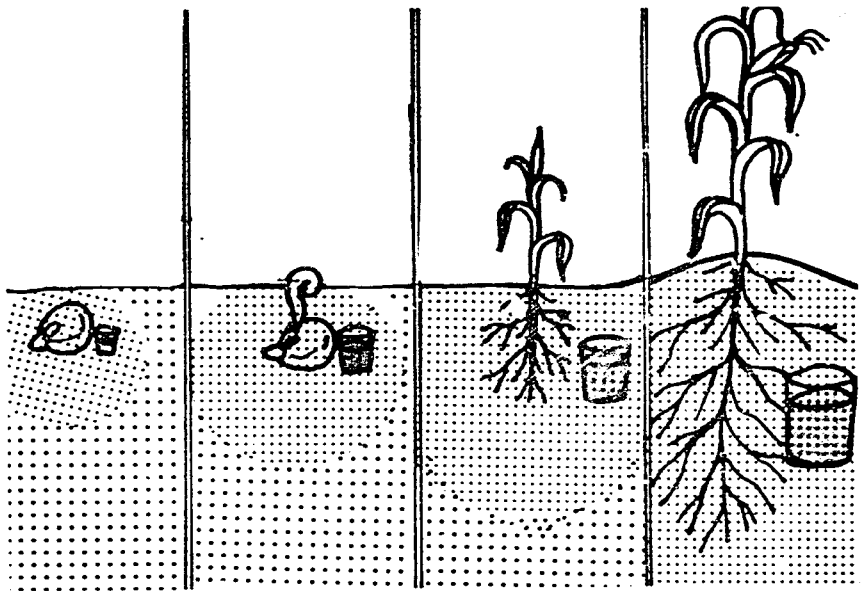
SOIL STRUCTURE

Structure is the way soil particles are held together. Soils with good structure have different sized clumps of soil particles held together by decomposed organic matter. Well-structured soils can hold more water and air for plants to use.

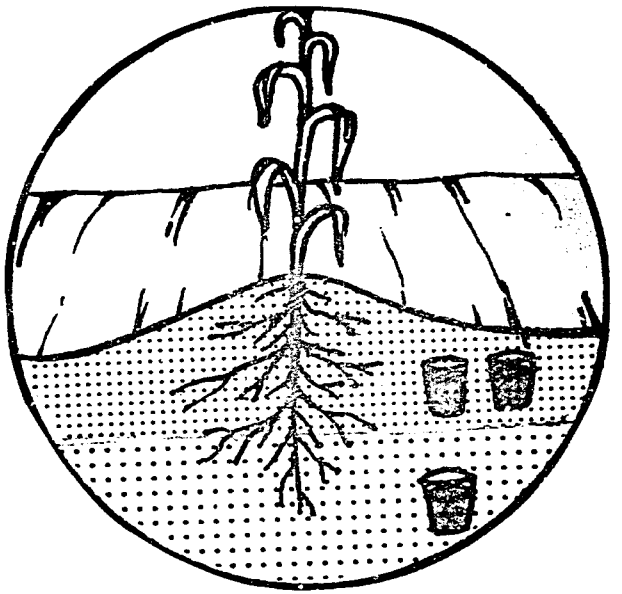


ROOT DEPTH

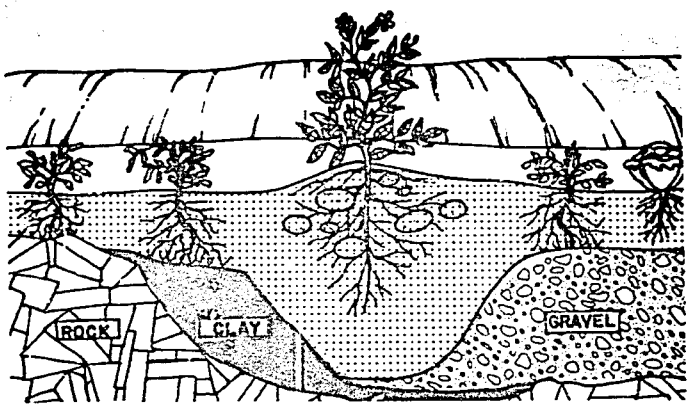
Root depth increases with plant development until the plant is full grown unless the plant roots encounter obstacles. Thus, the moisture reservoir available to the plants expands as the root depth increases.



The area where roots are present is called the root zone.

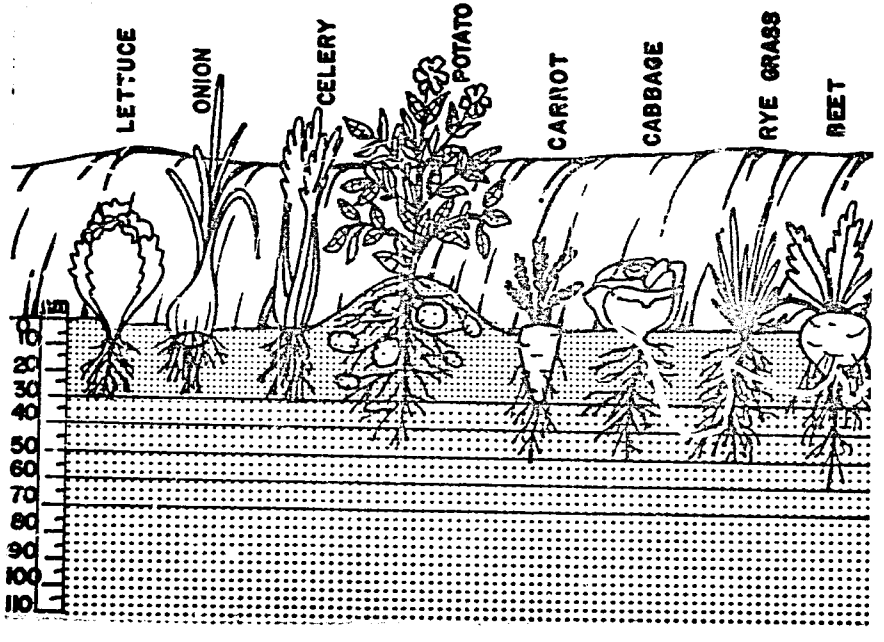


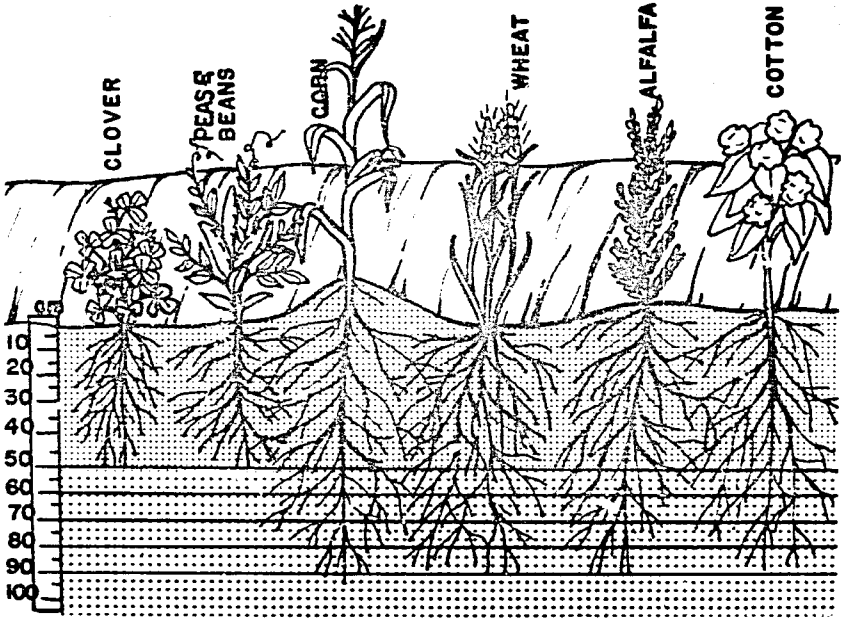
Plants use more water from the upper part of the root zone because that is where they have more roots.



The maximum depth of roots depends on the crop and on the depth of good soil.... Layers of rock, hard soil, gravel, salts or other obstacles limit the reservoir capacity of the root zone.

Where roots do not encounter obstacles in soils, they will reach to at least the following depths when they are fully developed.





Concept 2.

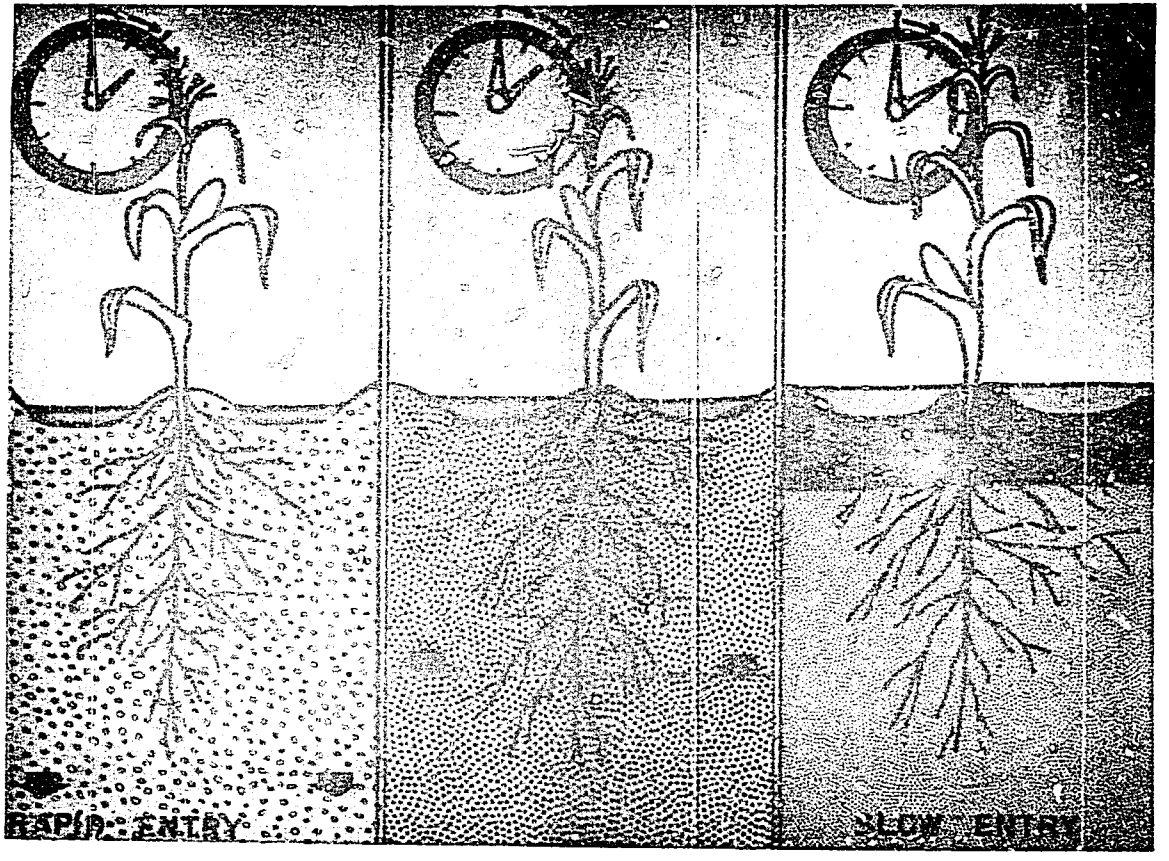
RATE OF WATER ENTRY INTO SOIL

(infiltration or intake rate)

How quickly water can penetrate into a soil varies with the kind of soil, the amount of moisture already present in the soil and the condition of the soil surface.

Water penetrates faster

- through sandy soil than clay soil
- through dry soil than wet soil
- through well-structured soil than compacted soil
- early in the irrigation season than later.

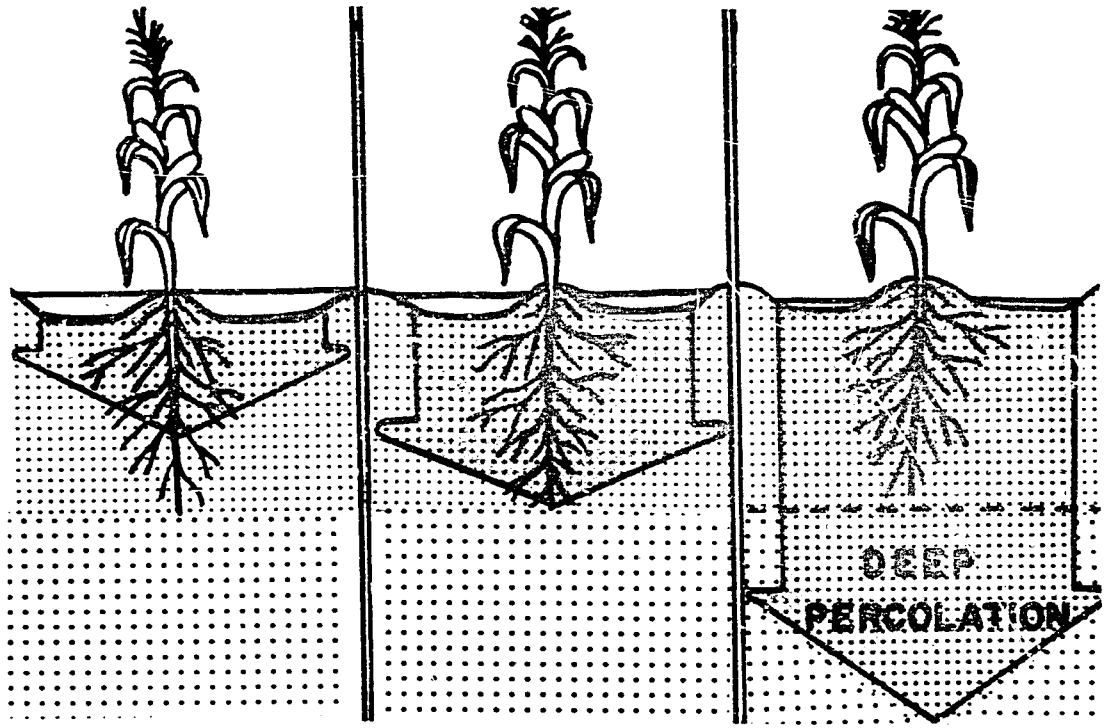


Concept 3.

DEEP PERCOLATION

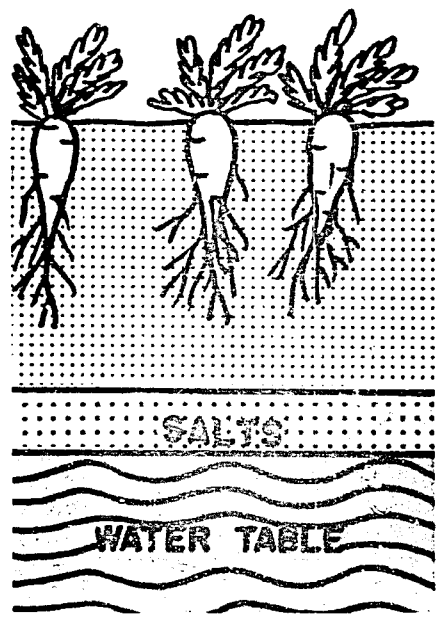
The penetration of water below the root zone is called deep percolation. Sometimes it is necessary to apply excess water so accumulated salts can be washed from the root zone.

This excess water may be costly, and it carries nutrients away. Thus, it should be limited to the amount necessary to eliminate harmful salts from the root zone.

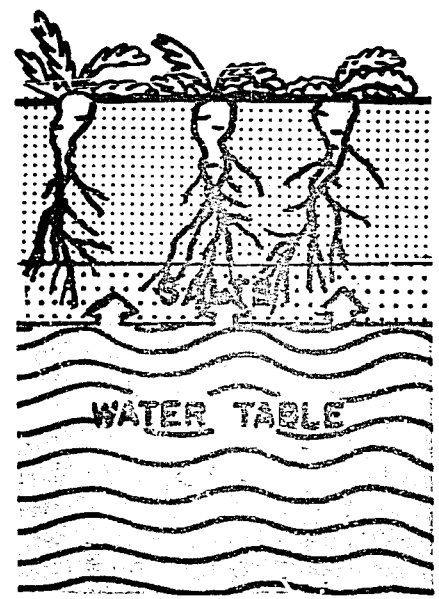


Soils with flat, impermeable layers or high water tables will have their drainage problems compounded by deep percolation in the following ways.

- soils can become waterlogged
- a rising water table can bring more harmful salts into the root zone

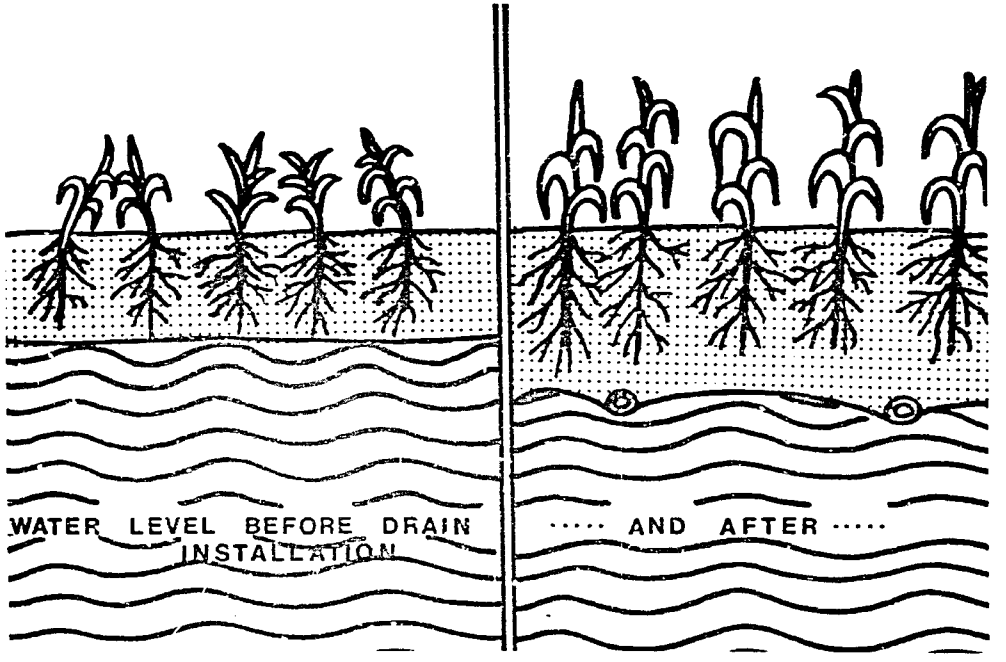


Desired

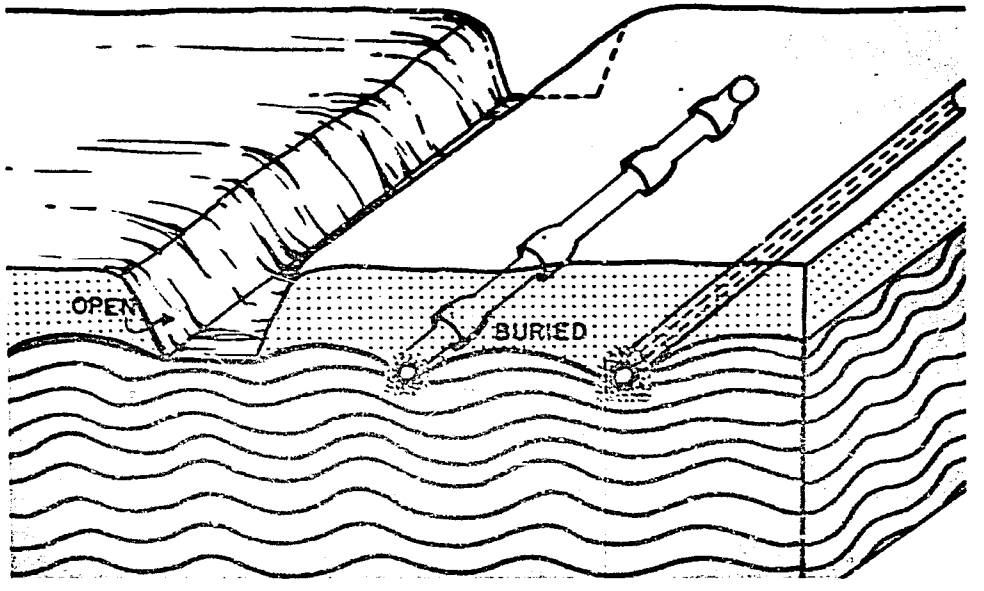


Undesired

When the water table rises to the point where crop production declines, the resulting drainage problem will have to be eliminated by constructing a costly drainage system.



The drainage system may consist of open drains or buried drains. The design and construction of these generally require technical assistance.

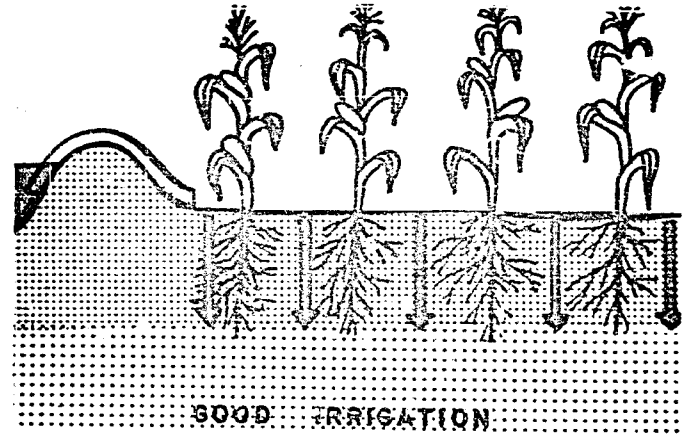


Concept 4.

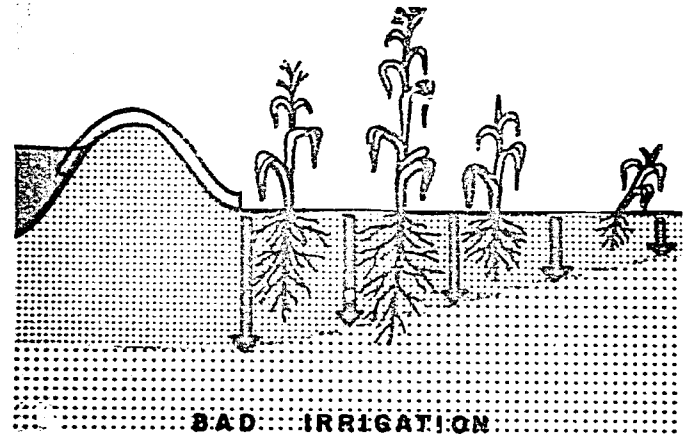
UNIFORMITY OF WATER PENETRATION

In a uniform irrigation, water penetrates to the same depth or about the same depth over the entire field.

Uniform penetration of water results in a uniform crop.

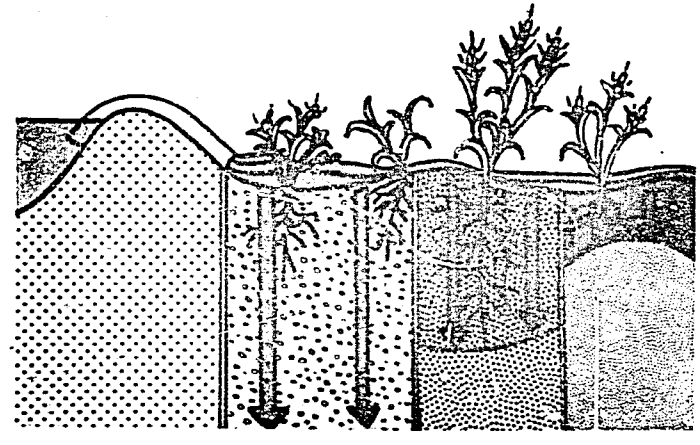


Non-uniform penetration of water creates uneven growth and yield.



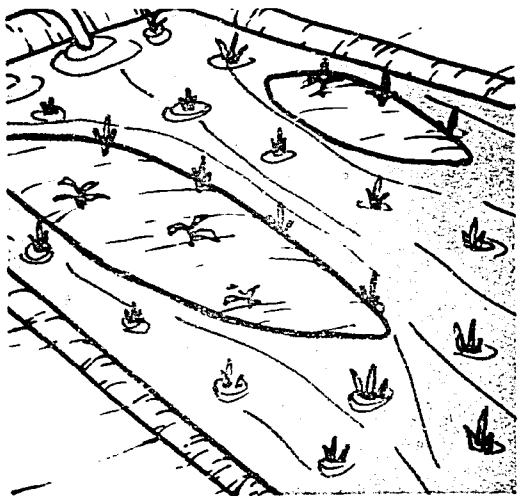
Causes of non-uniform penetration:

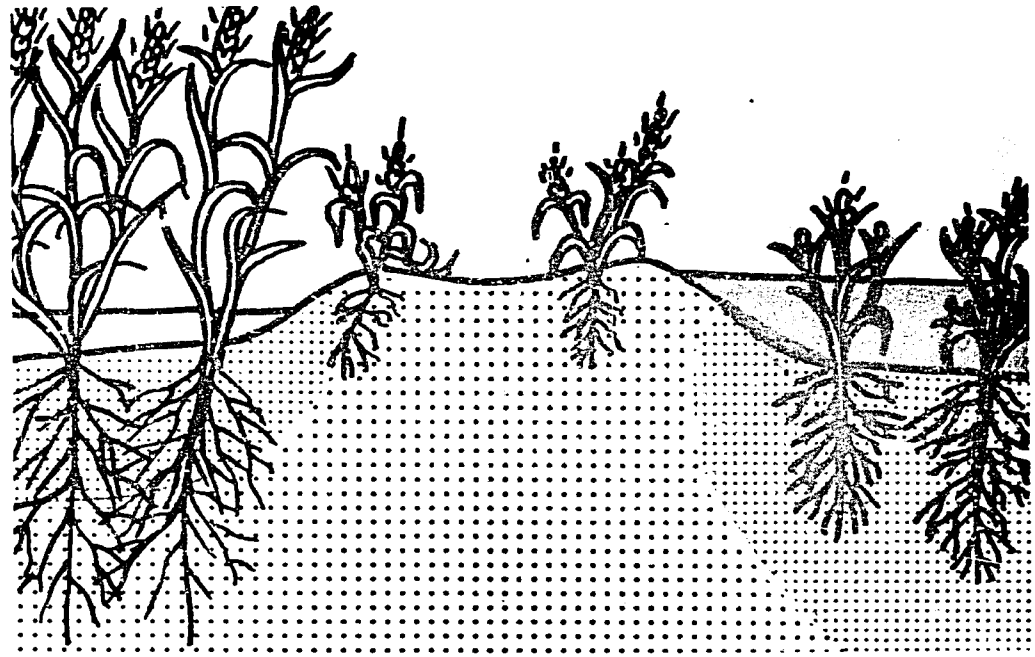
- variations of texture within the field
- uneven soil surface
- improper water management



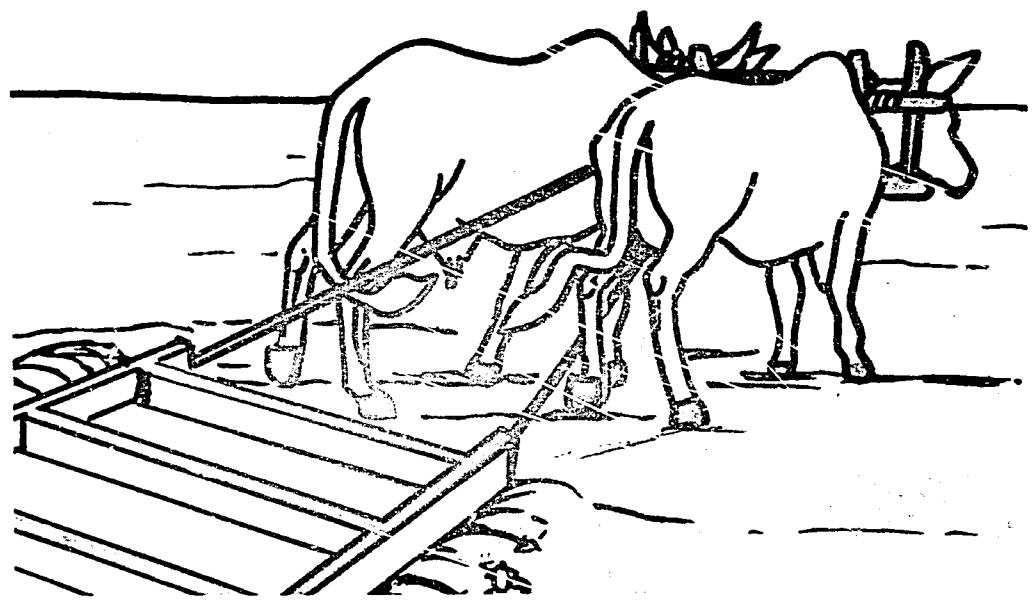
When the terrain is very uneven

- low spots receive too much water
- high spots remain dry
- water flowing through low areas can quickly erode the soils





Planing or leveling the field can eliminate problems of uneven water distribution due to uneven terrain, but technical assistance should be used when precision land leveling is required.



Concept 5.

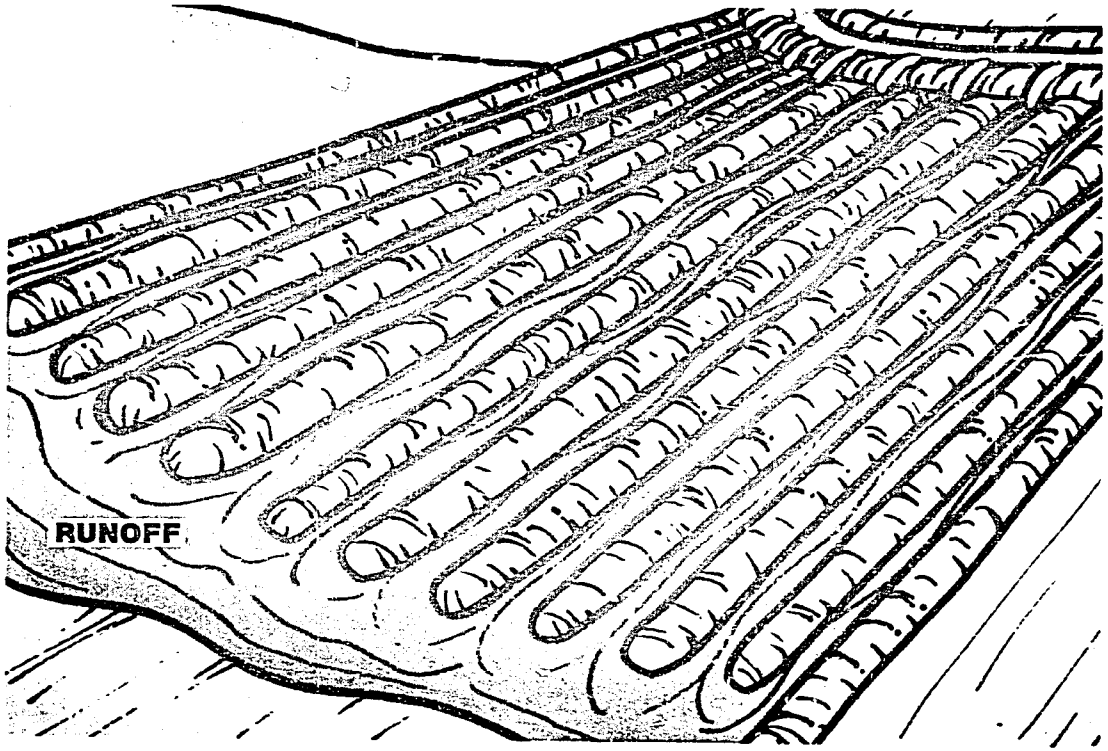
RUNOFF

Runoff is water that does not penetrate the soil and flows out of the irrigated field, or water which runs off of the high spots in a field and accumulates in the low areas.

On steep slopes runoff can erode fields and drains.

If irrigation water is scarce, runoff may be an unnecessary loss of precious water.

There are ways, discussed later, to reduce or eliminate these losses.



Concept 6.

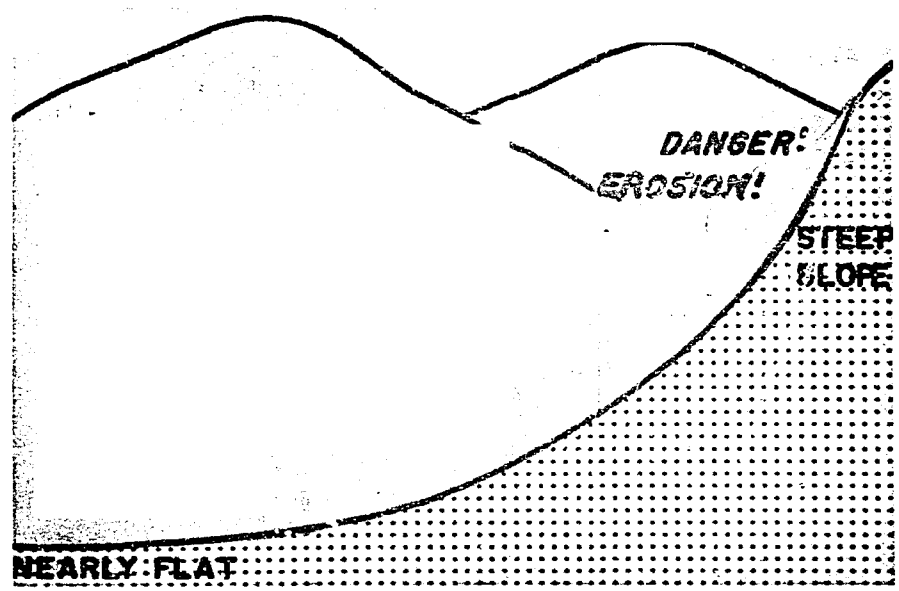
EROSION

Erosion due to irrigation occurs when water moves so fast over the soil surface that it begins to move soil particles. Slope, crop type, and water control together determine the amount of soil loss.

Slope is the steepness, grade, or inclination of a field.

Slope is a factor which determines what irrigation system to use and what methods or structures of water control are necessary for avoiding erosion.

Nearly flat terrain has very little slope.



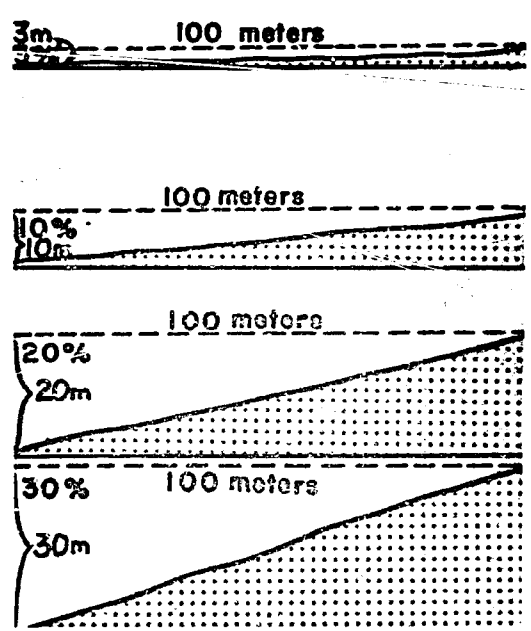
SLOPE: The slope of a field is measured in percent.

3%:Terrain rises or falls 3 meters in 100 meters.

10%:Terrain rises or falls 10 meters in 100 meters.

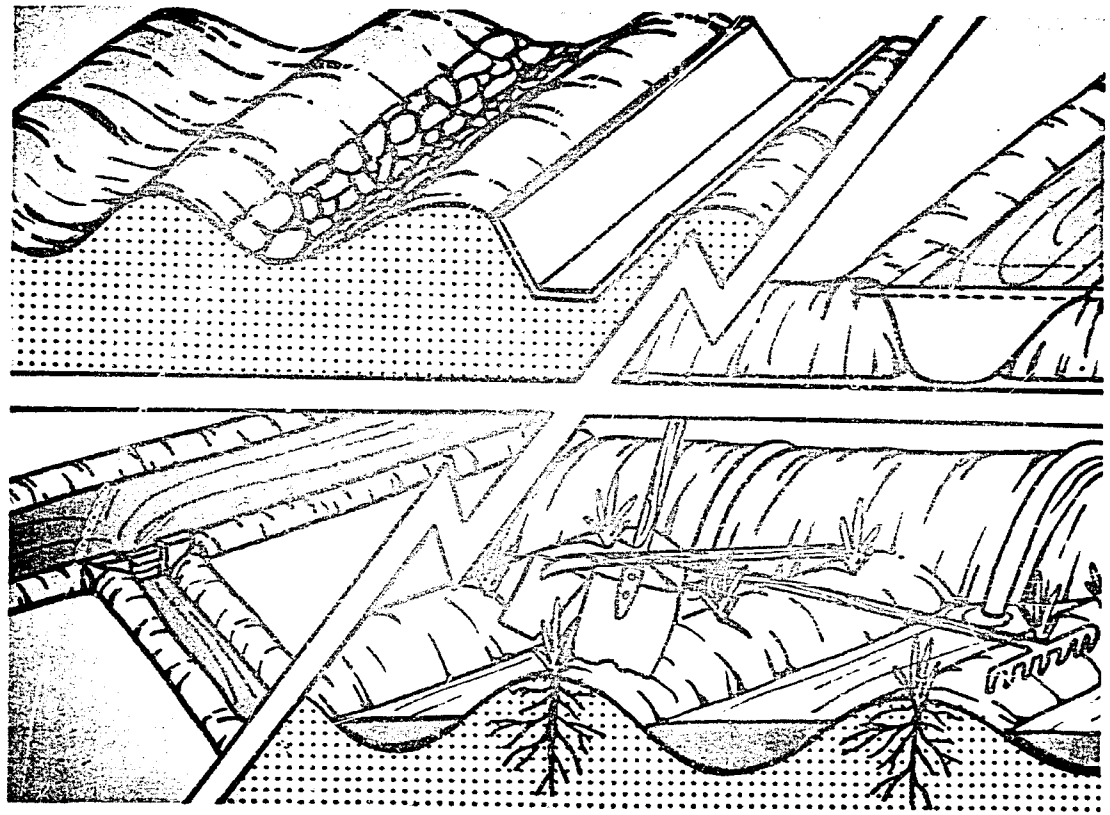
20%:Terrain rises or falls 20 meters in 100 meters.

30%:Terrain rises or falls 30 meters in 100 meters.



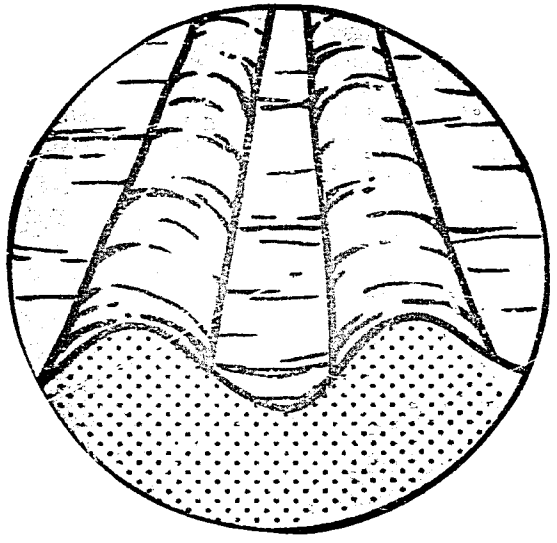
As slope increases, the danger of erosion increases.

STRUCTURES AND TOOLS FOR WATER CONTROL ON THE FARM

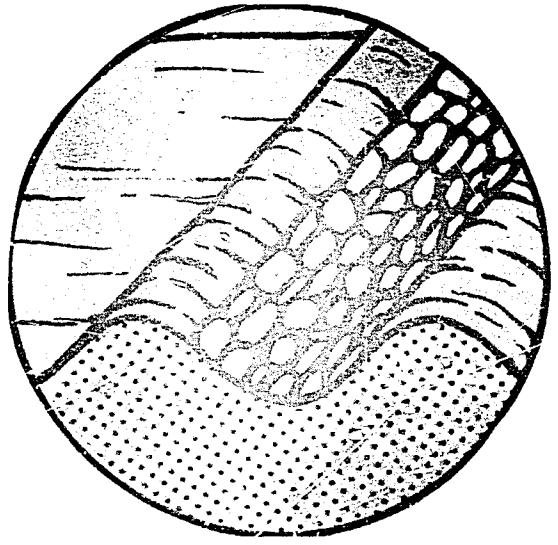


Canals, Drains and Other Farm Installations

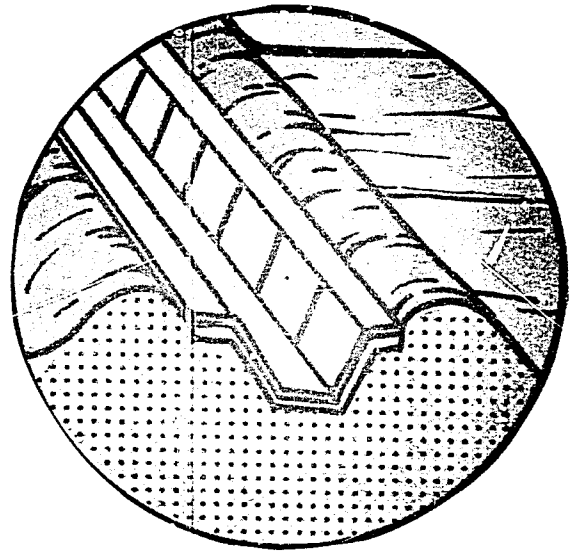
1. Canals and drains transport water.



Unlined

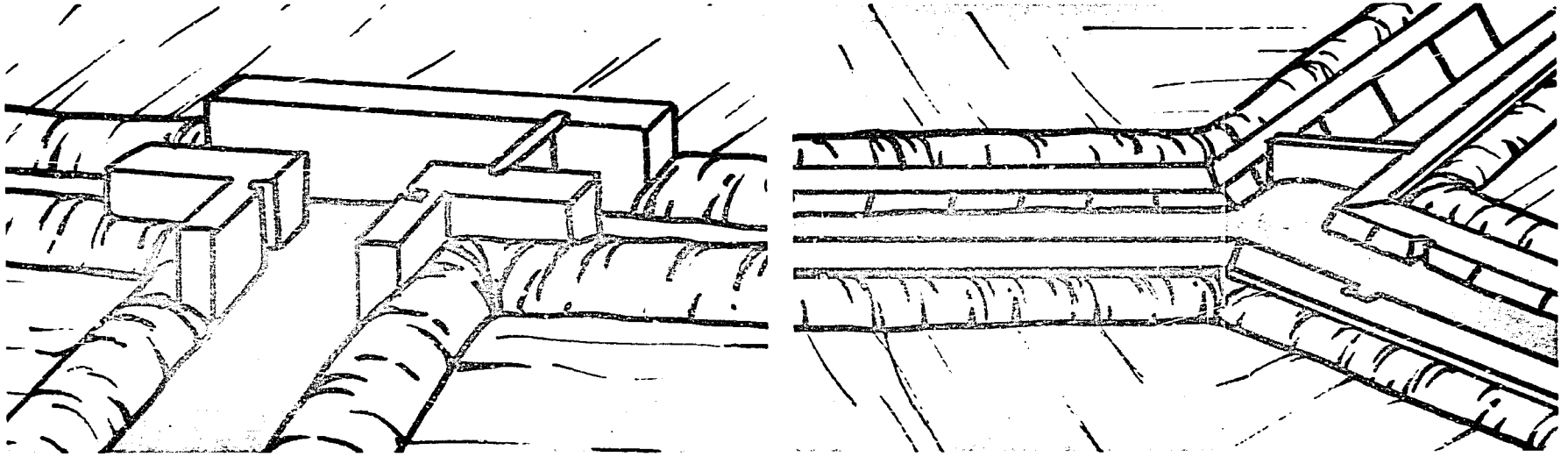


Rock masonry

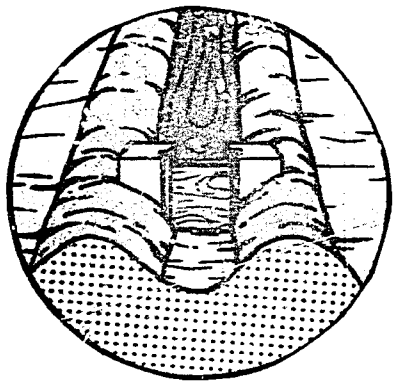


Concrete

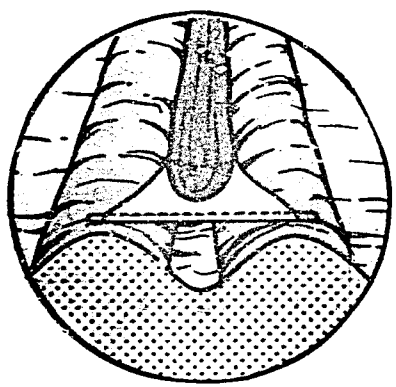
2. Flow division structures proportion the required water to the irrigated areas.



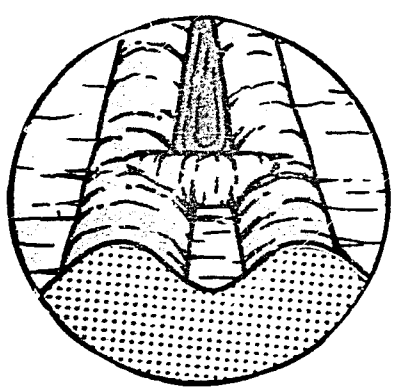
3. Check dams raise the water in the canal for distribution to other canals and to the field.



Wood, rock masonry, concrete

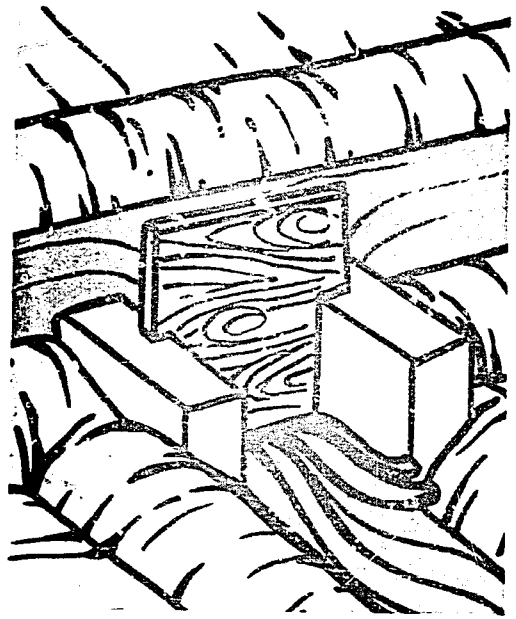


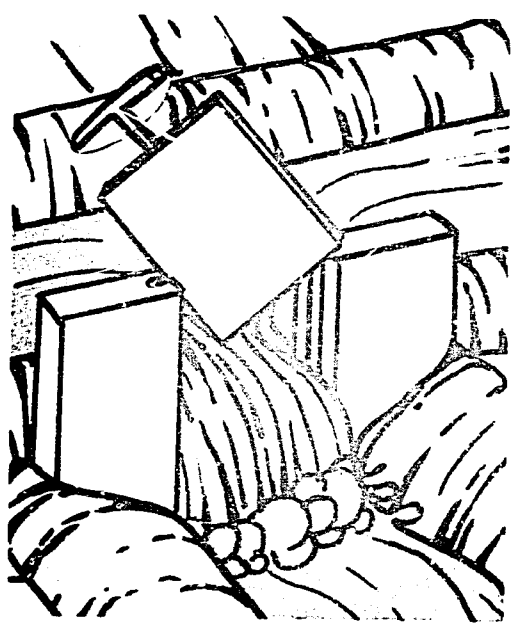
Canvas or plastic

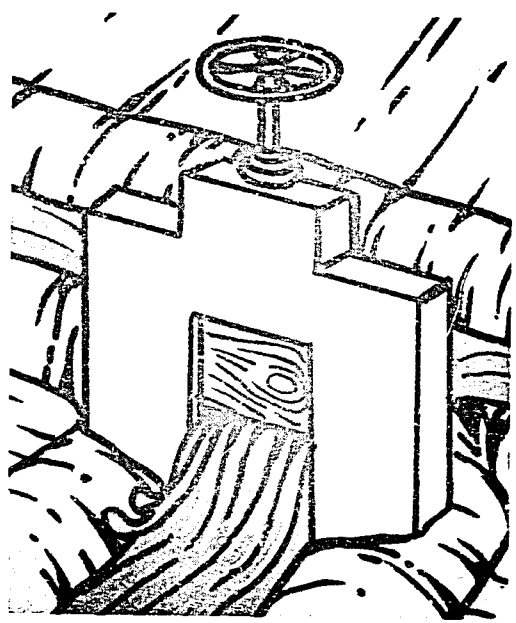


Sod or soil

4. Headgates control the flow of water from the canals.







Conservation and Maintenance of Canals, Drains, and Other Installations

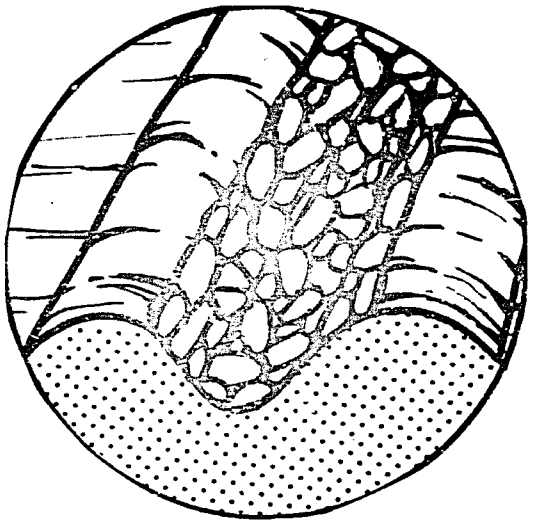
Canals can be eroded very easily, especially on steep slopes. The following methods can help prevent canal erosion.

1. Construct your canals with very little slope — usually with a slope of one-half-percent or less (50 cm/100 m or less).

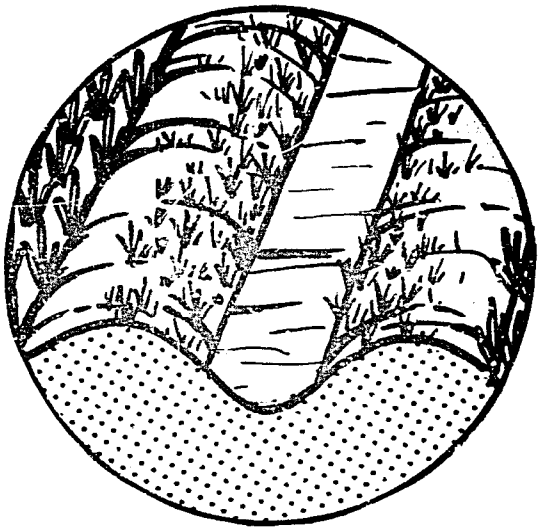
2. You may consider using the following:

   - rock masonry or concrete lining
   - grasses of a suitable kind to hold the soil in place.
   - on steeper slopes, drop structures to bring the water down in steps. Be sure to protect the downstream side of the structure.

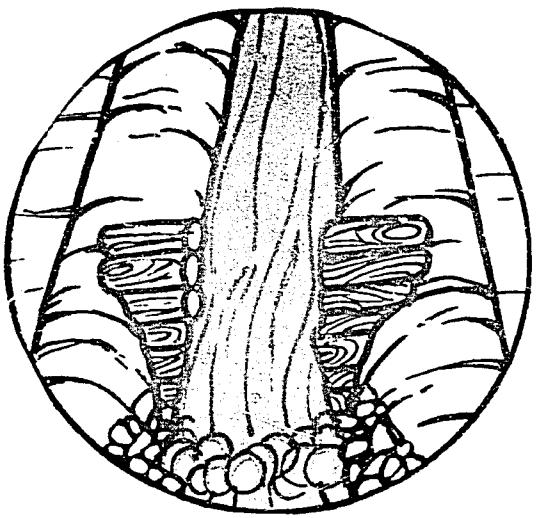
   Do not build drop structures that allow water to fall more than 30 cm without technical help.



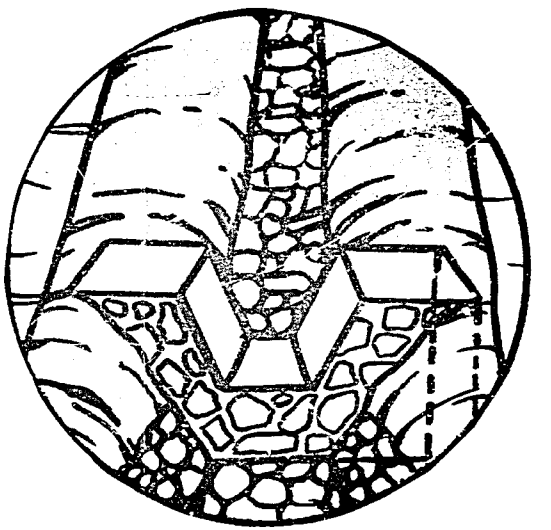
Rock masonry



Grass



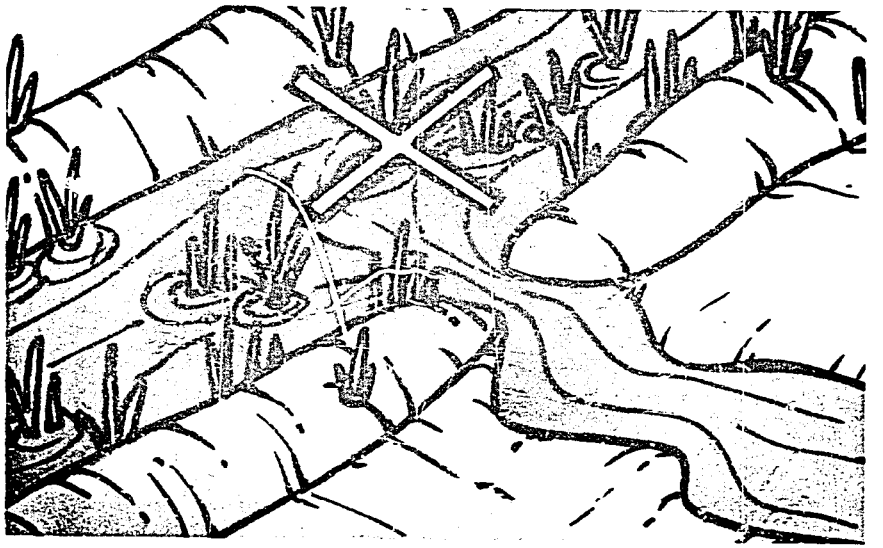
Wood



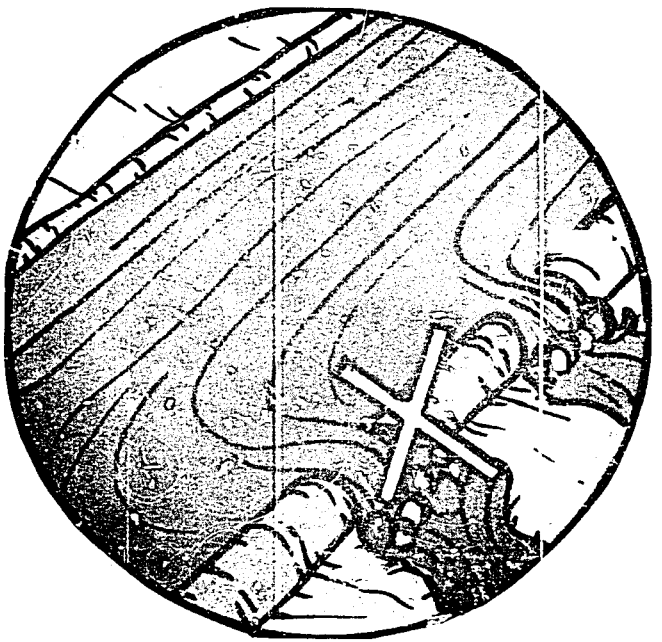
Rock or concrete

All water control structures must be periodically checked and maintained. Follow these recommendations:

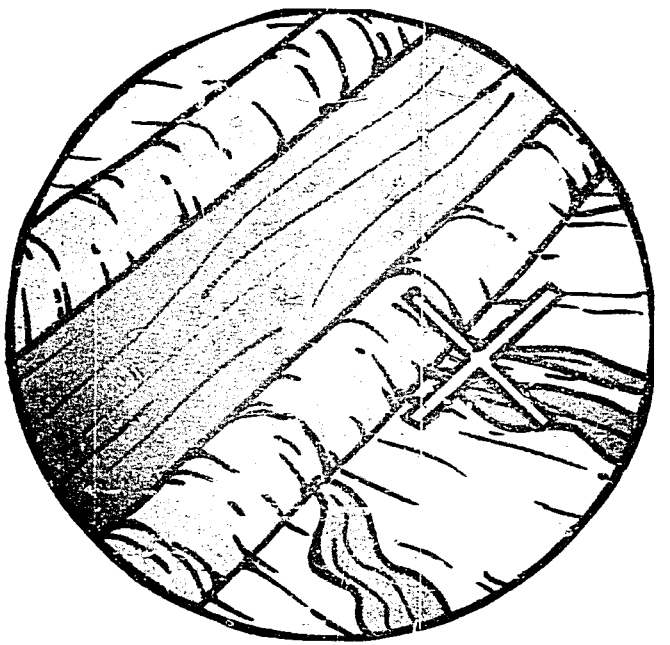
1. Don't let weeds and trash restrict the flow of water. Clean the canals and raise their banks when necessary.



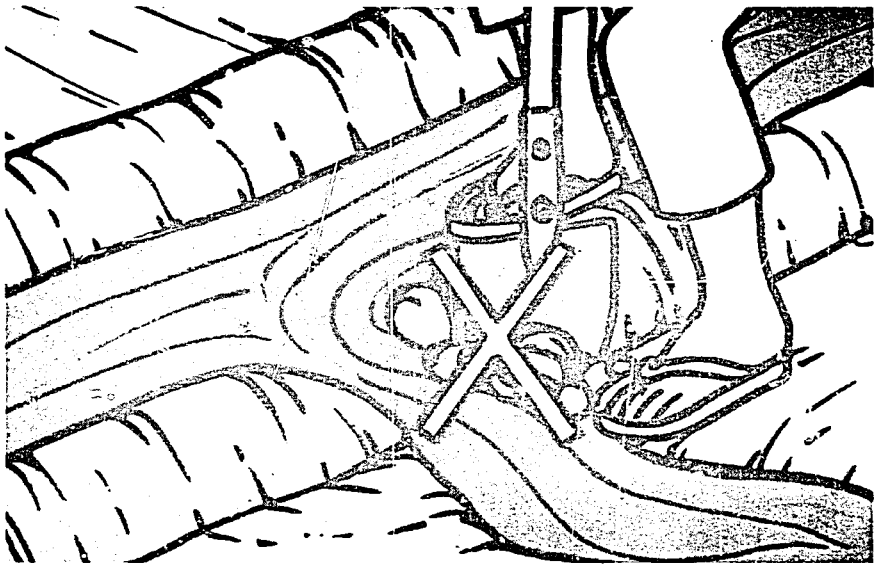
2. Don't put more water in the canal than it can carry.



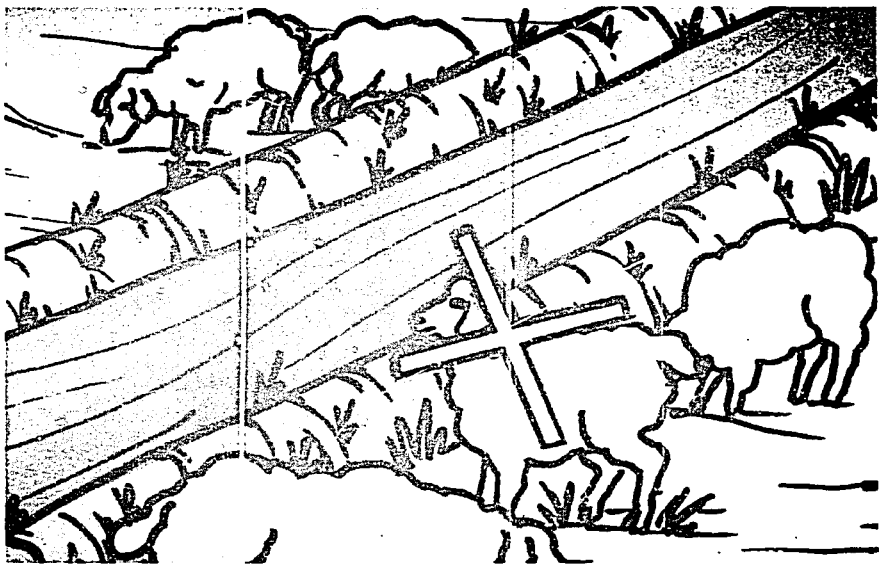
3. Don't let water seep through the canal banks. This usually occurs over fractured rock, sandy soil, or where animals have dug holes in the banks. Line the canals with concrete or clay in places where they would lose much water through seepage.



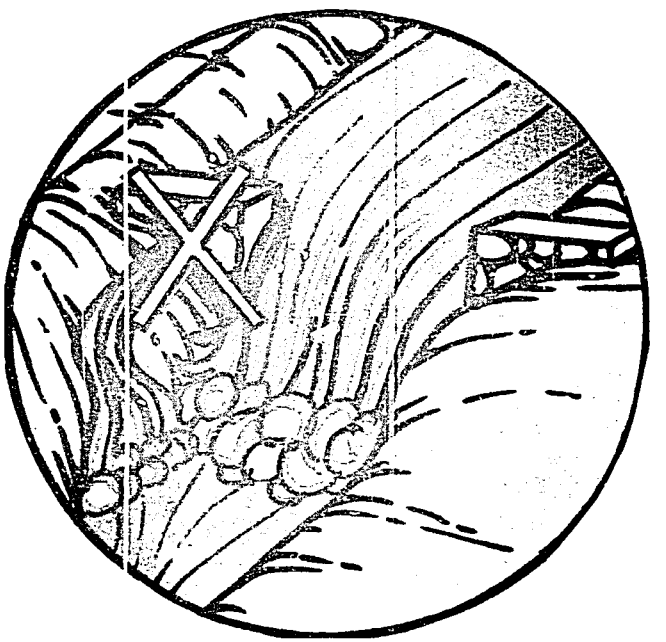
4. Don't cut ditchbanks just anyplace when water is needed. Select a few places and use the appropriate outlet structure.



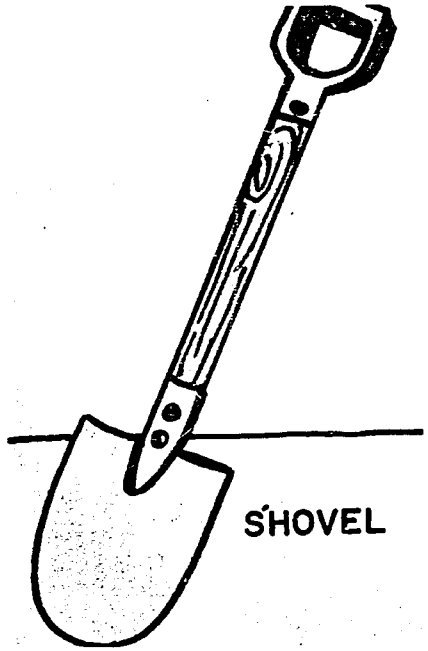
5. Don't pasture animals in the canal or on its banks. They destroy the banks and protective vegetation.

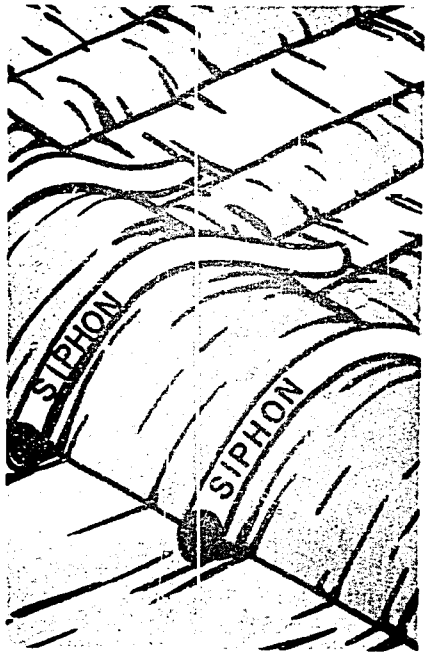


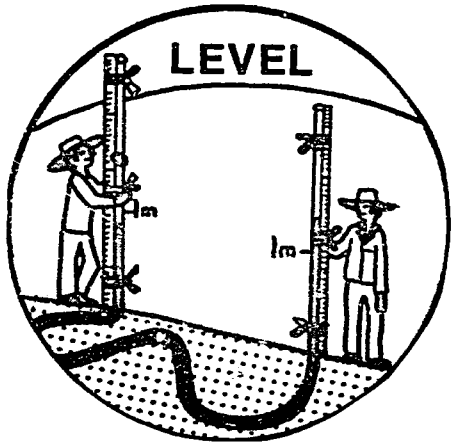
6. Don't let breaks in the structures go unrepaired. Fix them before they become serious.

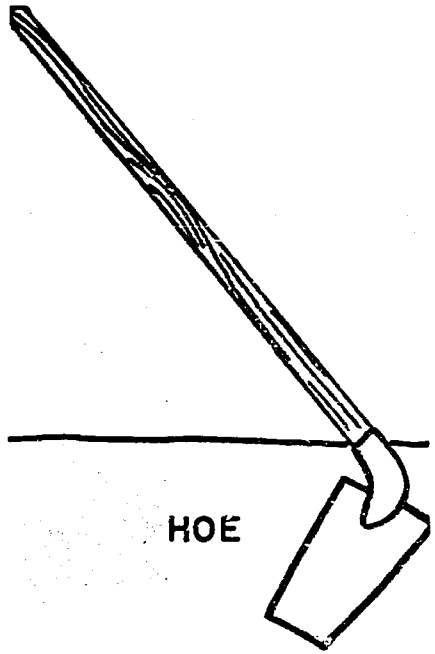


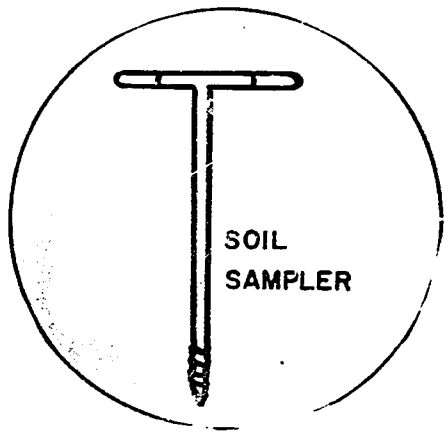
IRRIGATION TOOLS

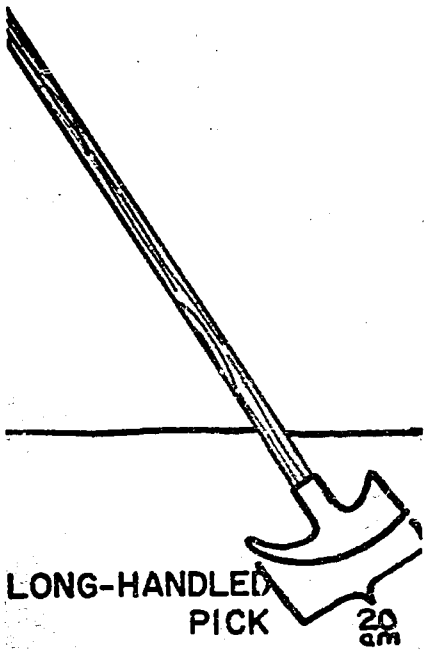


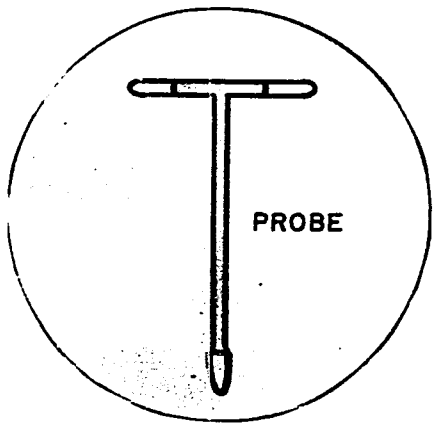


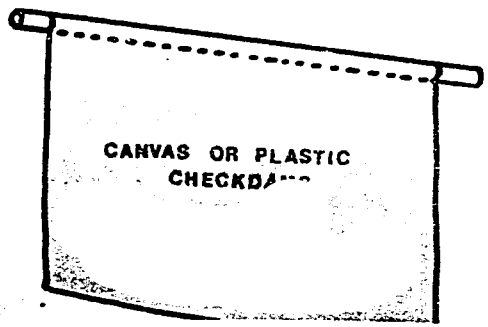


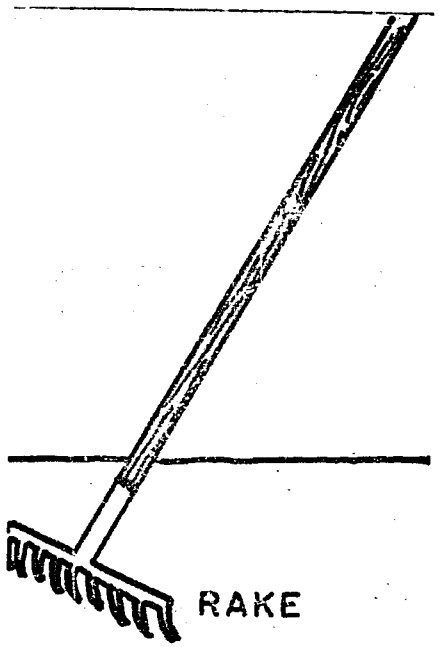












Because the construction and use of siphons, soil probes and soil samplers are not known to many farmers, these simple and effective irrigating tools are explained here.

SIPHONS

Siphons are curved tubes used to take water from a canal into a field.

WITH SIPHONS

- it is easy to control the amount of water going into furrows, borders and basins.
- water can be distributed fast, evenly, and without damaging the canal banks.

To use a siphon, the water must be higher in the canal than at the outlet of the siphon.

Siphon sizes for different uses:

1.9 cm — very short furrows

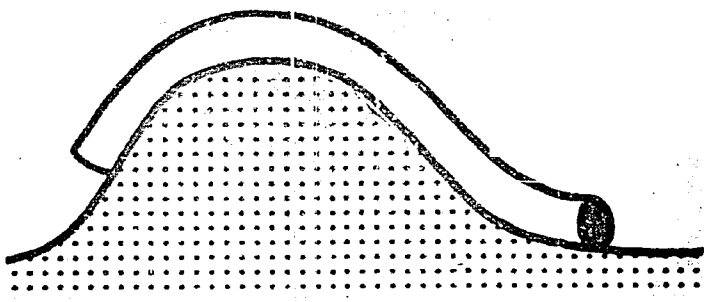
2.5 cm — longer furrows

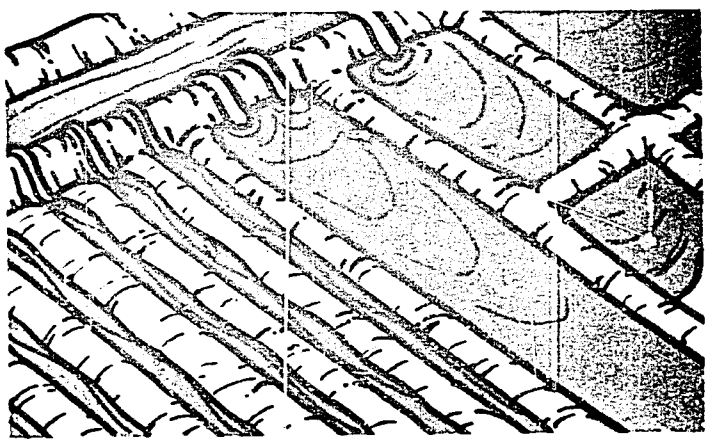
3.8 cm — long furrows or very sandy soils

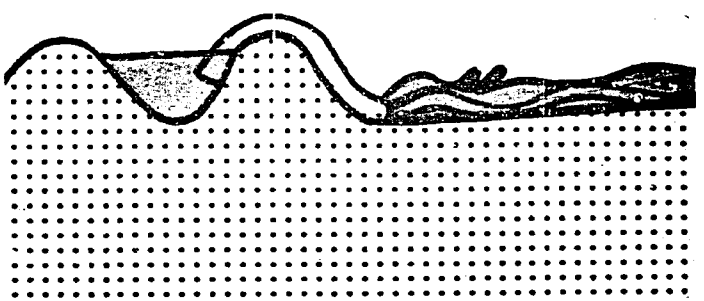
m — very large, long furrows or small borders and basins

7.5 to 10 cm — small borders and basins

12.5 to 15 cm — large borders or basins



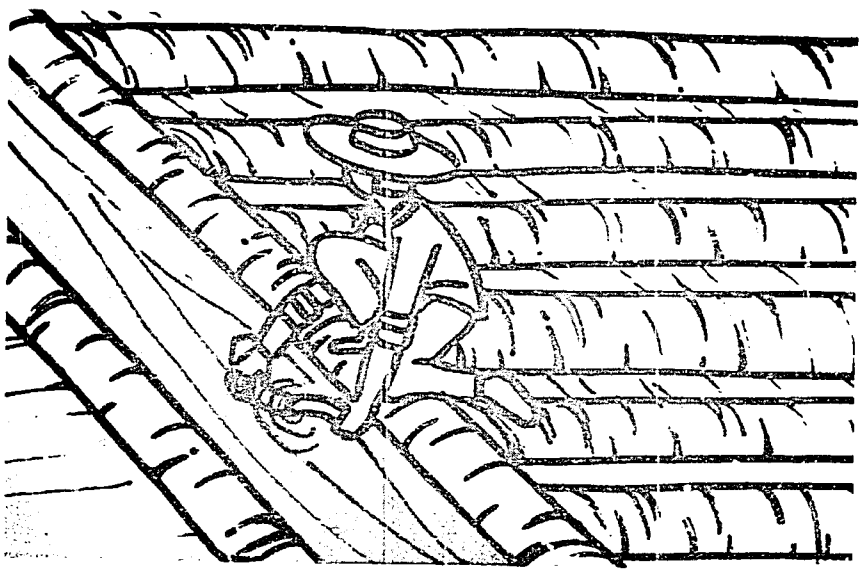




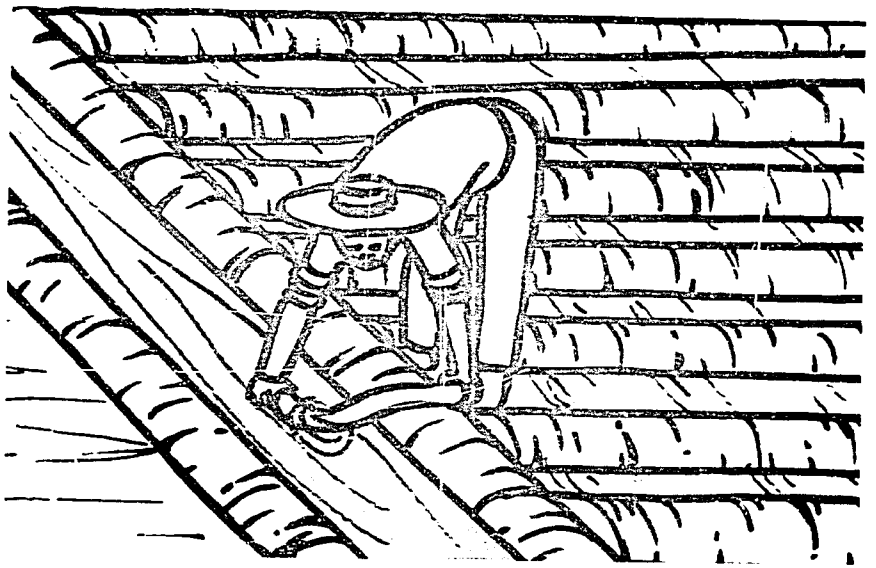
How Are Siphons Used?

1. Completely submerge the siphon in the water, with the curve lower than the ends so that the air escapes...

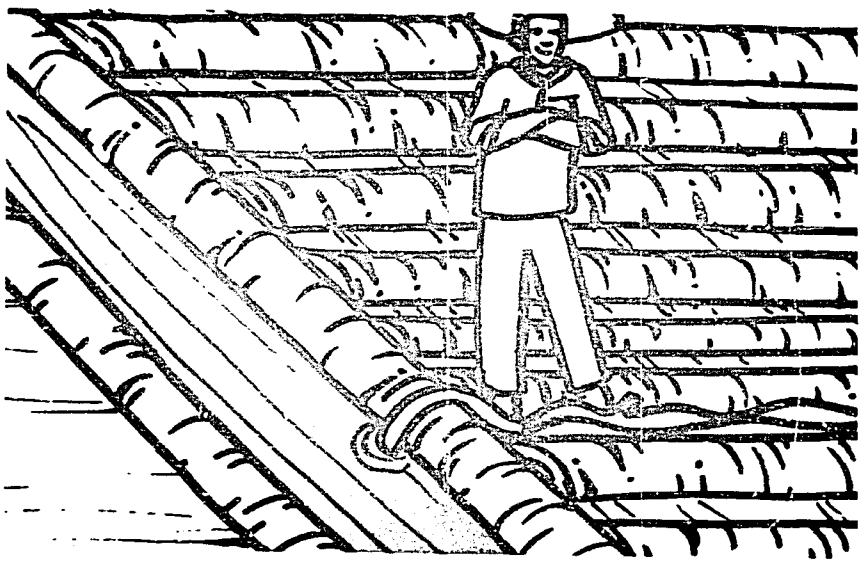
2. Place your hand over the outlet side of the siphon.



3. Take the outlet side of the siphon out of the water, keeping it covered. Leaving the other end in the water, place the outlet end of the siphon tube in the bottom of the furrow or border.

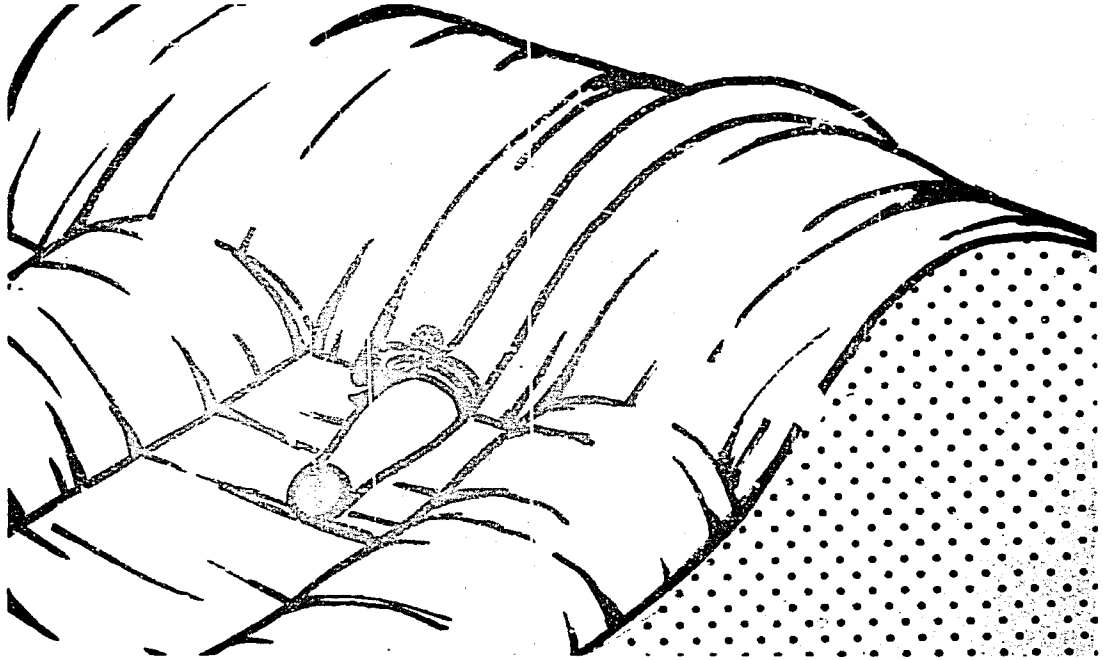


4. Take hands off the siphon, and water will flow by itself.



There are easier ways of priming siphons, but they require experience and practice. The method indicated is the fastest to learn.

To get water to flow in 7.5 to 15 cm diameter siphons (3, 4 and 5 inches), use a piece of rubber inner tube fastened over the outlet of the siphon. When the tube is full (primed), it can be twisted with one hand so that the tube stays full while the siphon outlet is pulled out of the water.



You Can Make Your Own Siphon

1. Buy as much plastic conduit of the correct size as you need at a hardware store. Conduit for electrical installations works very well. Cut the conduit to the proper lengths. 1.2 meters is usually adequate for 1 to 1½ inch siphons; 1.5 meters for 2-inch siphons.

2. Observe the form of the farm ditch banks.

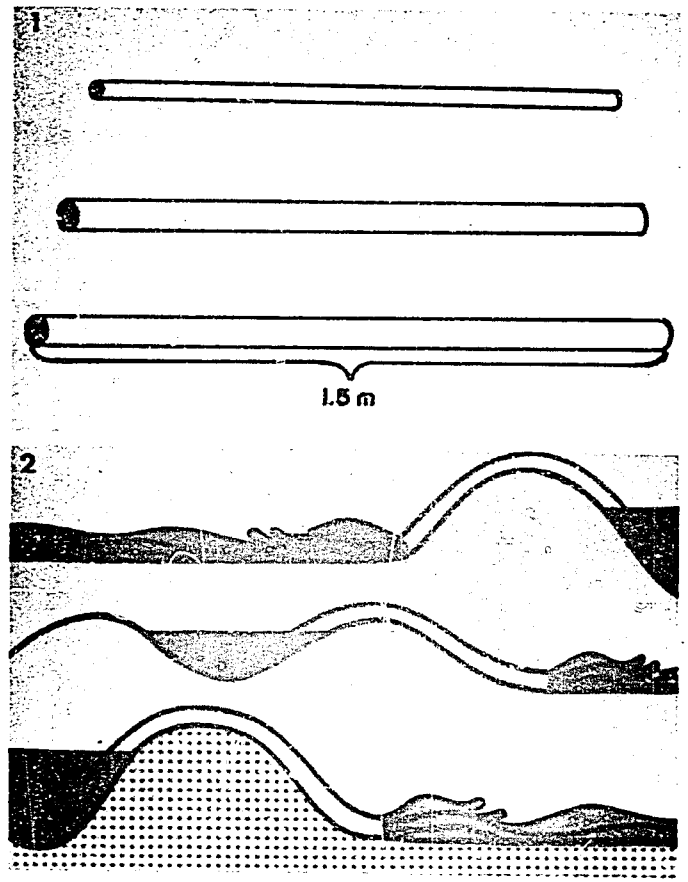
3. Make a mold with nails on a board, according to your observations.

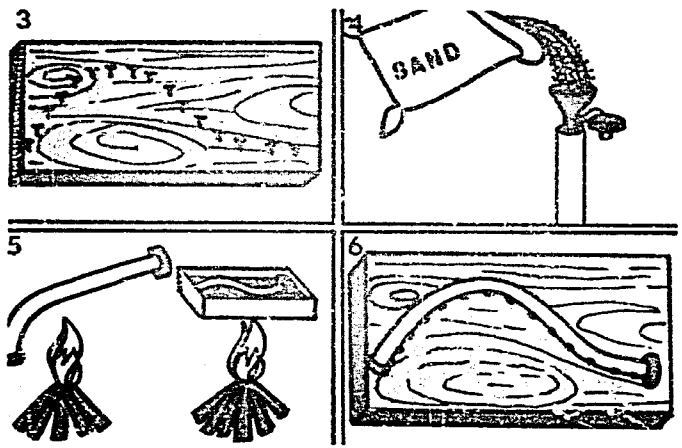
4. Fill a tube with sand and compact it.

5. Heat parts of the tube over a fire or in a very hot water (at least 92°C) or in hot sand.

6. Press the heated tube against the nails on the mold to give it shape. Continue the procedure until the tube has the desired form. Then remove the sand; the siphon is ready for use.

Siphons larger than 5 cm (two inches) are harder to make. They are usually made of metal and can be bought in irrigation equipment stores.





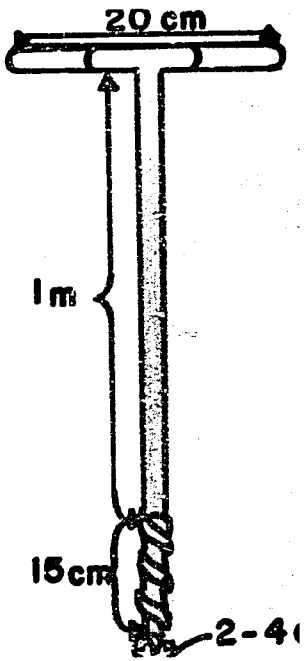
SOIL SAMPLER AND PROBE

The tools described on this page are very useful for sampling a soil to determine its moisture condition.

An auger-type soil sampler can be made easily from two metal rods welded into a 'T' and a 1¼ or 1½ inch drill bit as indicated in the drawing.

Weld the drill bit to the 'T' handle.

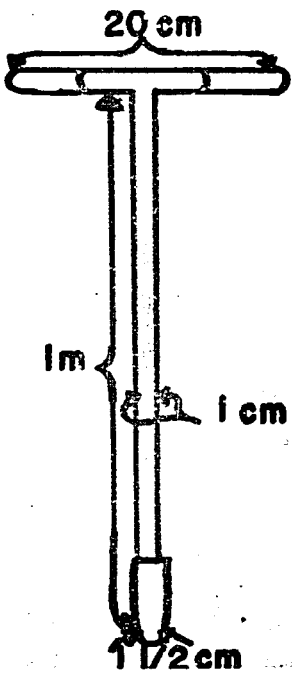
The sampler can then be introduced into the soil to obtain a soil sample from the depth desired.

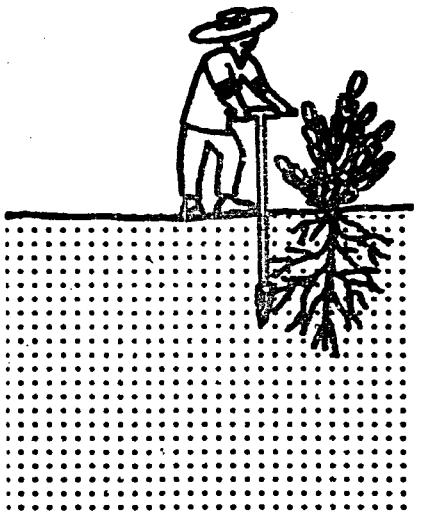


To determine how deep the water penetrates during an irrigation, construct a simple tool:

Weld a smooth round bulb to a 'T' handle.

The depth at which the round-tipped probe becomes significantly harder to push into the soil is the depth that the water penetrated during irrigation. The probe may not work on soils which are rocky or which have hardpans. Use a shovel or auger-type soil sampler instead.





LEVEL

You can construct a simple level for determining slope.

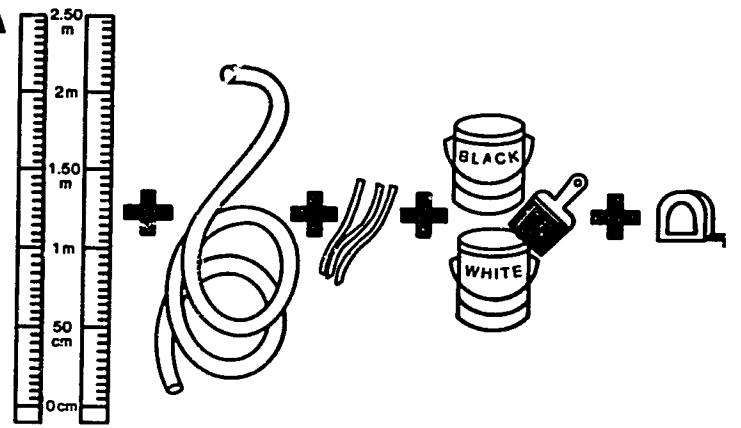
I. Gather the following materials (**A**):

1. A transparent plastic hose, 16 meters long and 1.5 to 2 cm in diameter
2. Two thin rods or boards, or other thin, rigid material about 2.6 meters long
3. Strips of wire, rubber, or string with which to tie the hose
4. Small cans of white and black paint
5. Tape measure

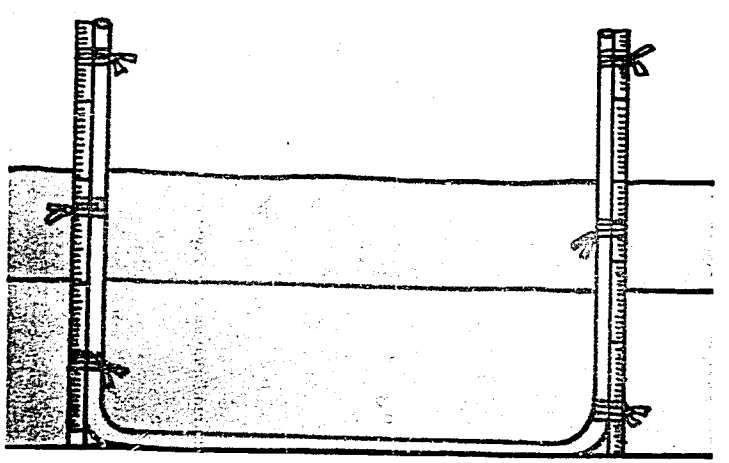
II. Construct the level.

1. Mark the rods every 5 cm, starting 10 cm from one end.
2. Tie the hose to the graduated rods so that it lies against the rods from top to bottom. (**B**)
3. Place the two rods side by side on the same level. Stretch the hose downhill on a slope. (**C**)
4. Fill the hose with water so that it rises to the one meter mark on each end of the hose. Make sure that no air bubbles remain in the hose. The simple level is complete!

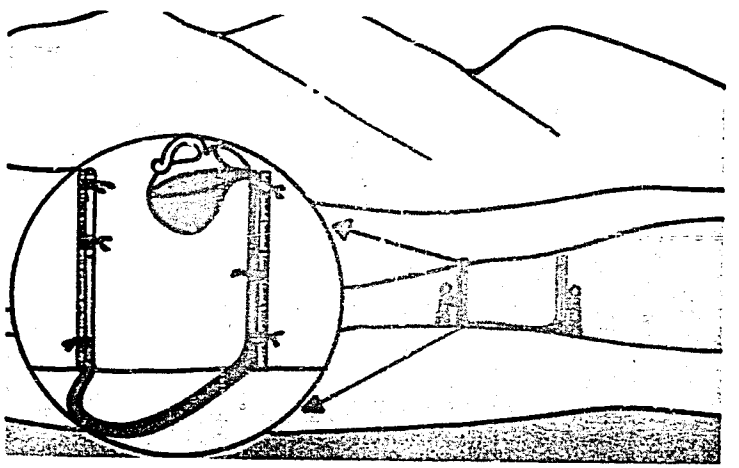
A



B



C



To use the tool to find slope:

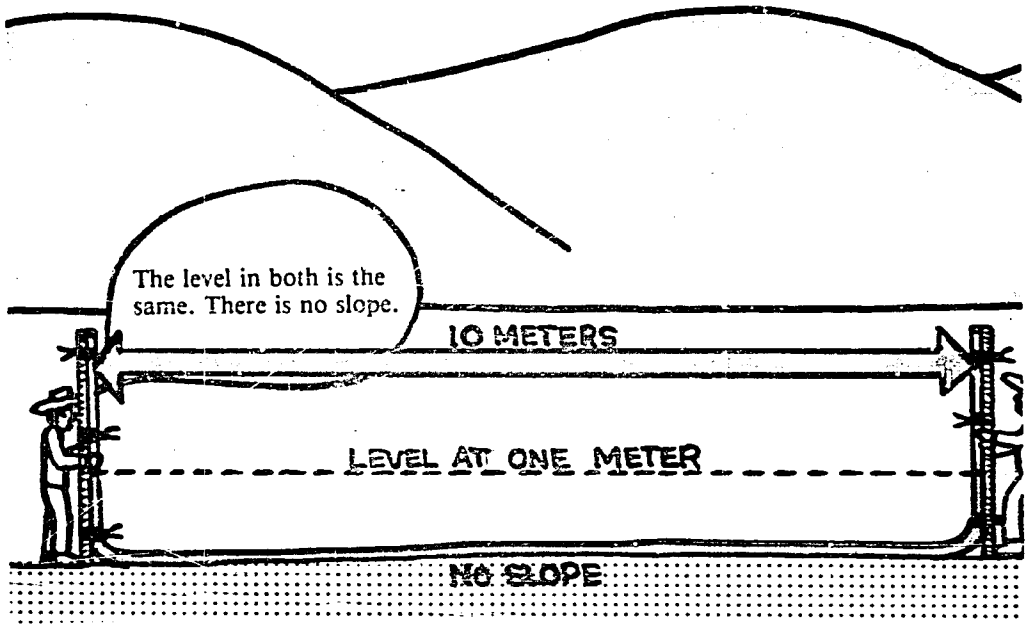
1. Separate the rods by 10 meters.

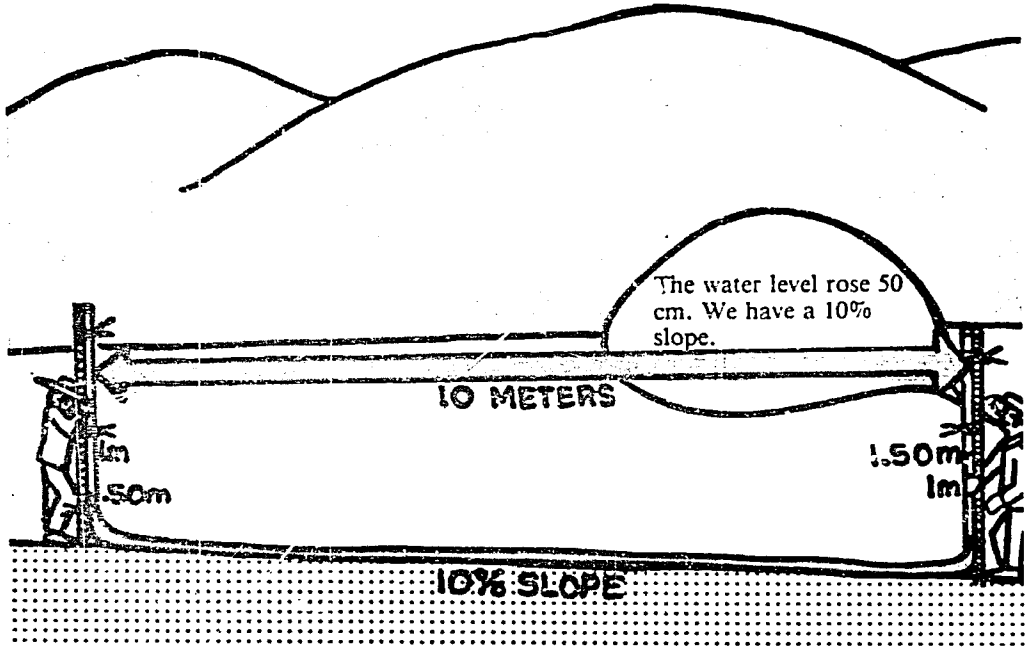
2. Note how much the water has changed in the hose. If the water level at both rods are equal, then the two points are at the same elevation. The slope between the two points is 0 percent.

   If the water level lowers 5 cm from the 1 meter mark on the upper rod, it will rise 5 cm above the 1 meter mark on the lower rod. (10 cm total difference.)

   With each 5 cm change against either of the rods, there is a one percent change in slope, so that with a 5 cm change the slope is one percent, with a 10 cm change the slope is two percent, with a 50 cm change the slope is 10 percent, and with a 100 cm (1meter) change the slope is 20 percent.

   If the water in the downhill end goes over two meters, the slope is greater than 20 percent and should be measured with the method on the next page.





3. Slopes between 20 and 40 percent can be measured as follows.

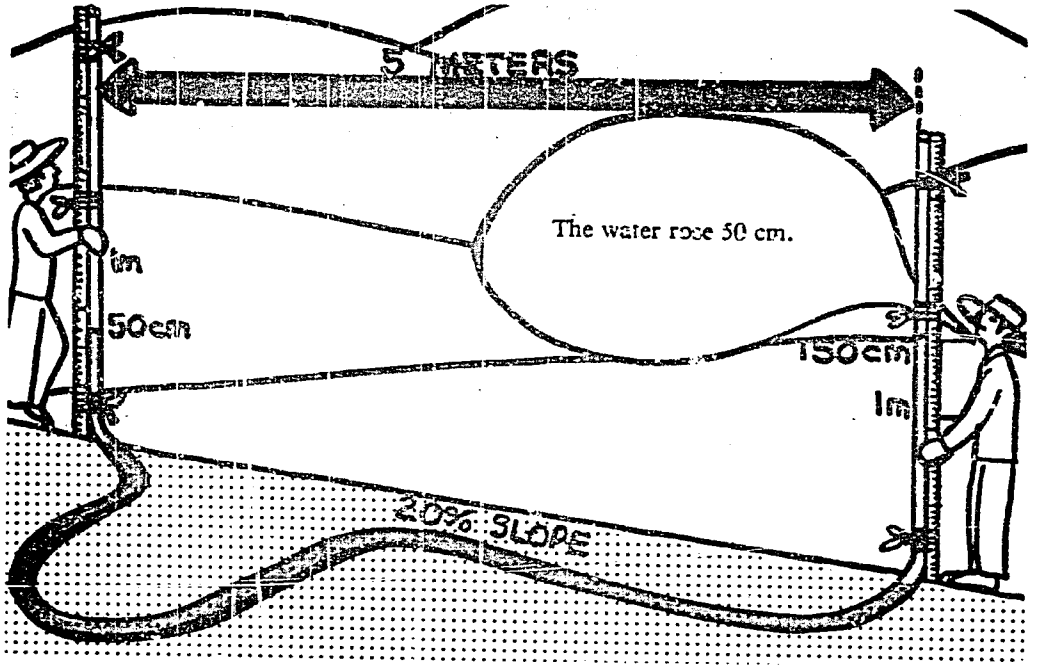
   a. Separate the rods by five meters.

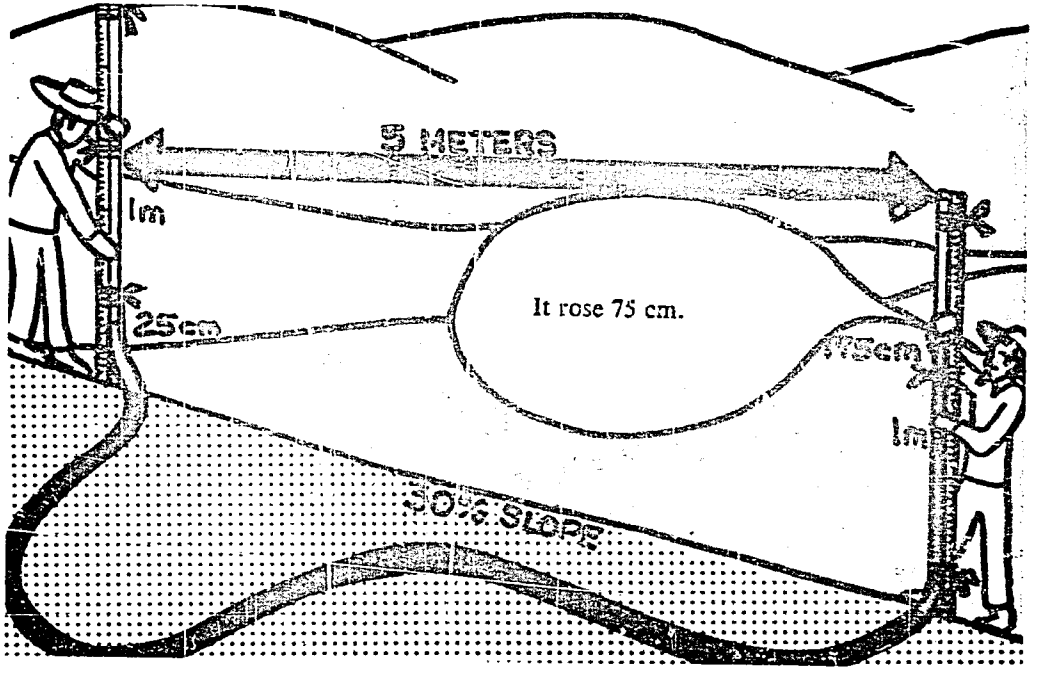
   b. Note the change in water level on either side.

      - a 50 cm change indicates 20 percent
        — for each 5 cm change there is two percent more slope.

      - if the water level changes 75 cm, the slope is 30 percent.

      - if the water level changes 100 cm, the slope is 40 percent.





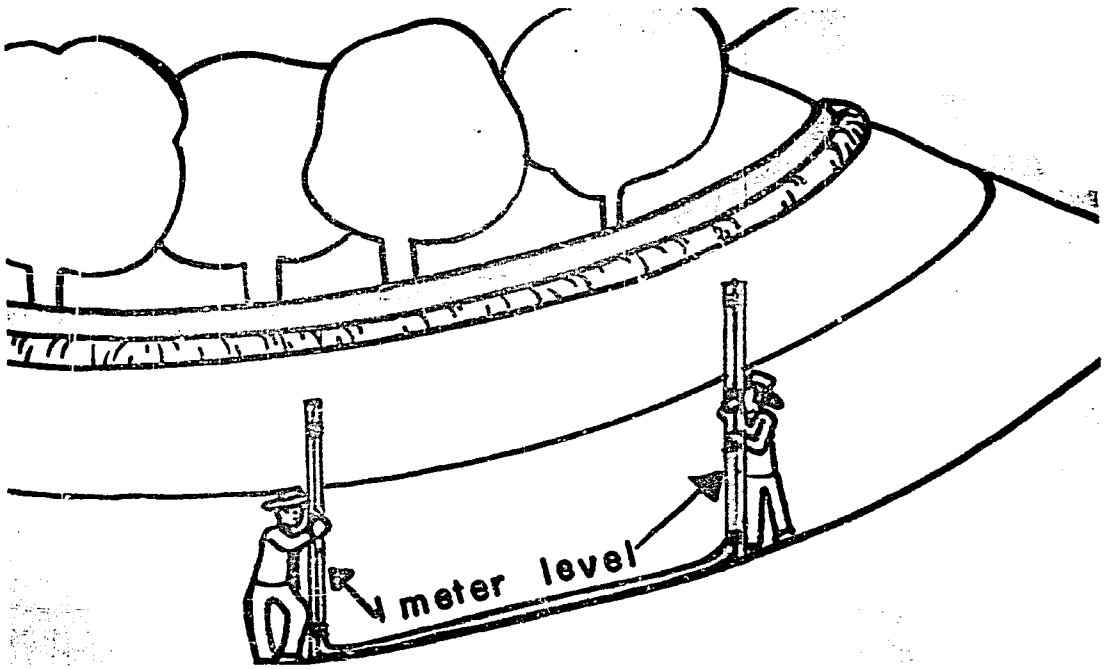
The simple level can be used to mark a level contour line in the field in the following way.

1. Select a starting point and mark it with a stake, rock, etc.

2. Separate the rods by 10 meters or some convenient distance.

3. Move the leading rod up or down, until its water level is the same as that in the rod at the initial point. Mark this point.

4. Follow the same procedure from point 2 to point 3, point 3 to point 4, and so on.



We can also mark lines with one, two or three percent slope. (We will find out why we need to know this in a later section.)

1. Choose a starting point.

2. Separate the rods by 10 meters.

   The water level at each rod must change...

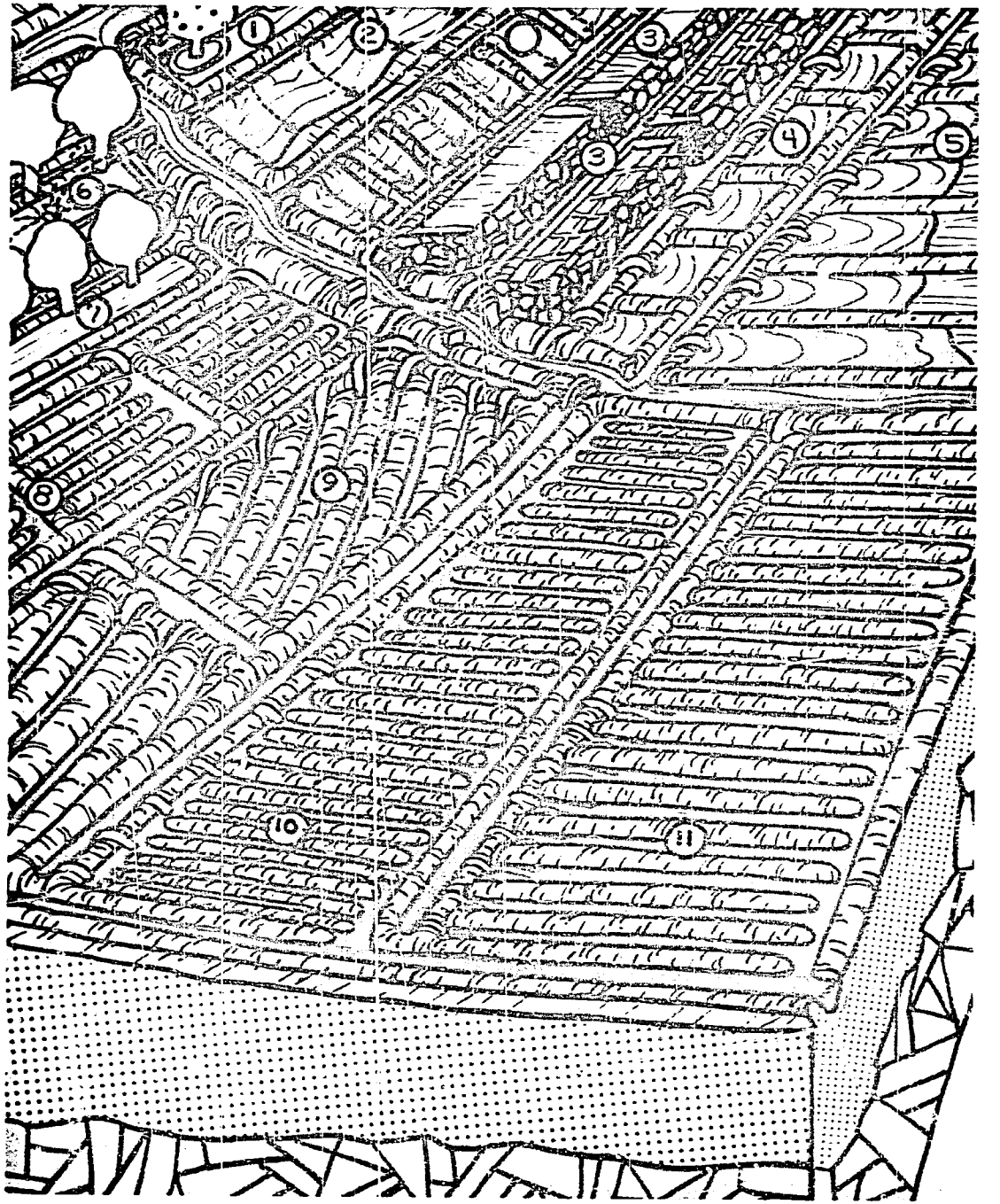
   5 cm for a one percent slope,
   10 cm for a two percent slope,
   15 cm for a three percent slope.

   If the water level indicated in the leading rod rises, the slope is downhill. If the water level drops, the slope is uphill.

3. Repeat the procedure for succeeding points.

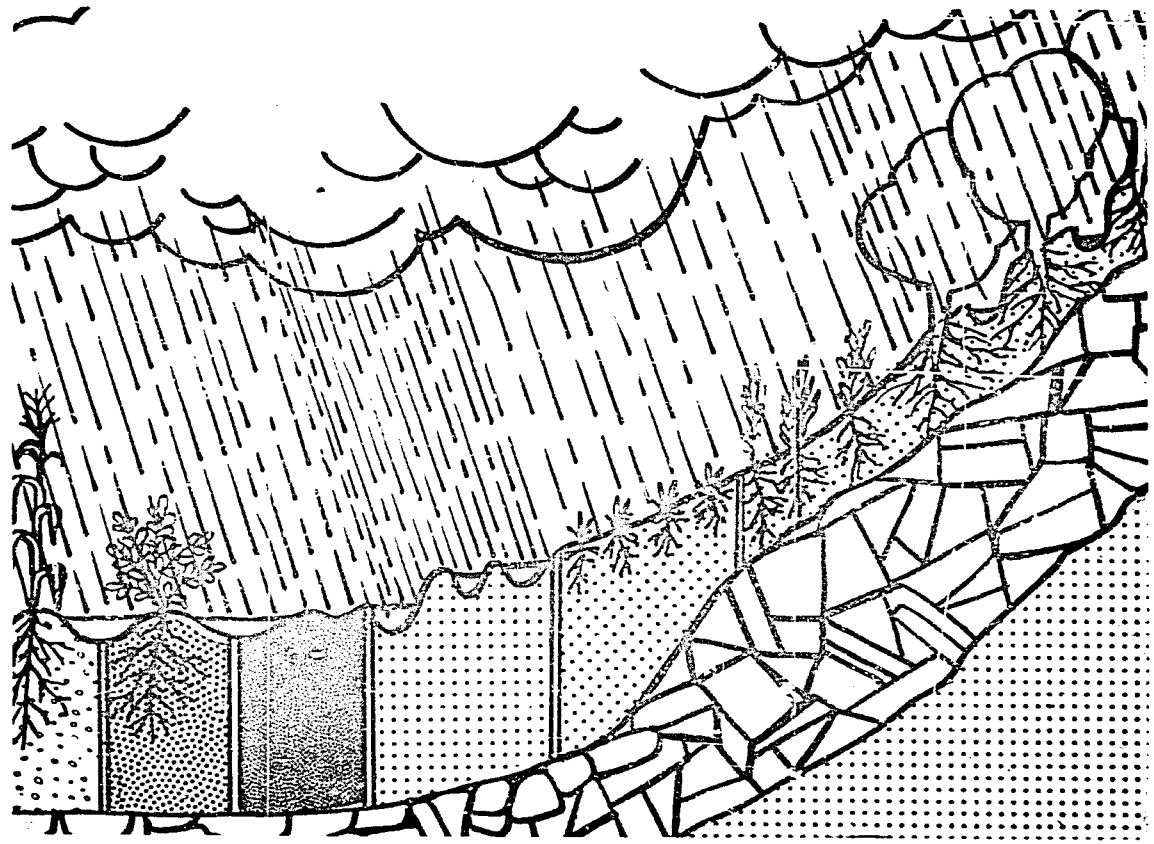
IRRIGATION METHODS

1. Drip
2. Wild flooding
3. Terraces
4. Basins
5. Border
6. Sprinkler
7. Contour ditches
8. Level furrows
9. Contour furrows
10. Corrugations
11. Furrows



To select the irrigation system that is best, you should consider

1. slope
2. crop type
3. field size and geometry
4. soil texture
5. soil depth
6. topography
7. available irrigation stream size
8. amount and intensity of rain
9. economic and social aspects (labor, materials, other costs)

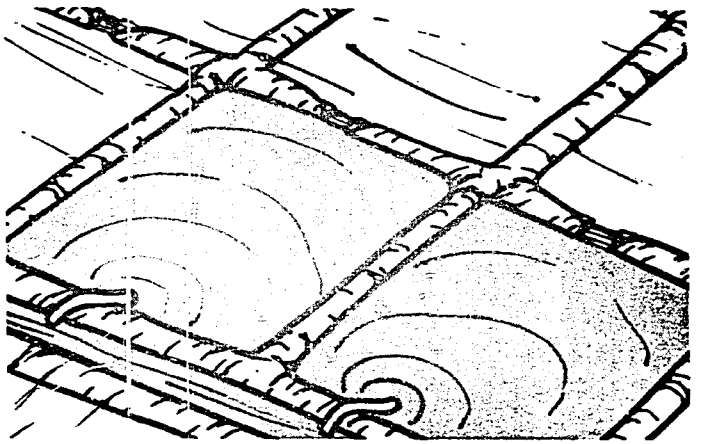


Choosing the Best Irrigation System for Your Farm

If your SLOPES are:	And you can grow these CROPS:	The best SYSTEM for your farm may be:	For more INFORMATION, turn to page:
usually to 1 percent; sometimes to 20 percent	wheat, oats, barley, rye, pastures	border	47
to 3 percent	row crops	straight furrow	50, 51
to 10 percent	wheat, oats, barley, rice, rye, pastures	basin	43
	row crops	contour furrow	50, 52
		level furrow	50, 54
	small grains, pastures	corrugation	56
	most crops	sprinkler	62
to 20 percent	permanent pastures	wild flooding	61
to 30 percent	wheat, oats, barley, rye, pastures	terrace	58
	tree crops	contour ditch	60
	permanent pastures	sprinkler	62
all slopes	trees, shrubs, vegetables	drip	64

1. BASIN IRRIGATION

Basins are small, level pieces of land surrounded by dikes which can be filled with water. The dikes contain the water in the basin while it penetrates into the soil.



CROPS:

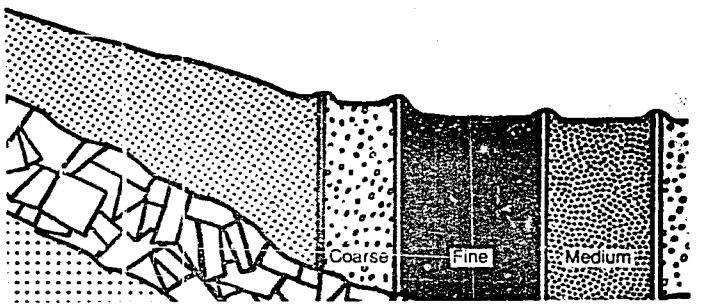
fruit trees, pastures, cereals such as wheat, oats, barley, rye, rice

SOILS AND TERRAIN:

Small basins are used on steep slopes, but are not recommended on slopes over 10 percent with soils that crack as the dikes may break easily. Also, the necessary leveling on steep slopes may be very costly.

On level or almost level land:

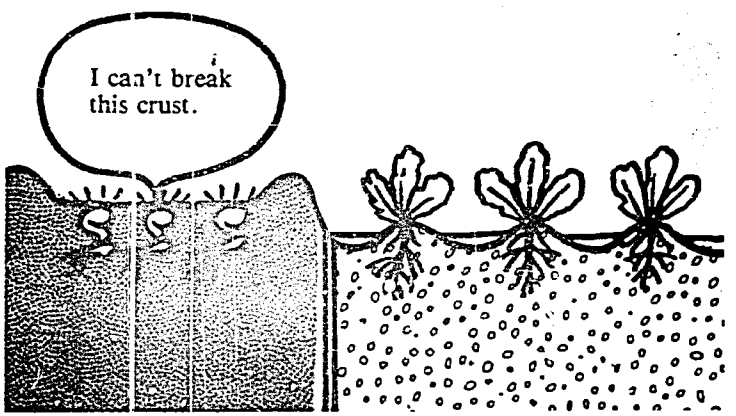
- small basins are used on sandy soils
- medium-sized basins are used on medium-textured soils
- large basins are used on fine-textured soils



Small basins permit efficient irrigation with small stream sizes.

Small basins allow you to irrigate very small fields without runoff, but much productive land is lost to ditches and dikes.

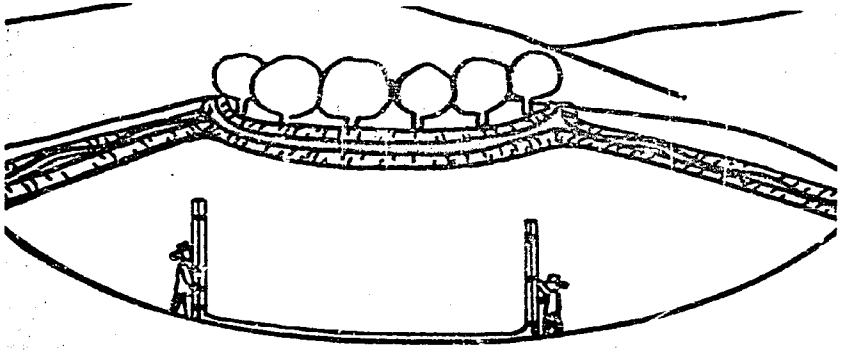
Basins are not used on soils which form hard, dry crusts that interfere with emergence and growth, or with crops which should not be immersed in water.



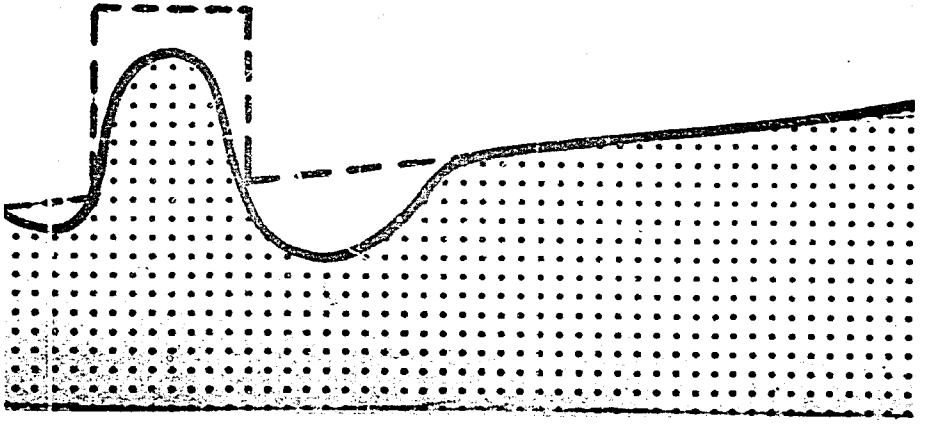
Small basins may be constructed without technical assistance.

CONSTRUCTION:

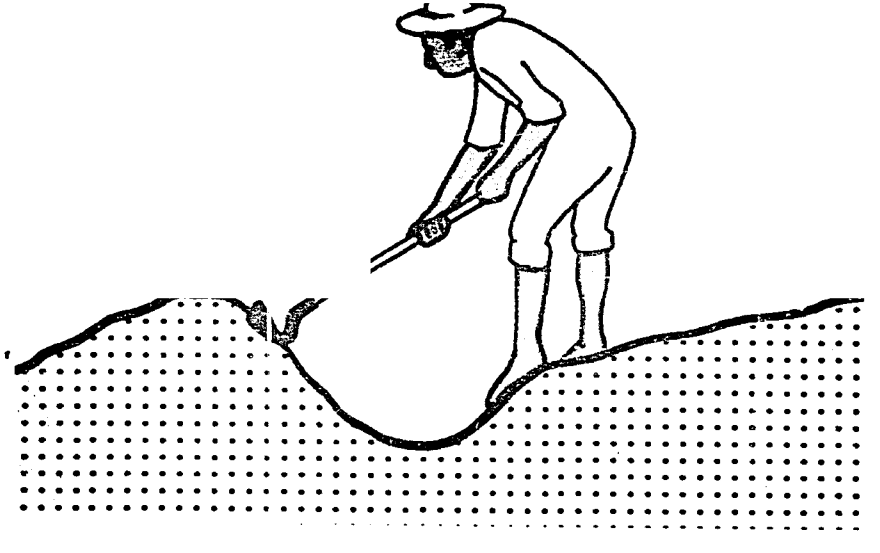
1. Mark a level contour line starting on the lower side of the field. (You can use the leveling instrument explained before on p. 36 .)

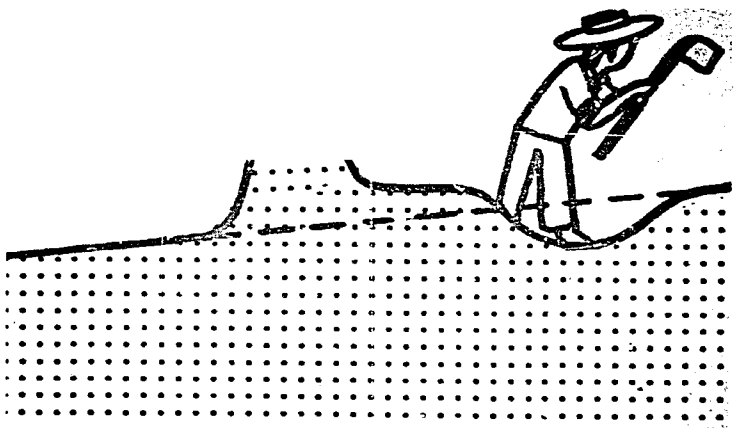


2. Raise a dike on the curve with soil taken uphill of the contour line. Make the width and height about equal.

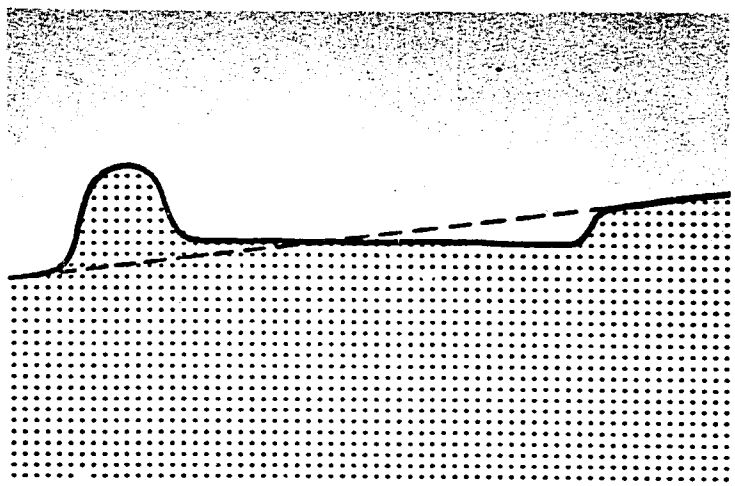


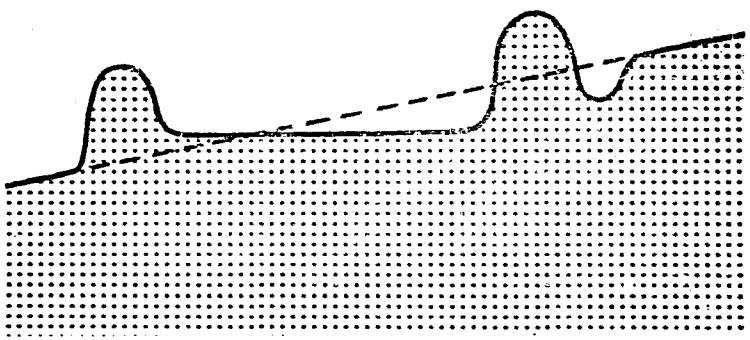
3. Compact the dike in layers as you build.





4. Fill in behind the dike but make sure to retain a dike that is at least 20 cm above the highest water level you expect in the basin.

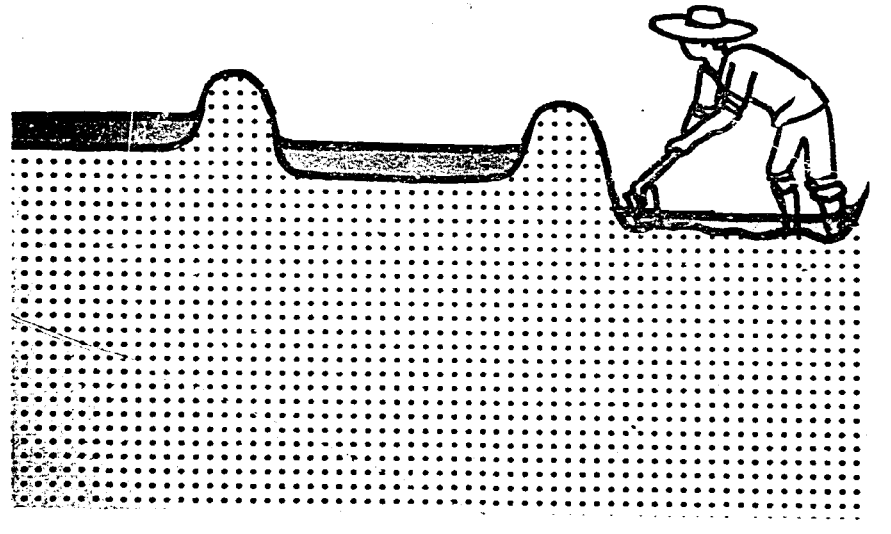




6. To start the next basin, make another level dike above the first terrace. Repeat the procedure for the rest of the basins.

7. Flood the basins with a thin layer of water. The high and low spots will be easily visible and can be marked and eliminated.

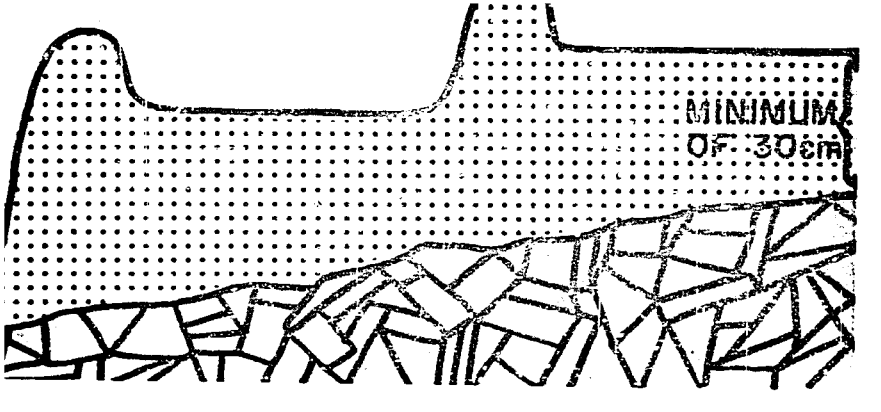
   If the water surface is approximately the same height above the soil throughout the basin, the basin is level.



8. If the soils are very shallow:

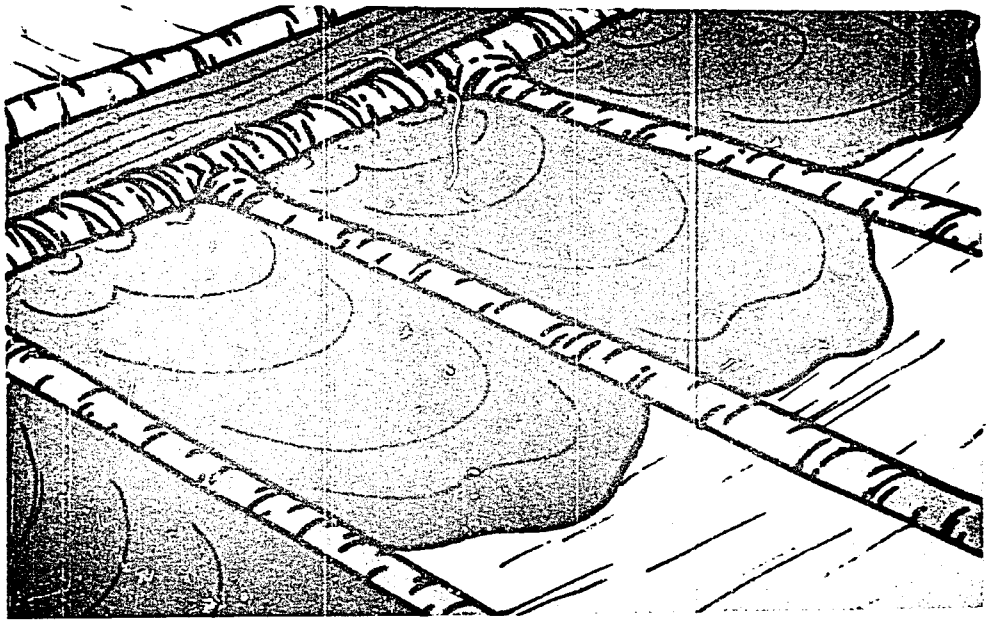
   - remove the good soil from the surface.
   - level the basin bottom.
   - cover the basin bottom with the good soil.

   Never leave less than 30 cm of good soil in any part of the basin as shallow soils are very unproductive.



2. BORDER IRRIGATION

Borders are strips of land surrounded by dikes (borders) that run in the direction of the slope. The dikes guide the water over the field when it leaves the head ditch.



CROPS:

close growing crops such as wheat, barley, oats, pasture grasses and alfalfa

SOILS AND TERRAIN:

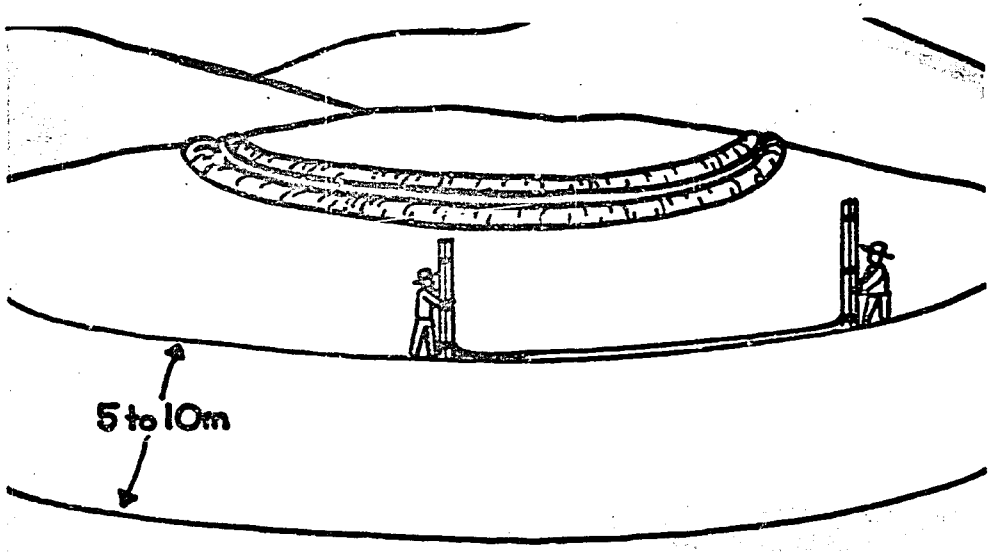
Slopes are usually up to one percent. However, permanent pastures on well-graded land can have slopes up to 20 percent if they are irrigated with extreme care to avoid erosion.

Borders are used mostly on long fields with medium to fine textured soils. On very sandy soils, use borders only with permanent pasture crops to avoid erosion.

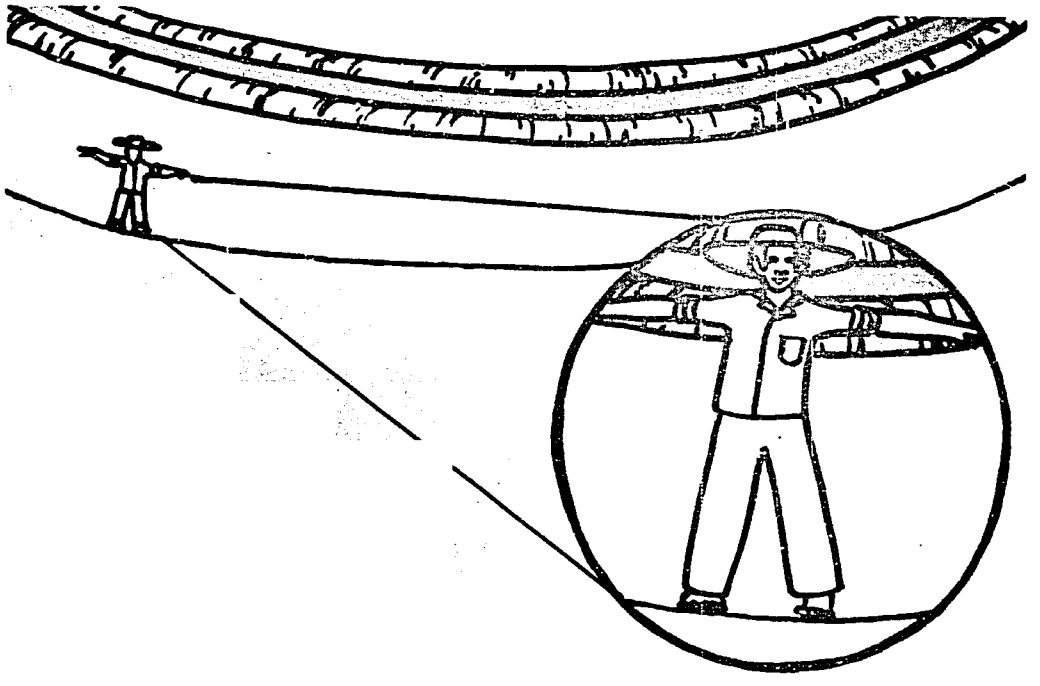
CONSTRUCTION:

Small borders may be constructed without technical assistance.

1. Stake out level curves every 5-10 meters, starting at the high part of the field.



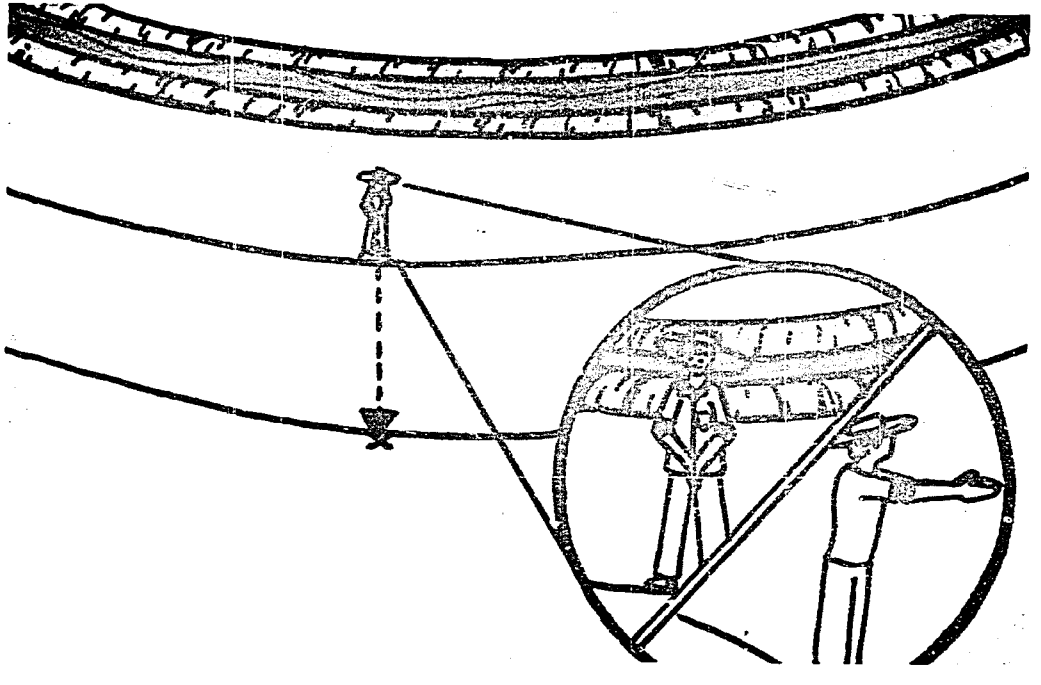
2. Choose a point near one end of the field on the uppermost contour. Place both feet on the contour and open your arms parallel to the contour.



3. Join your hands pointed in the downhill direction and mark the point to which the hands point on the next contour line.

4. Starting at the point just marked on contour 2, mark contour 3 repeating steps 2 and 3. Continue in this manner until all contour lines are marked.

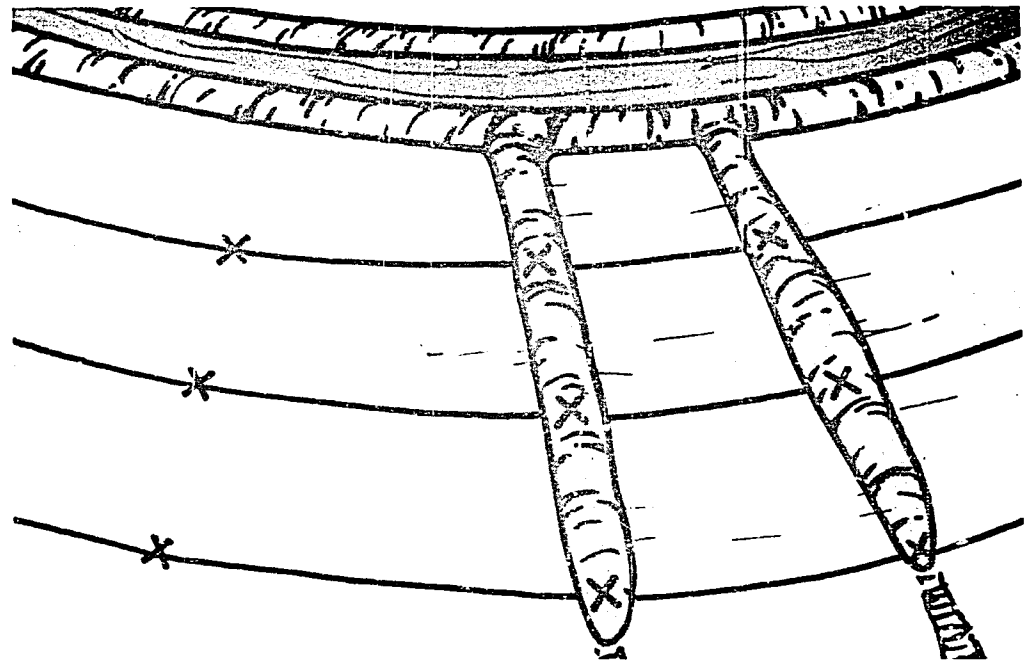
   To mark the location of the rest of the borders, repeat steps 2-4 at the desired spacing.



5. Construct the borders at the marks.

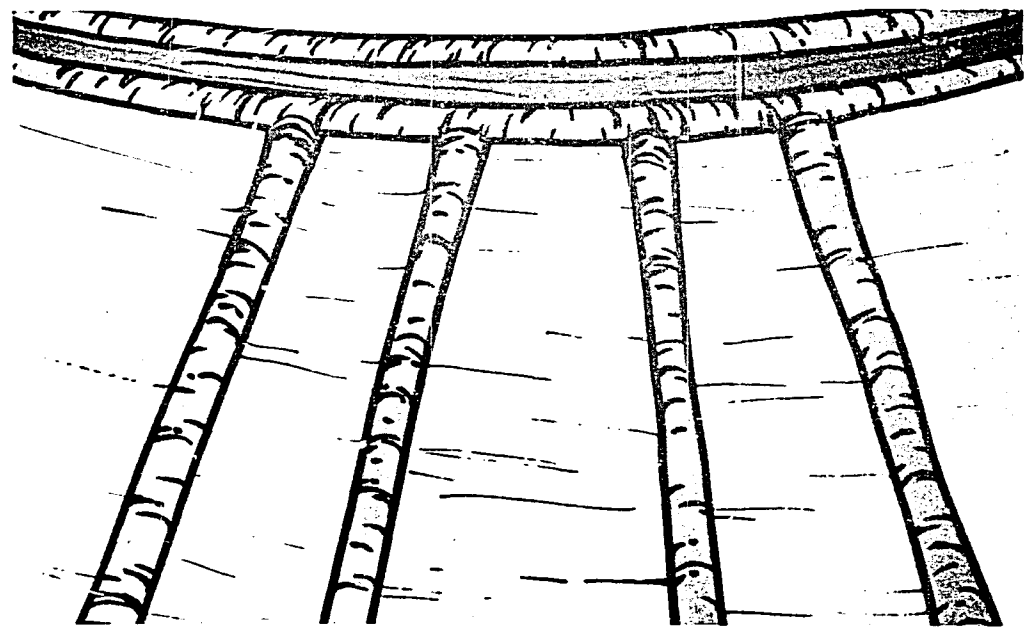
Length of borders:
•up to 90 meters for coarse-textured soils •up to 250 meters for medium-textured soils •up to 350 meters for fine-textured soils

For borders longer than 100 meters, it may be necessary to obtain technical help to construct the borders properly.



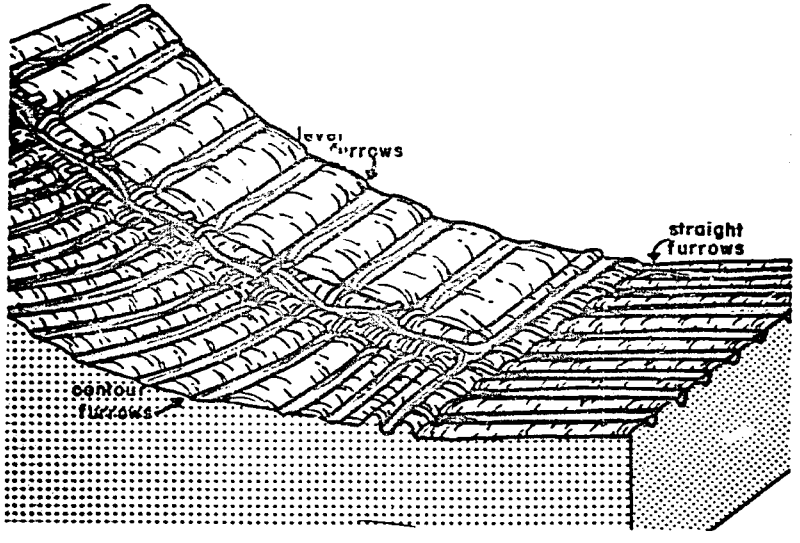
6. Make sure the soil within each border is level across the border so that the water will spread evenly. If the irrigating stream is too small to cover the soil surface, or if the water advances very slowly, then increase the stream size or decrease the border width.

   In fields with slight unevenness, small furrows within the borders can help guide the water.



3-4-5. FURROW IRRIGATION

Furrows are small, closely spaced channels that carry water to the crops that are planted on their banks. Typical spacings between furrows may vary from 50 cm to over 1 meter. The height of the furrows may vary from 10 to over 30 cm.

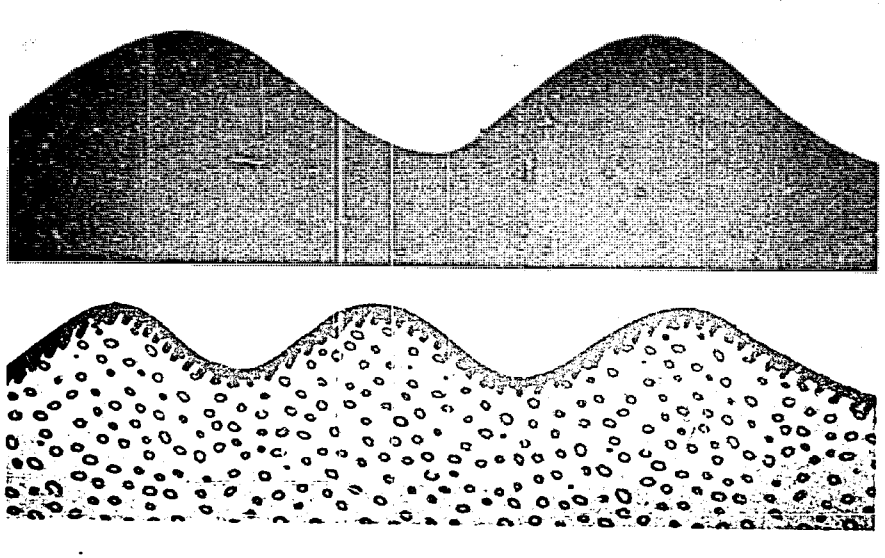


CROPS:

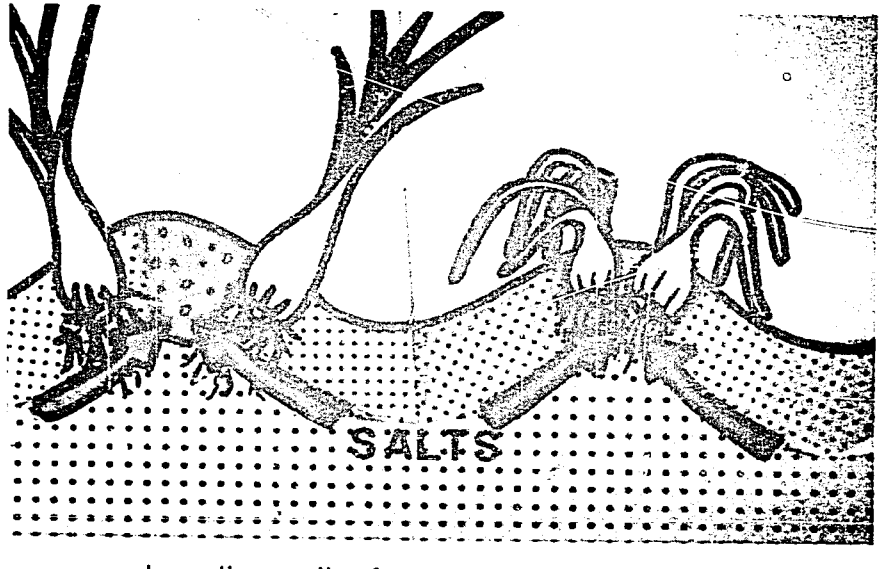
corn, potatoes, beans, vegetables and other crops that must be cultivated.

SOILS AND TERRAIN:

Furrows are a good method for irrigating soils which crust over easily.



Furrows on coarse-textured soils may need to be spaced more closely to assure sufficient lateral penetration.



In saline soils, furrows may help alleviate salt problems because the seed can be placed on the furrow sides, away from the center where salts concentrate.

3. STRAIGHT FURROW IRRIGATION

Furrows that run in the direction of the primary slope.

CROPS:

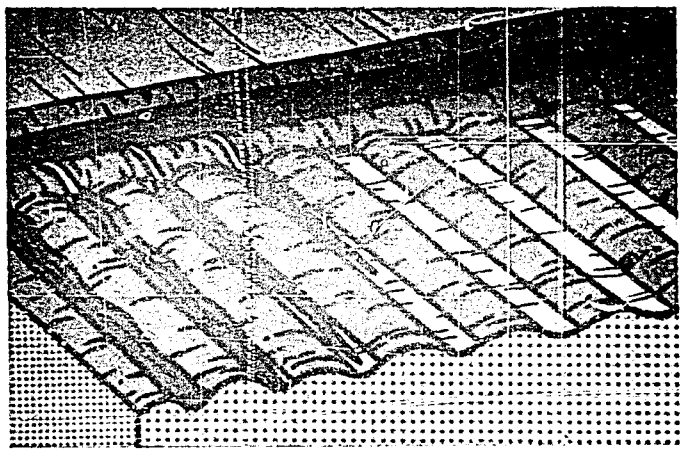
corn, potatoes, beans, vegetables and other crops that must be cultivated.

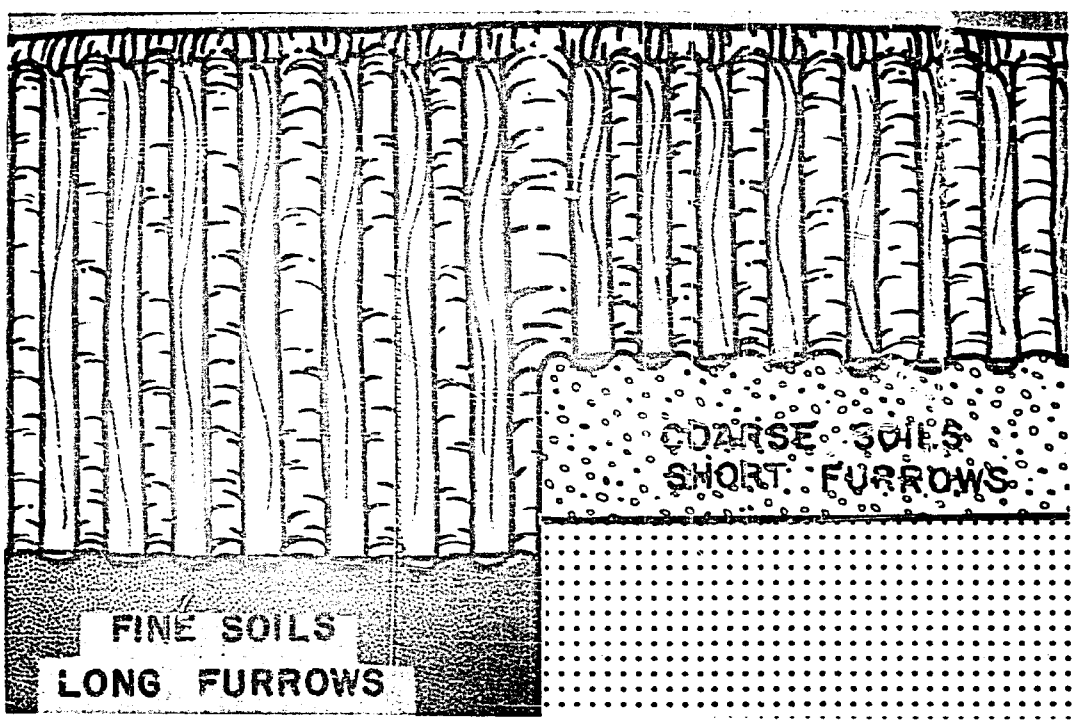
SOILS AND TERRAIN:

Almost flat, fairly uniform terrain with slopes up to three percent. Furrows are a good method for irrigating soils which crust over easily.

When making furrows, remember...

- Plane or even out the terrain in the direction of the slope.
- Make the furrows in the direction of the slope. This may be done before or after planting depending on the method of planting, customs, etc.
- Clean the furrows well before irrigating in order to avoid overtopping.
- Beware of erosion.





4. CONTOUR FURROW IRRIGATION

Short, deep furrows laid out on the contour with the furrow slope three percent or less, although the hillside slope may be up to 10 percent.

CROPS:

corn, potatoes, beans, vegetables and other crops that must be cultivated.

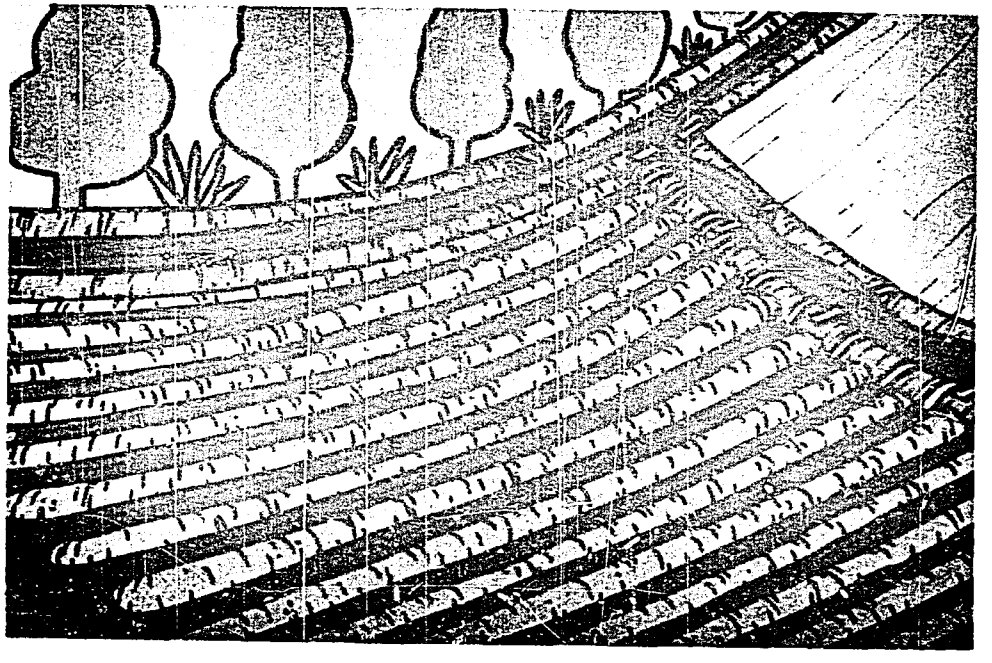
SOILS AND TERRAIN:

- undulating terrain
- shallow soils which should not be leveled
- slopes to 10 percent
  - — on very even terrain the furrows may be one to two percent in slope
  - — on terrain with more irregularity, thev may be two or three percent

Contour furrows should be short and deep to avoid overtopping.

Rainy regions and uneven terrain require steeper, shorter furrows to drain excess rainfall. (Sometimes less than 60 m).

Arid regions and uniform terrain permit the use of less steep and longer furrows (sometimes longer than 120 m).



CONSTRUCTION:

1. Starting at the upper part of the field and from the canal which will feed the furrows, mark the first guide furrow at the chosen slope (usually 1, 2, or 3 percent).

2. Stake out additional guide furrow lines every 5 meters in uneven terrain and every 10 meters in uniform terrain.

3. Make the first furrow where the first guide furrow was marked. Make the additional furrows parallel to the initial furrow, until half the distance to the next guide furrow is reached.

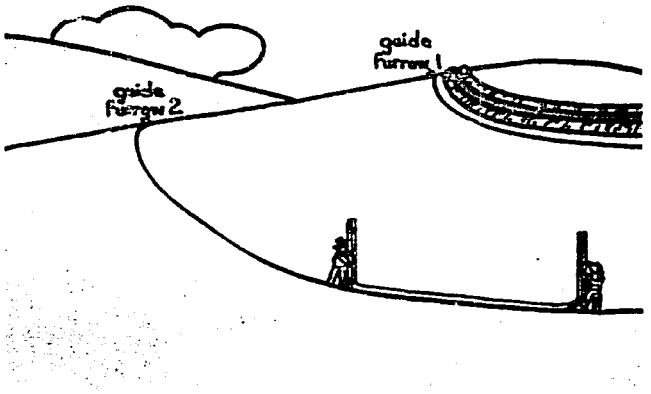
   From guide furrow 2, construct furrows halfway to guide furrow 1 and then halfway to guide furrow 3.

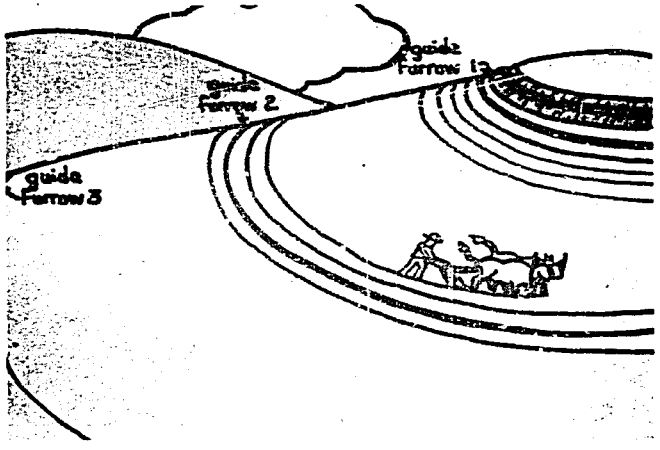
   Repeat the procedure from succeeding guide furrows.

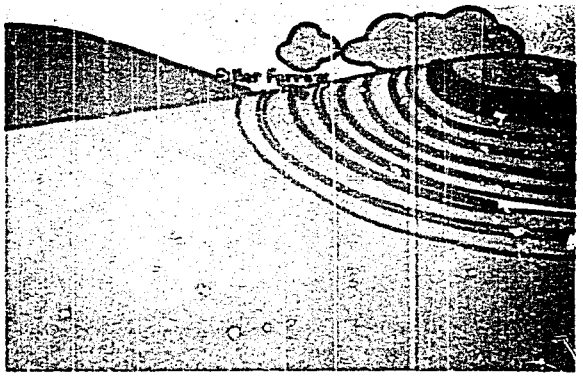
4. If large spaces remain between some furrows, these spaces may be filled in by short filler furrows.

   To prevent erosion, the furrows should all lead to well-vegetated drains. Check the furrows before each irrigation to insure their good condition.

   Remember: Make large, deep furrows and maintain them well.







5. LEVEL FURROW IRRIGATION

Short, deep, level furrows with no outlet. Water is introduced rapidly to fill the furrow which holds the ponded water until it has penetrated.

CROPS:

corn, potatoes, beans, vegetables and other crops that must be cultivated.

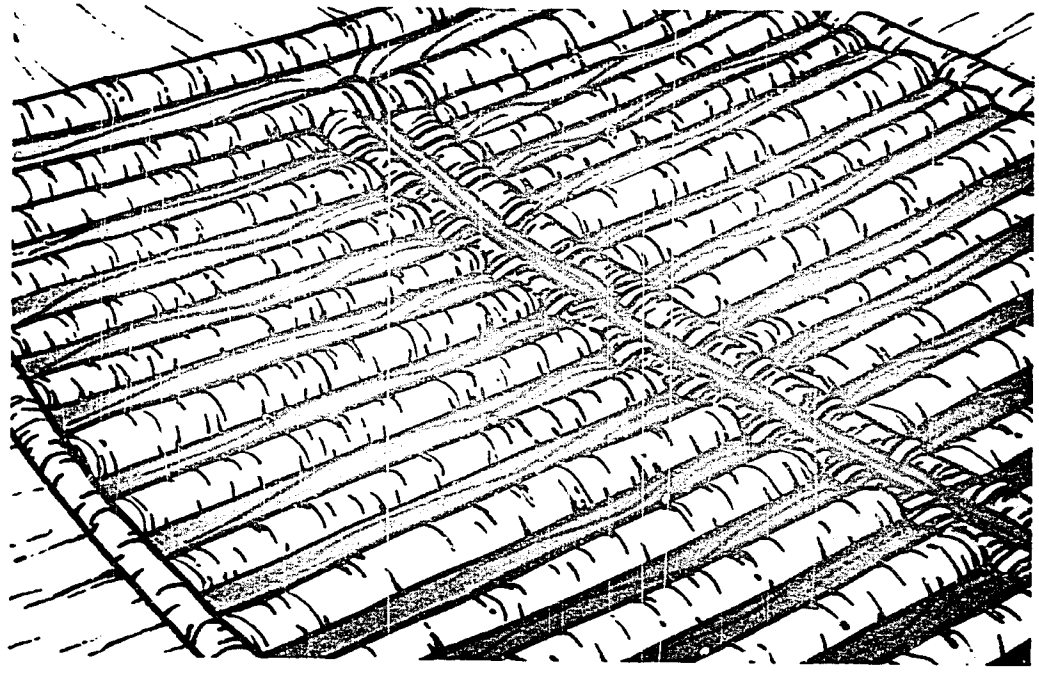
SOILS AND TERRAIN:

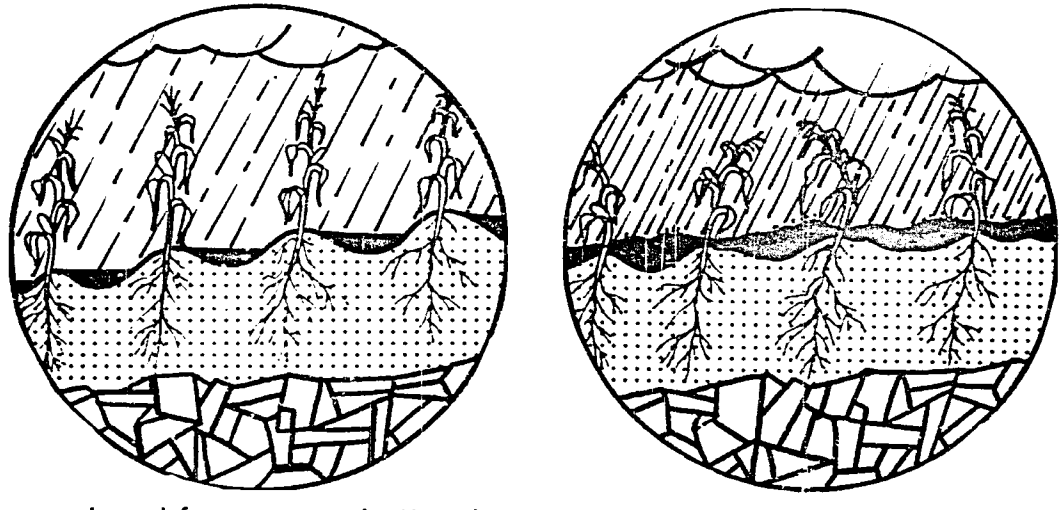
Generally the same as with contour furrows. However, they are also very useful in short fields where other furrows would lose much water as runoff.

CONSTRUCTION:

The procedure is essentially the same as with contour furrows; however:

- Make guide furrows level (0 percent grade).
- Make furrows deep, wide, and short (30 to 50 cm deep).
- With light rains, furrows up to 50 meters long
- With heavier rains, very short furrows



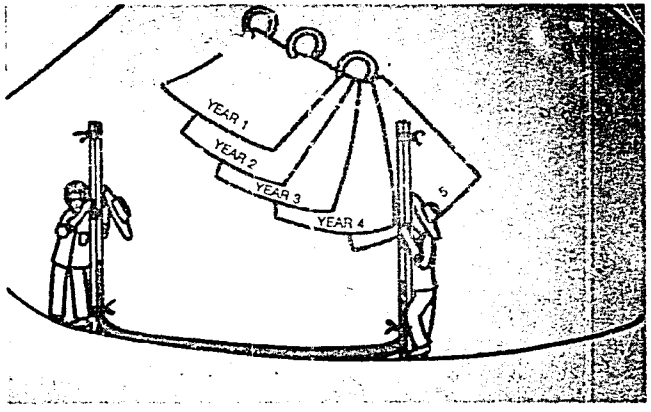


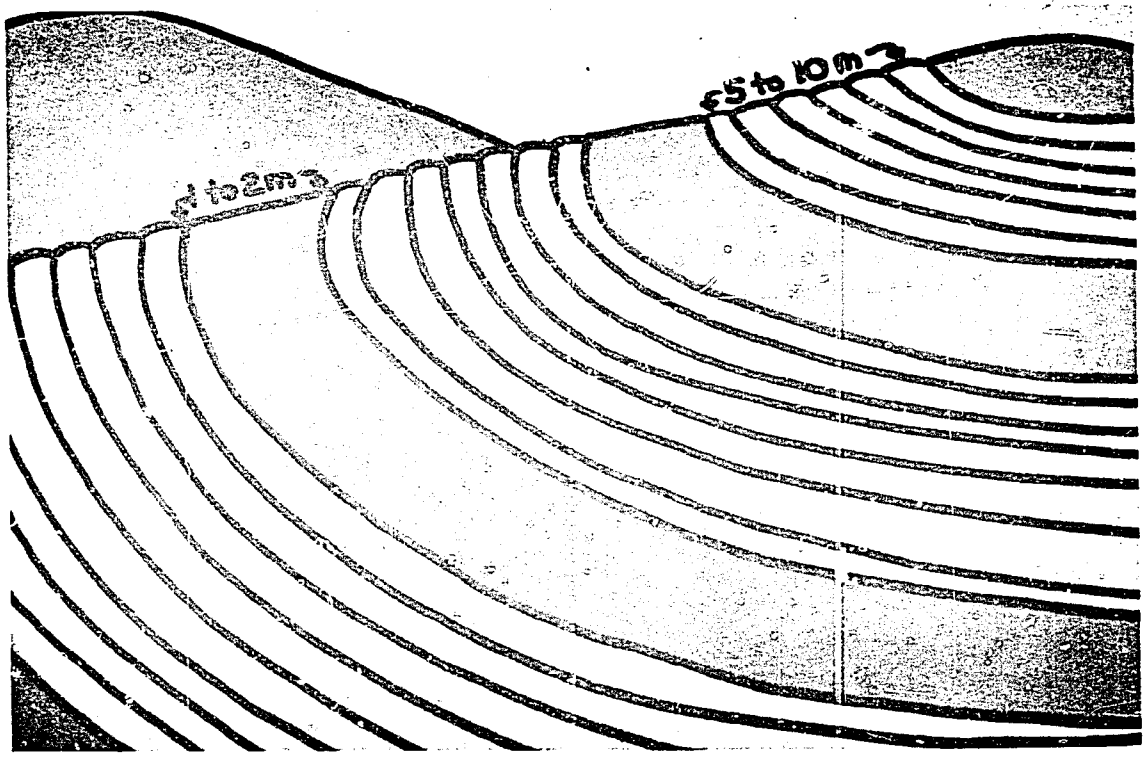
Level furrows are better than contour furrows if rain is scarce because they retain all the moisture. Level furrows should not be used where there is intense rainfall because the furrows may break. In high rainfall areas, excessive water may enter the root zone.

To maintain contour furrow or level furrow orientation from year to year:

- Plant strips of permanent pasture where the guide furrows were.
- Follow these markers in future plantings.

Strips of pasture are also excellent protection against erosion.





6. CORRUGATIONS
(small furrows)

Small furrows guide water in the direction of the slope.

CROPS:

close growing crops like wheat, barley, oats, rye, alfalfa, pastures

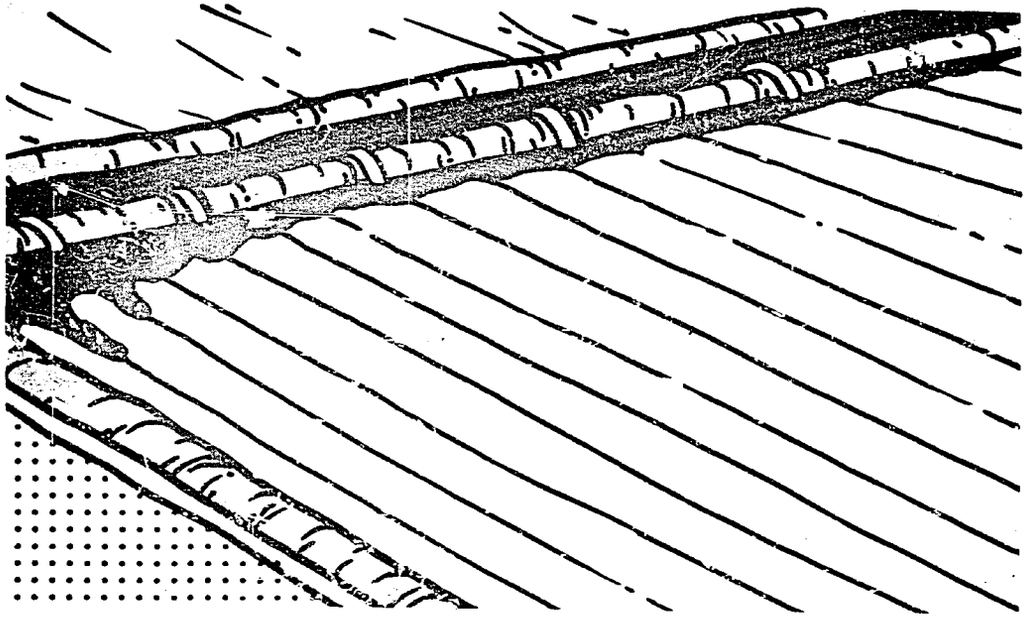
SOILS AND TERRAIN:

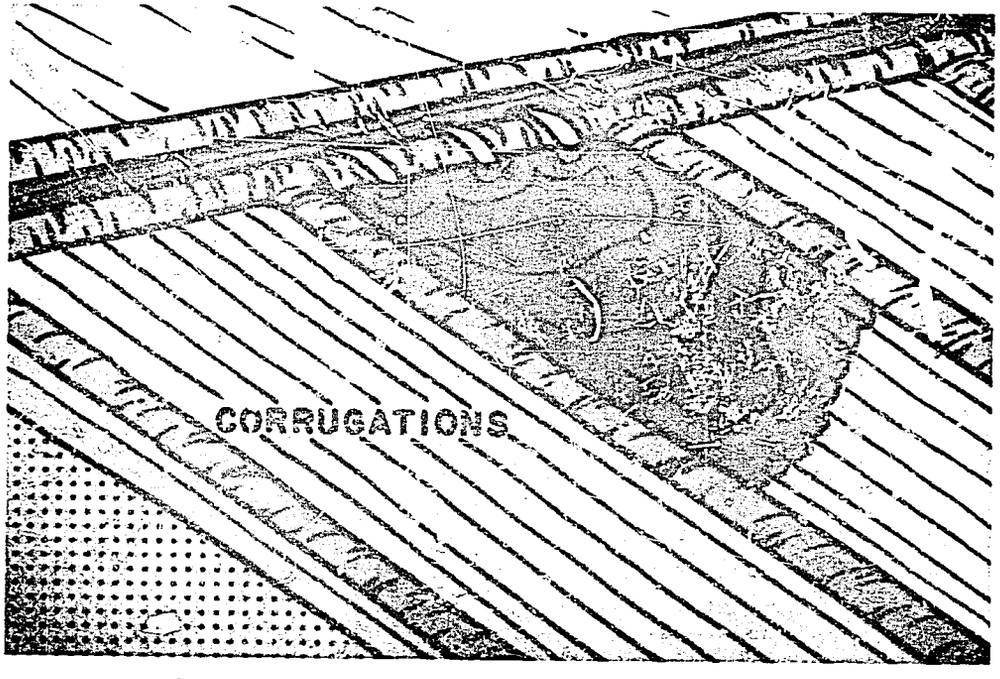
- Use on fields without great irregularities
- On slopes up to 10 percent
- On medium and fine textured soils
- With small stream sizes

CONSTRUCTION:

Separate the corrugations by 30 to 75 cm and make them 10 to 15 cm deep.

Watch your stream size and avoid erosion!!

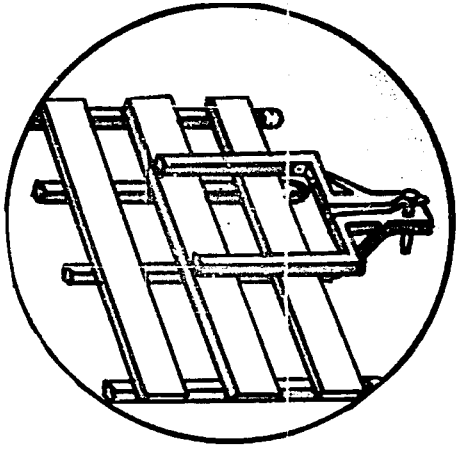


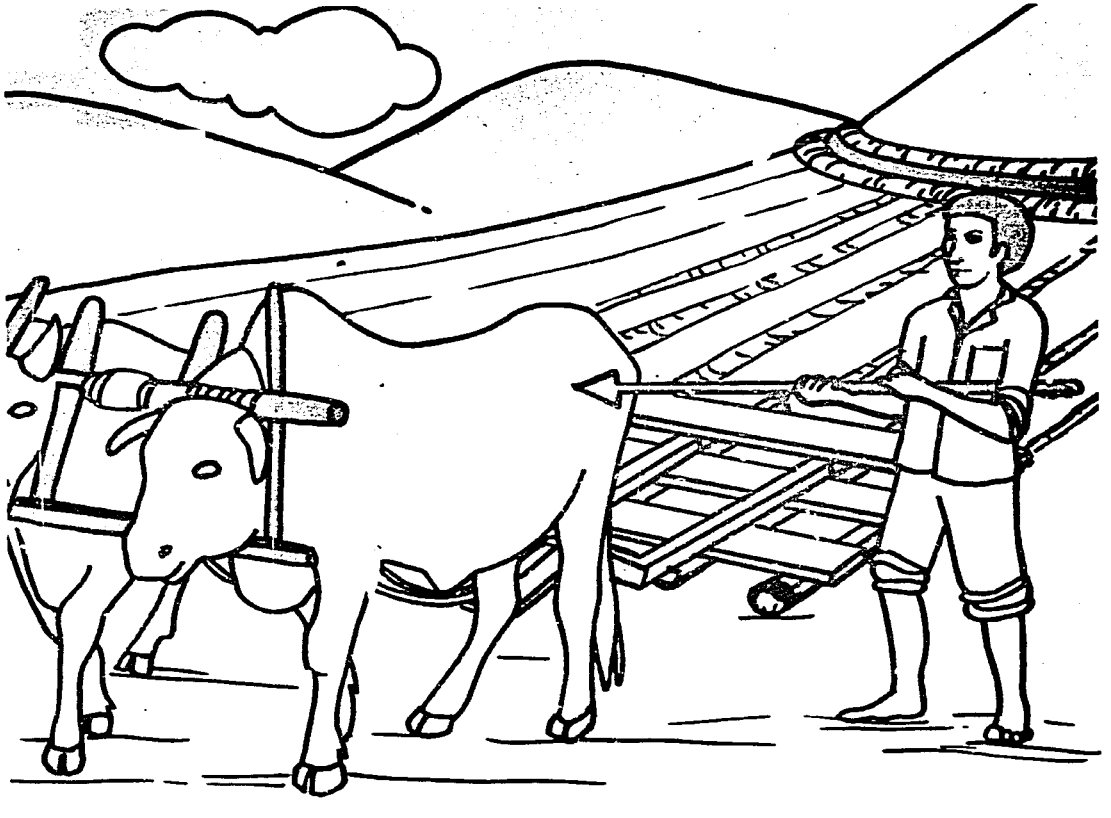


Corrugations may be used inside of borders to help guide the water.

There are many ways to make corrugations in a field. Sometimes the corrugations are made before planting and sometimes after. The simple implement illustrated here is a commonly used tool. Add weight to make deeper corrugations.

A simple wooden plow may be used for making corrugations in the field after planting.





7. TERRACES

Level beds which permit crops to be irrigated with:

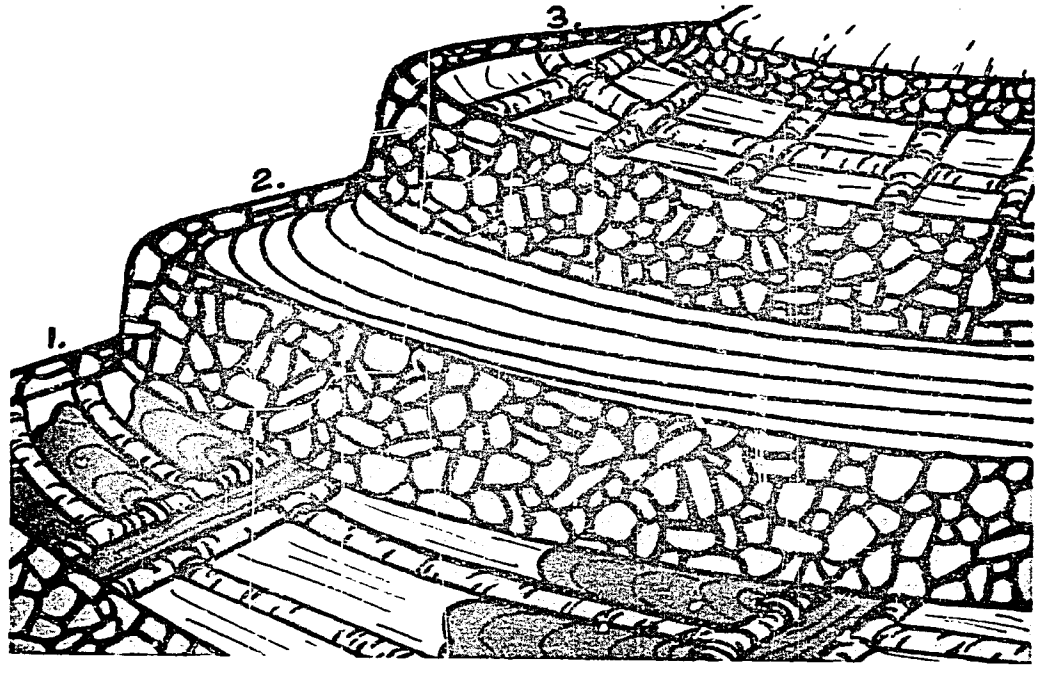
borders (1)
furrows (2)
basins (3)
or any other form of irrigation

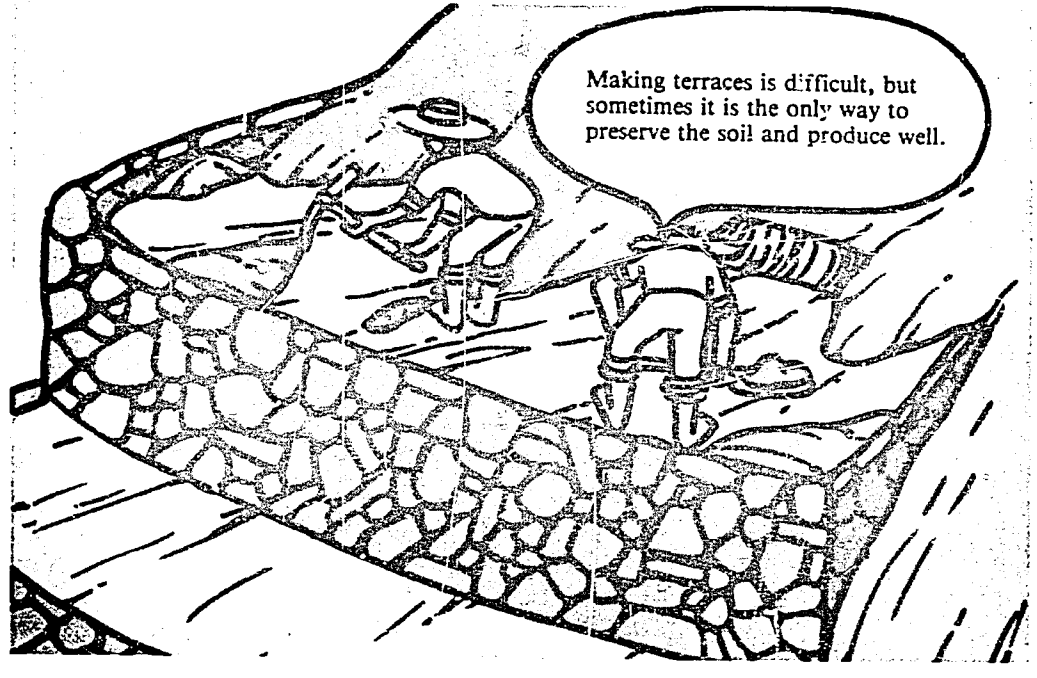
CROPS:

any crops

SOILS AND TERRAIN:

- on any soil which does not crack excessively
- on slopes up to more than 30 percent
- on nonuniform slopes

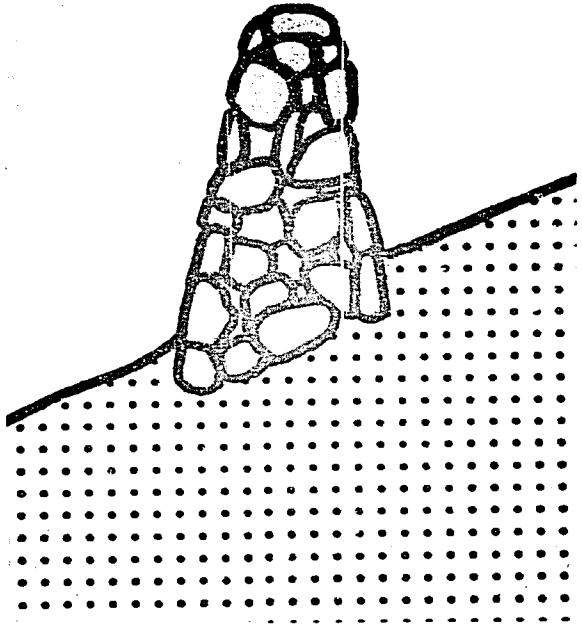


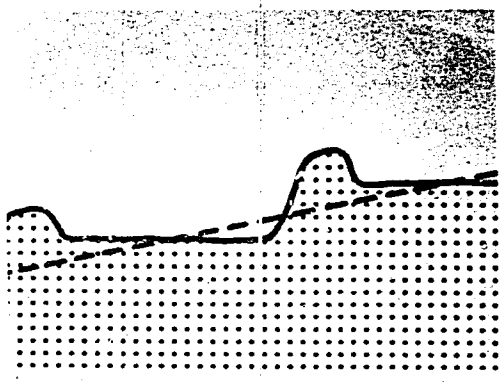


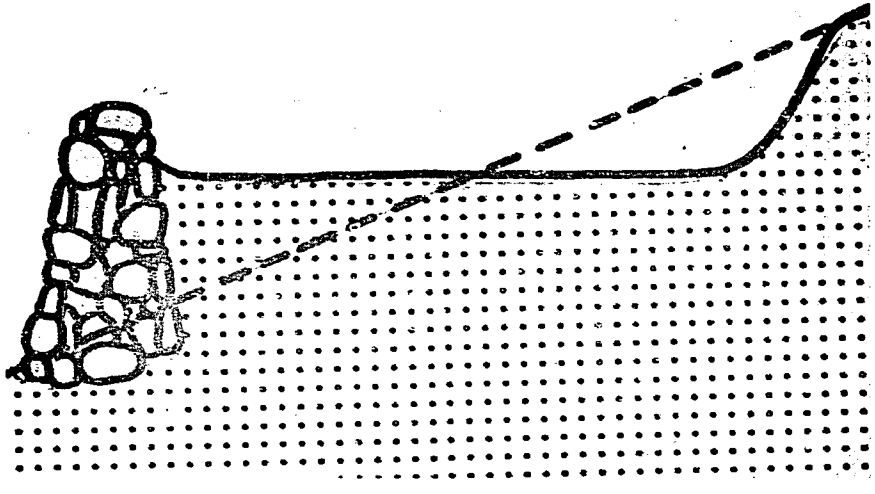
CONSTRUCTION:

1. Make a wall of rock or other material on the lower part of the field. The top of the wall should be nearly level along its length with slopes not to exceed the intended slope of furrows, borders, etc.

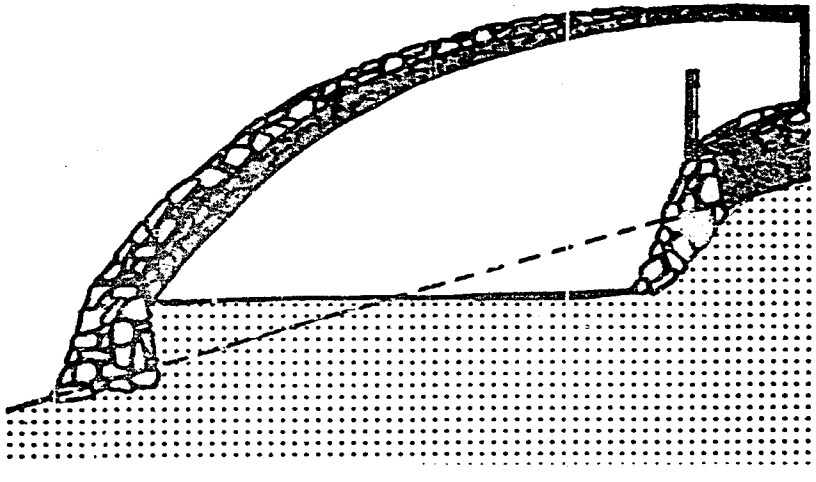
   On terrain with less than 10 percent slope, the wall can be made of compacted soil or sod.







2. Fill in behind the wall with soil from above until level.



3. Repeat the process for other terraces.

8. CONTOUR DITCH IRRIGATION

Canals constructed on level contour lines on steep slopes that serve to collect precipitation and to irrigate the crops planted on the banks.

CROPS:

shrubs and trees

TERRAIN:

Contour ditches can be used on slopes to 30 percent.

The ditches capture rain water and let it penetrate into the soil for the plants to use. The water does not become concentrated on the slopes so erosion is avoided.

The ditches can be filled with water from a canal when rain is insufficient.

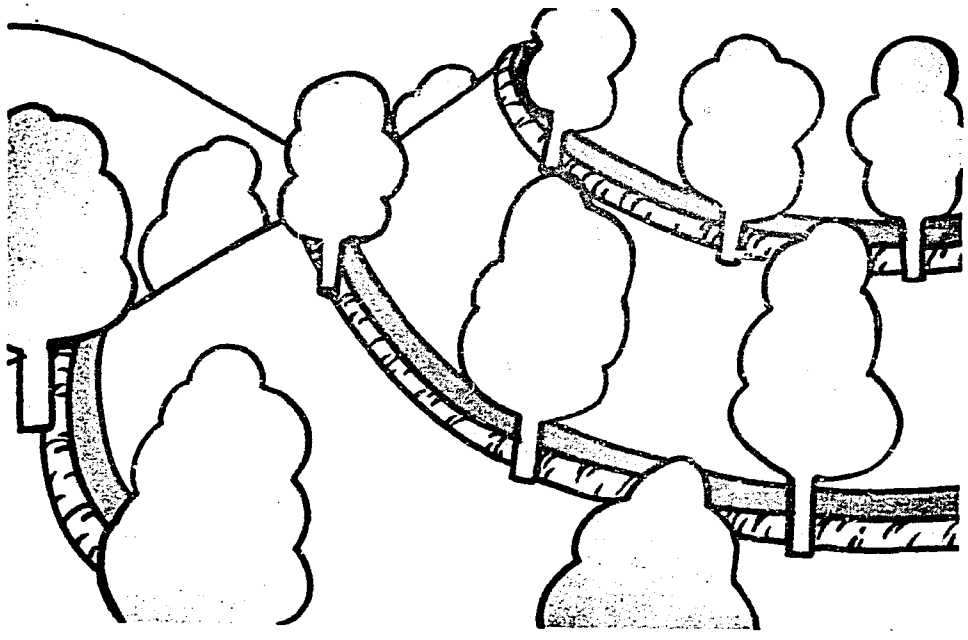
CONSTRUCTION:

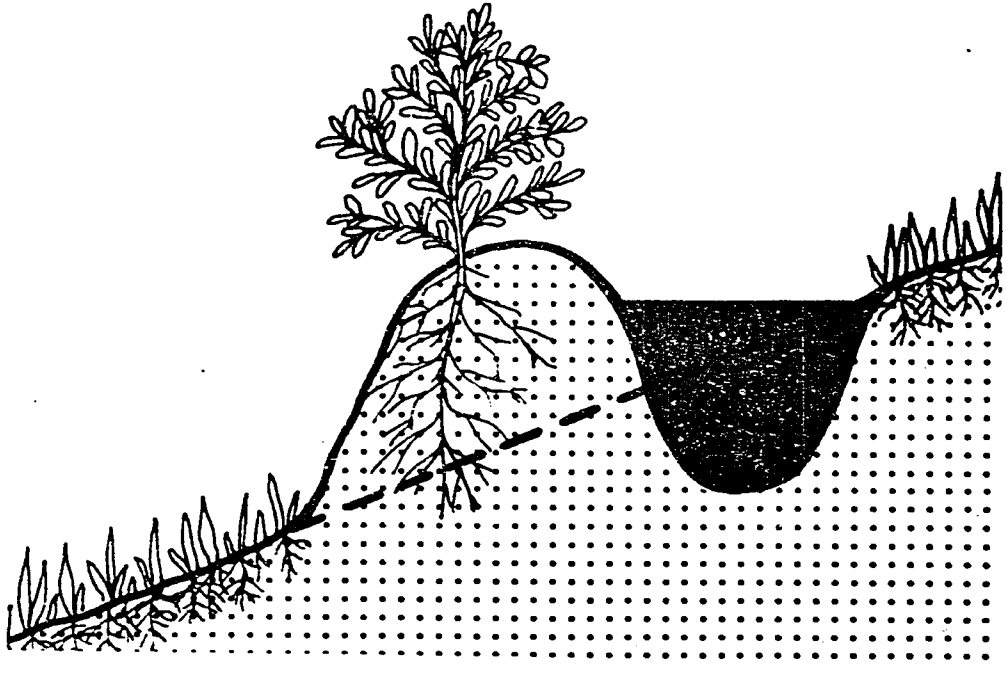
1. Mark the contour lines on the slope at the distance desired between rows of trees.

2. Excavate ditches on the contour 60-80 cm in depth. Do not make the walls too steep.

3. Compact and reinforce the downhill side.

4. Plant on the downhill bank and irrigate plants until they take root.





9. WILD FLOODING IRRIGATION

The field is flooded from the head ditches. The soils are leveled or planed at a minimum.

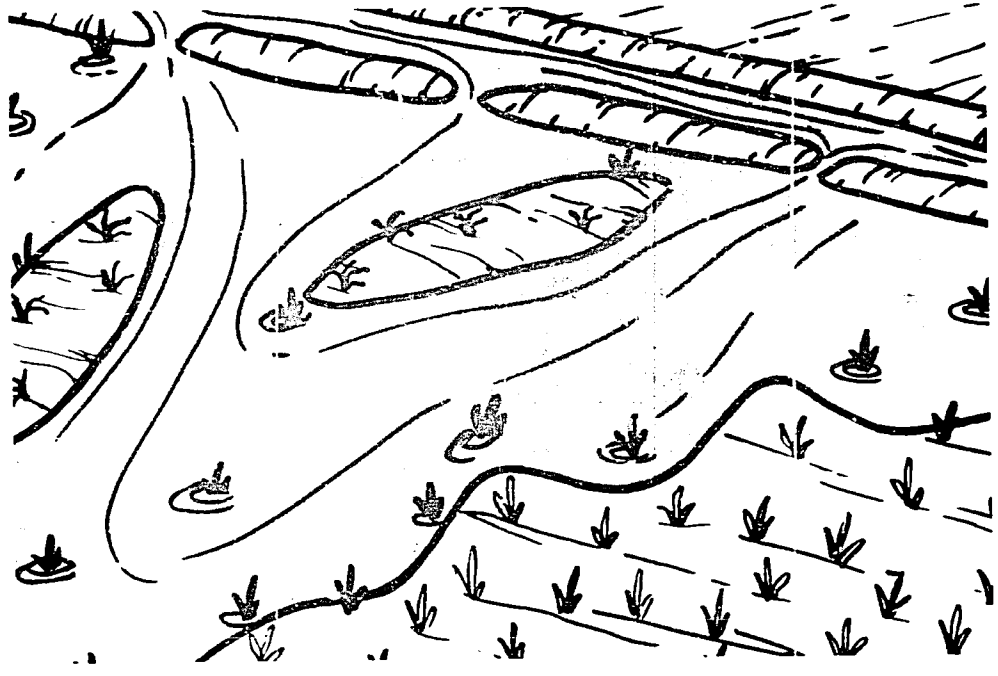
CROPS:

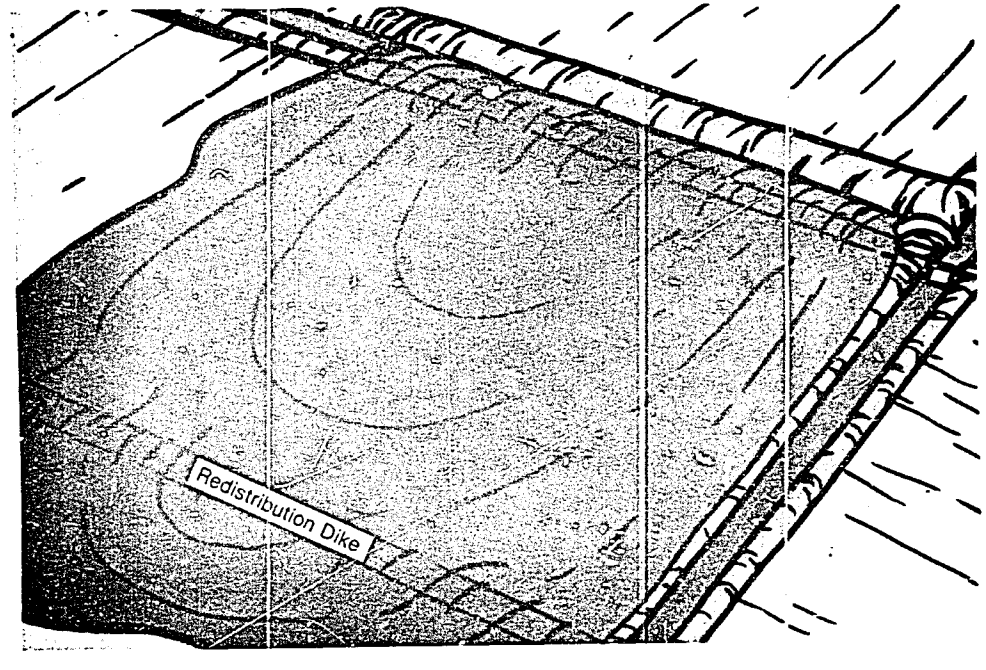
close growing crops like wheat, barley, oats, rye, alfalfa, other pastures

SOILS AND TERRAIN:

With wild flooding, it is impossible to irrigate a field uniformly and efficiently. Wild flooding should be used only on very low value crops where water is inexpensive.

Permanent pastures are sometimes irrigated on slopes up to 20 percent. However, to avoid erosion, grains and annual pasture crops are irrigated only on nearly level soils.





Redistribution dikes can help in spreading the water out more evenly.

10. SPRINKLER IRRIGATION

Mechanical devices apply water to the soil surface as water droplets, similar to rainfall.

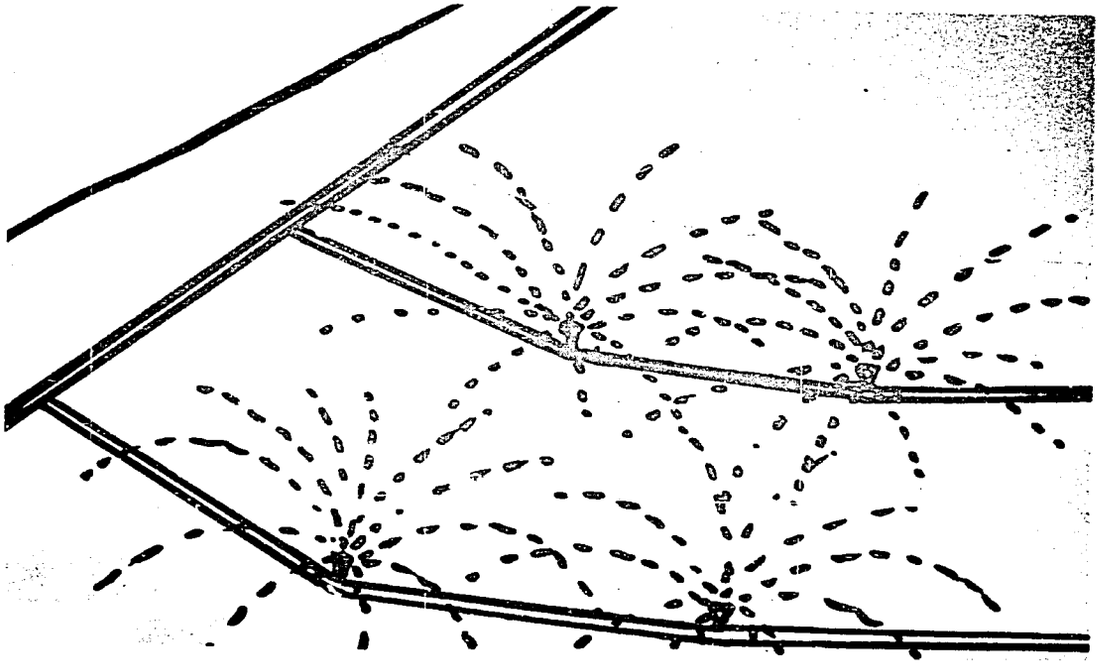
Sprinkler irrigation systems usually are designed and installed by trained persons. They may be very expensive, but at times they are the best way to irrigate well. In this case, the additional yield may easily pay for the cost.

CROPS:

all except those damaged by water on their leaves. Be careful when using saline water because some crops have leaves which can be damaged by salts.

SOILS AND TERRAIN:

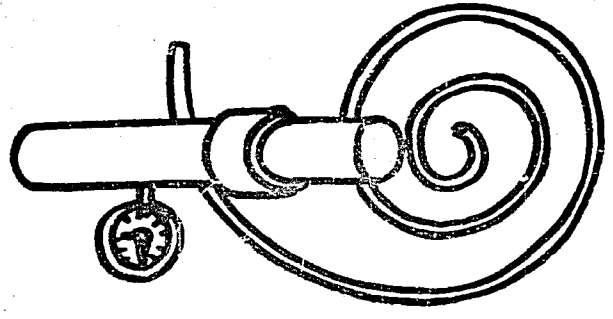
Sprinklers can be used in all types of soils, on uneven terrain and slopes to more than 30 percent. With sprinkler irrigation, water is not wasted and soils are not eroded.



Necessary Equipment

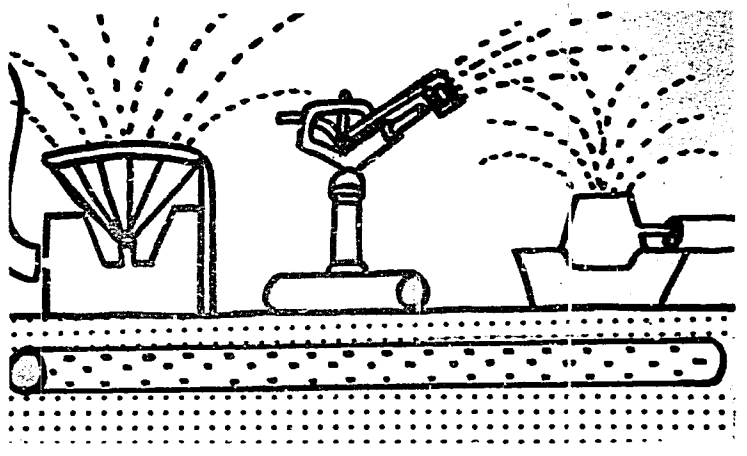
•a ***hose*** or ***pipe***

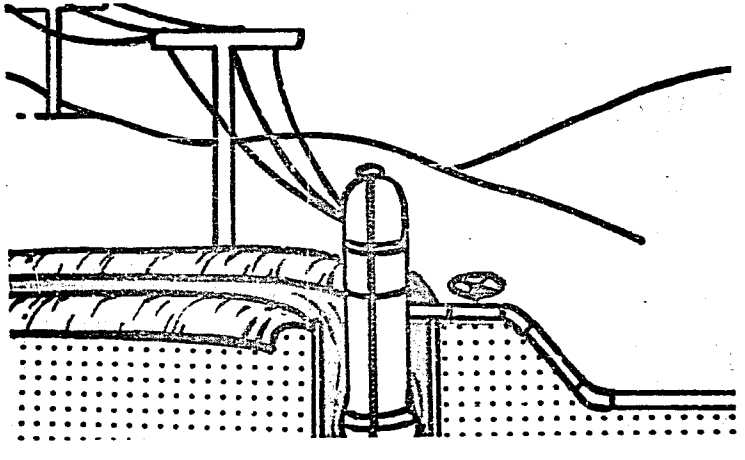
to carry water under pressure. The hose and connections can come from a hardware store or irrigation equipment supplier.

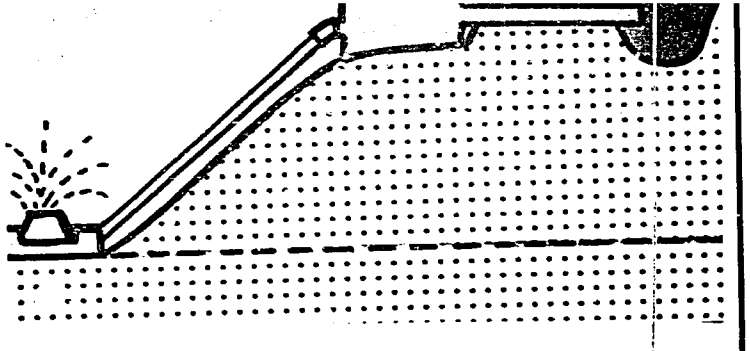


•a ***sprinkler***

Plastic and metal sprinklers are found at hardware stores or irrigation equipment suppliers. In some countries local artesans make good ceramic sprinklers.





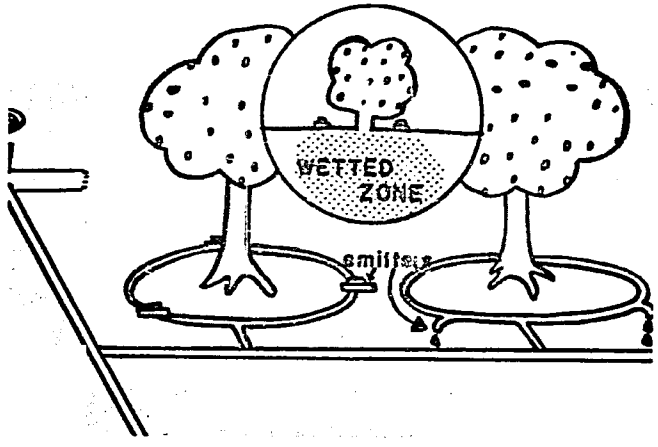


•a ***pressure source***

This may consist of a pump and power unit, or where there is significant difference in elevation (more than 5 meters) between the source of water and where the water will be used, you have a source of natural pressure.

11. DRIP (TRICKLE) IRRIGATION

Water (and usually fertilizer) is applied to each plant individually. Drip irrigation is well adapted to all soils and terrains, but it can be very costly and is used only on high cash value crops.



CROPS:

fruit trees, shrubs, vegetables

In some countries, efficient, low cost, simple methods have been devised which are much like drip irrigation without the clogging problems and pressure requirements.

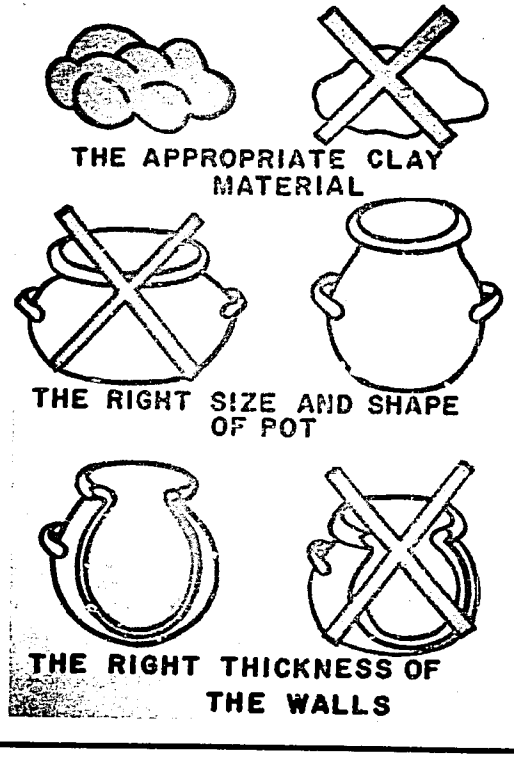
EXAMPLE:

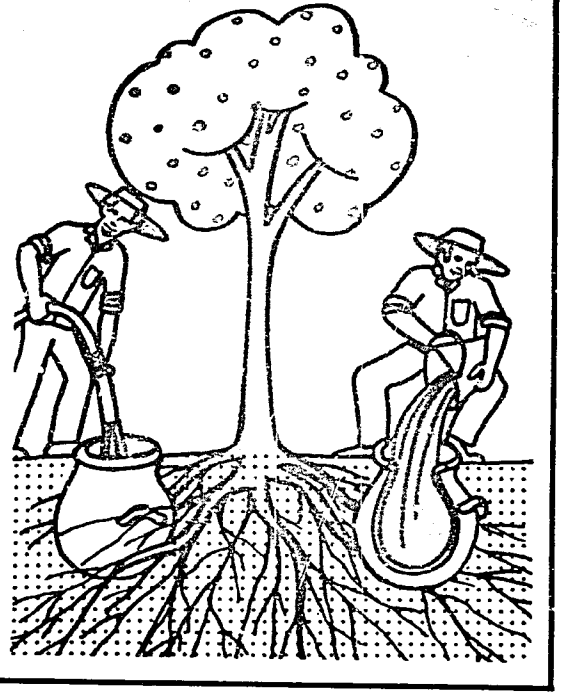
Porous Clay Pot Irrigation

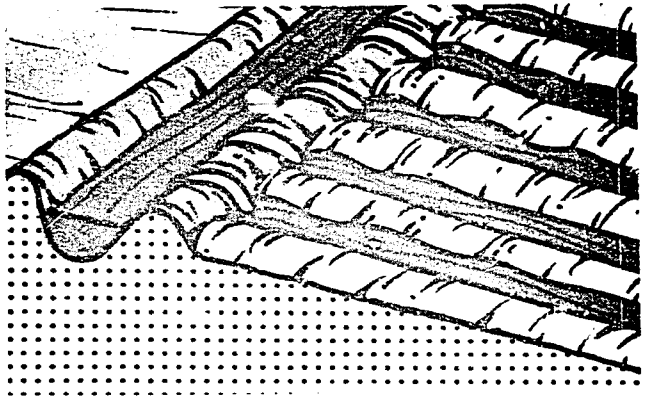
The pots must allow water to pass through the walls slowly. We must experiment to find out:

- the appropriate clay material
- the right size and shape of pot
- the right thickness of the walls

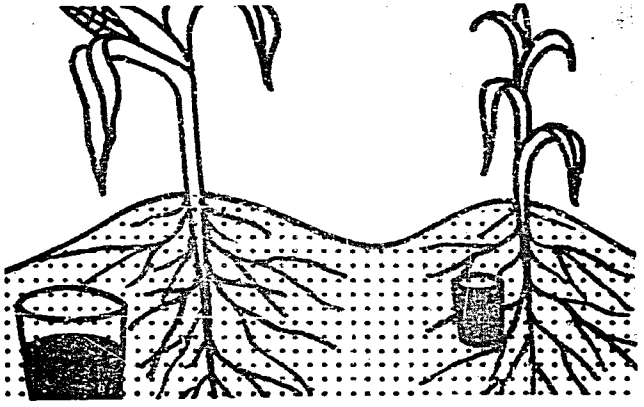
To irrigate — fill the pot with water. With a few trials you can determine how much and how often to fill the pots to provide plant needs. Not all pots will work!







What is a Good Irrigation?

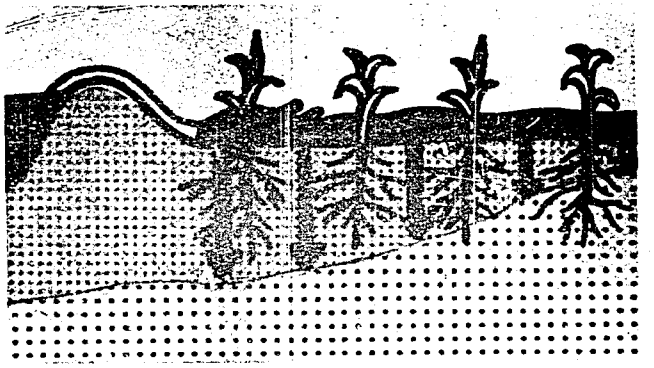


What are Crop Water Needs?

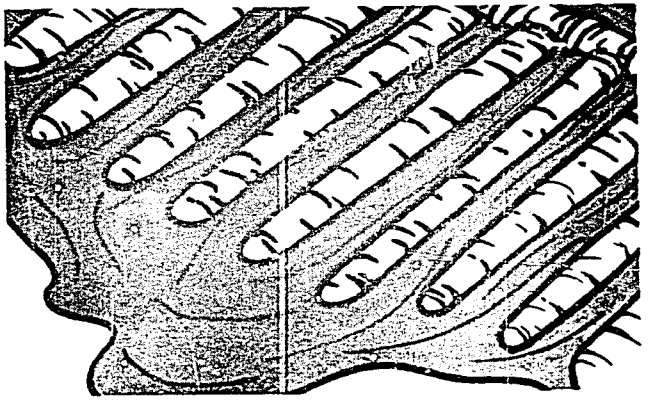
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

How Do I Know When to Irrigate?

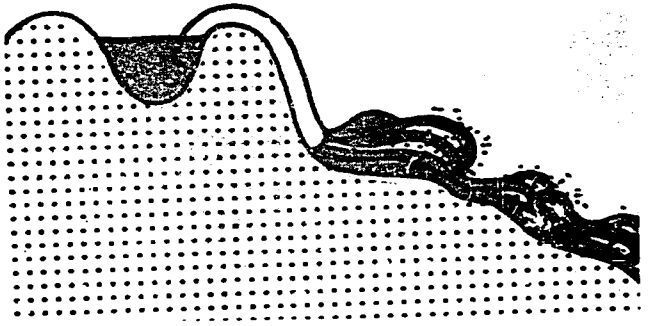
FARM WATER MANAGEMENT



How Do I Keep My Irrigations Uniform?



How Can I Keep My Runoff Losses Down?



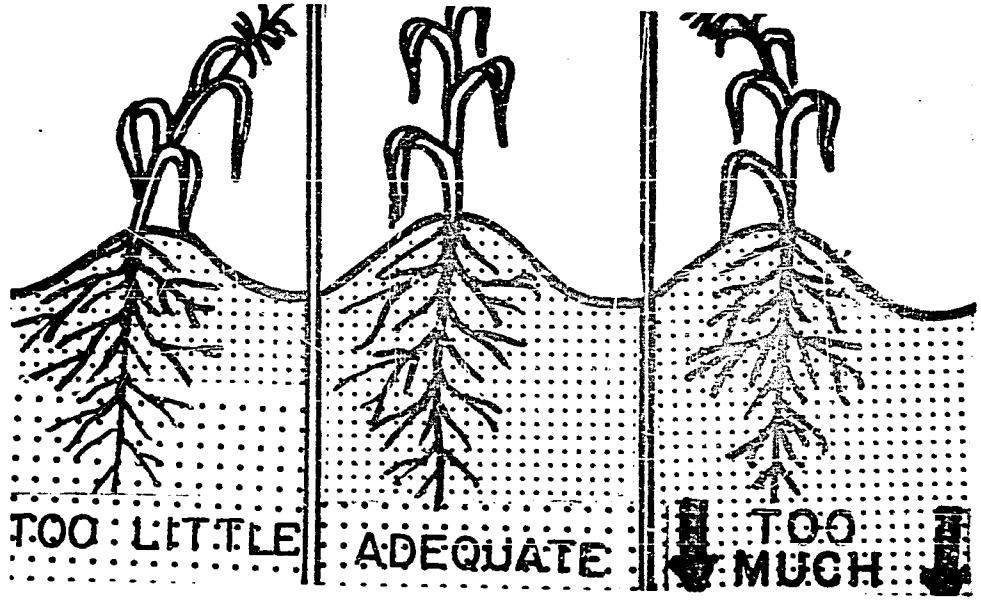
How Can I Stop Erosion?

WHAT IS A GOOD IRRIGATION?

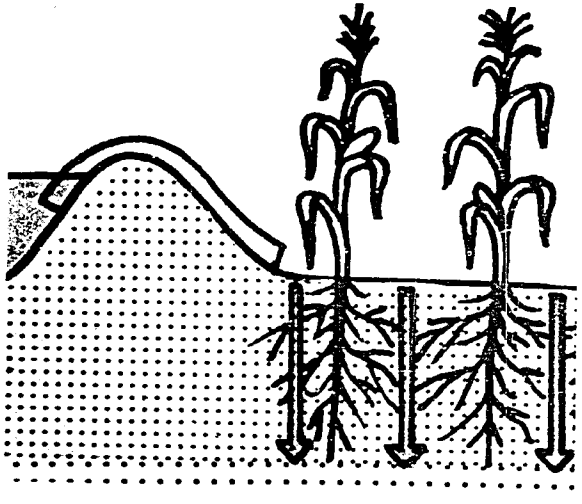
A good irrigation is when:

1. water is applied when the crop needs it...not when the plants look like this...

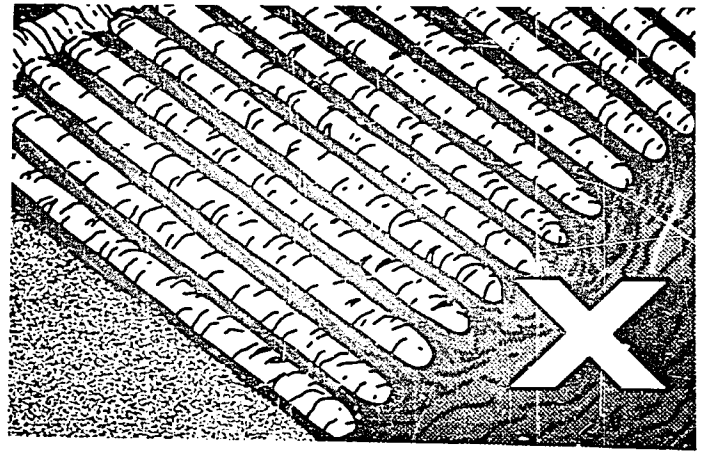
2. the right amount of water is applied to the root zone.



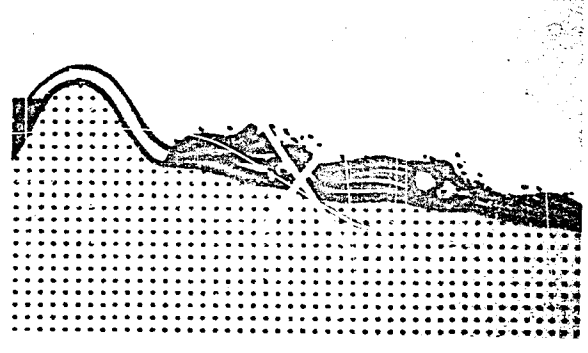
3. the penetration is uniform or almost uniform.



4. Irrigation does not result in excessive runoff and wasted water.



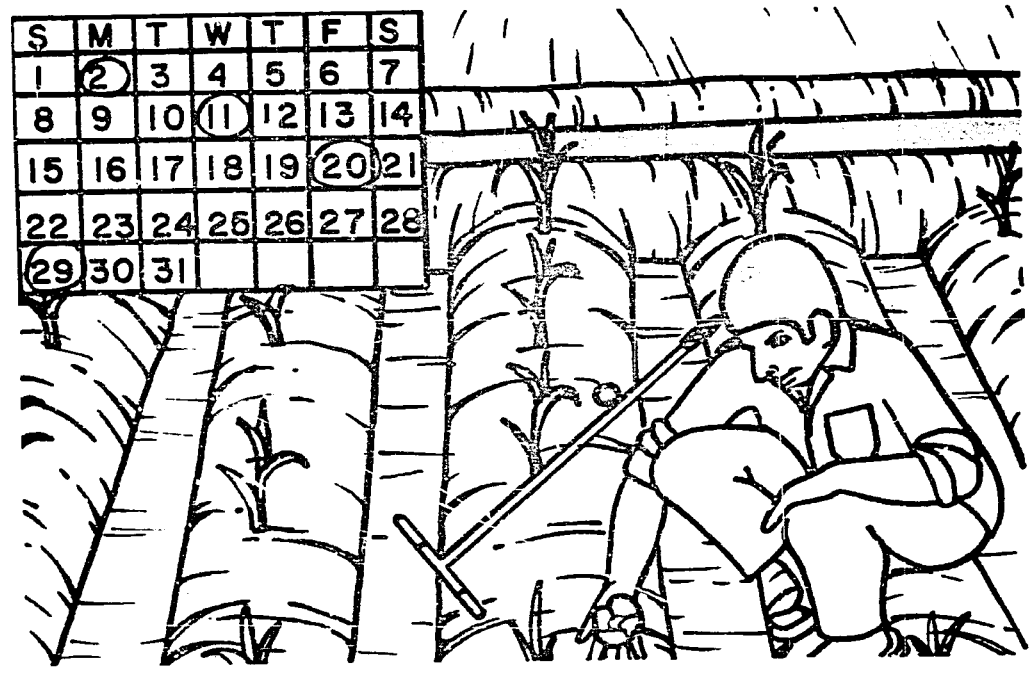
5. The water does not erode the soils.



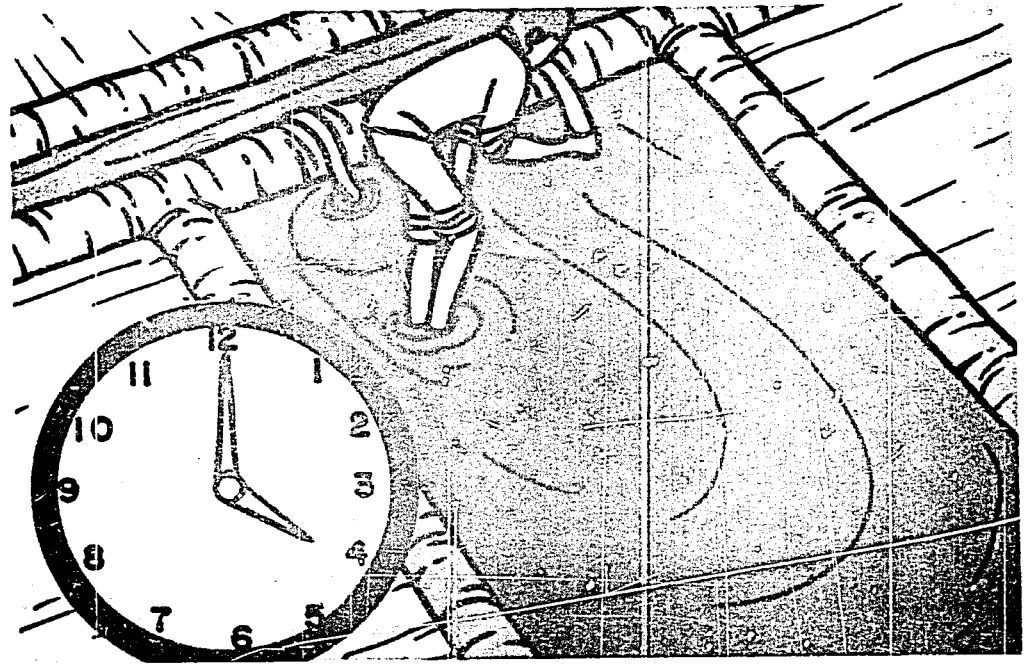
To irrigate well, the farmer must know:

1. The water needs of the crops.

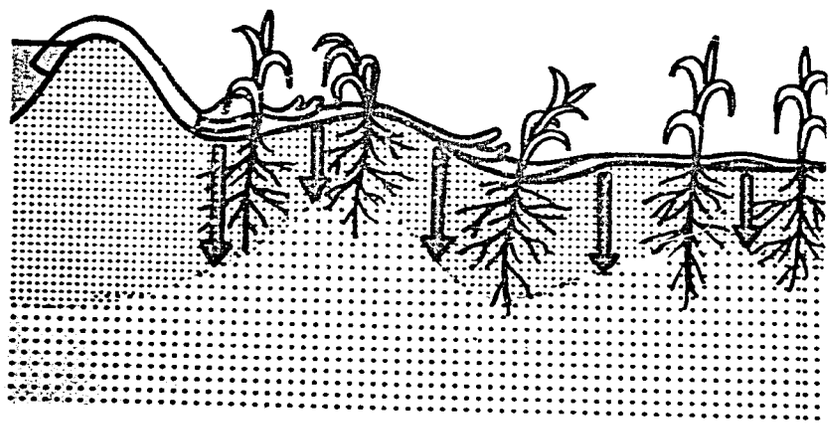
2. The approximate time that should elapse between irrigations; how to tell with certainty if it is time to irrigate crops.



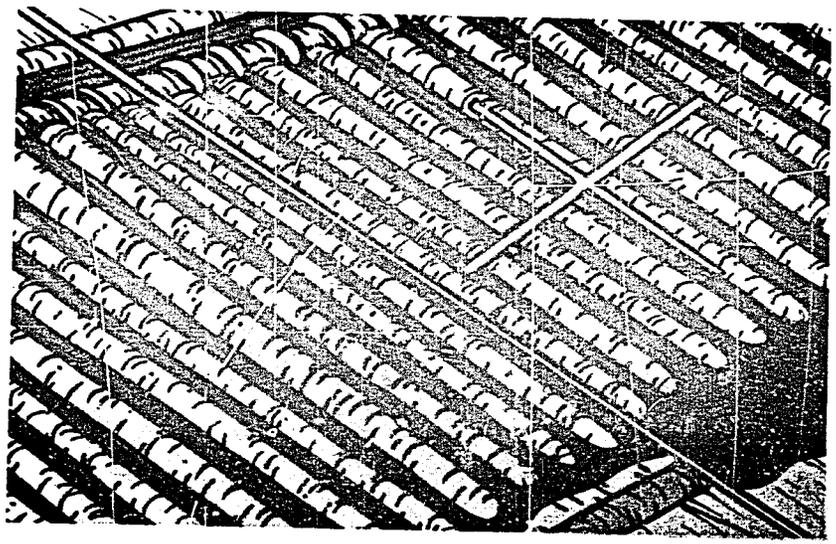
3. When to cut off the water.

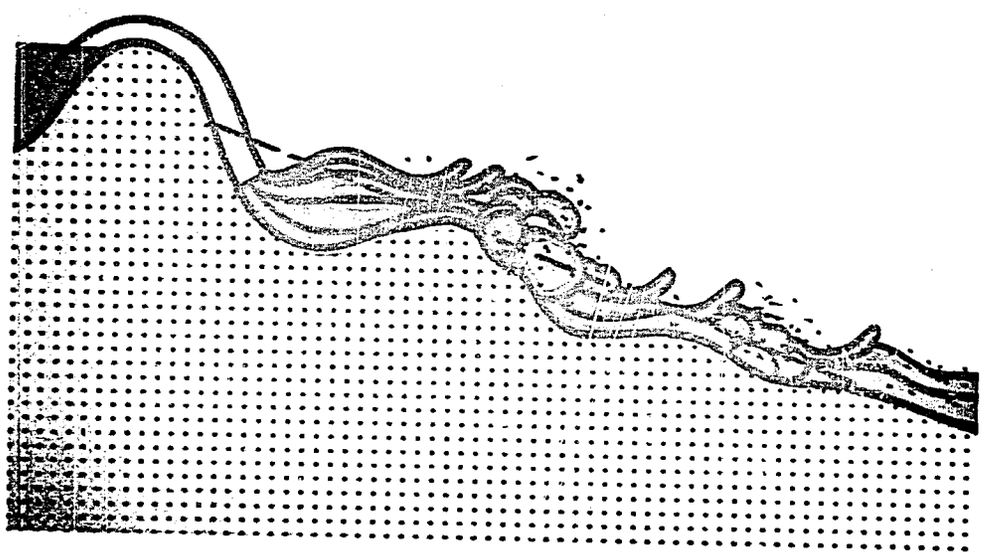


4. If the irrigations are uniform. If not, how to improve them.



5. How to keep runoff losses low.

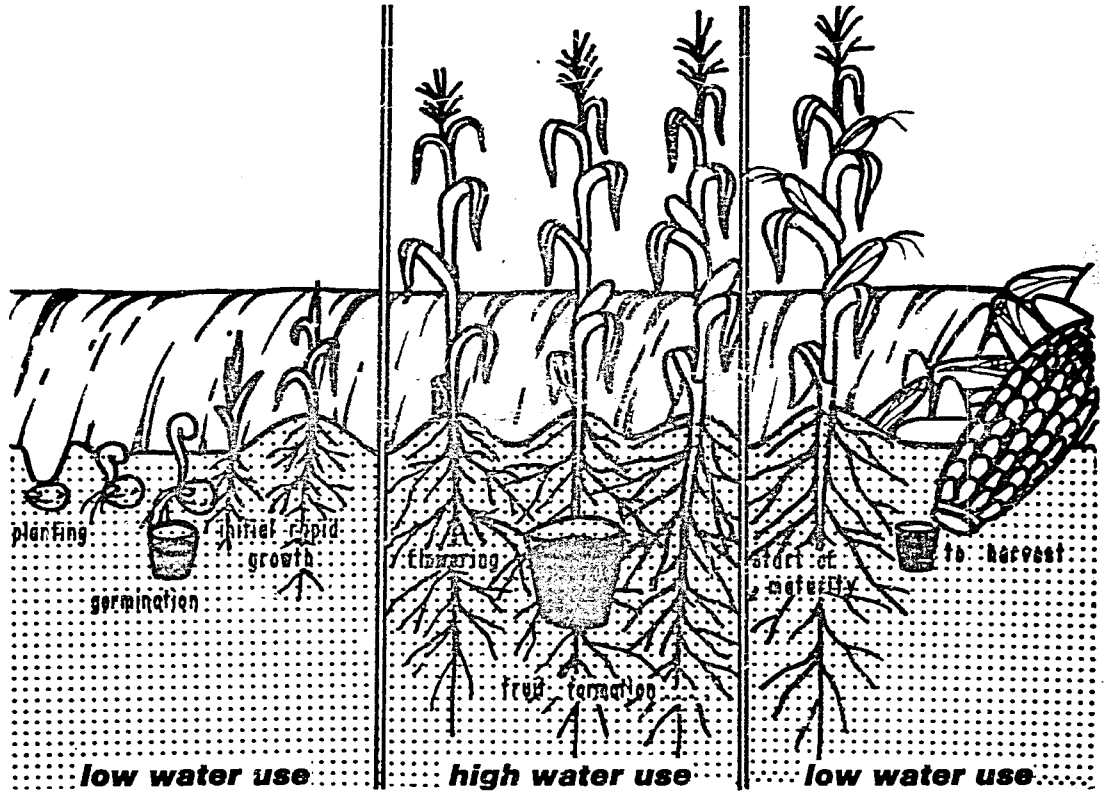




6. How to identify erosion problems and eliminate them.

WHAT ARE CROP WATER NEEDS?

Water requirements vary as the crop develops, but in general:



Some crops withstand lower soil moisture levels better than others without lowering yield.

NOT TOLERANT to low moisture

- potatoes
- lettuce
- onions
- spinach
- celery
- strawberries

SEMI-TOLERANT to low moisture

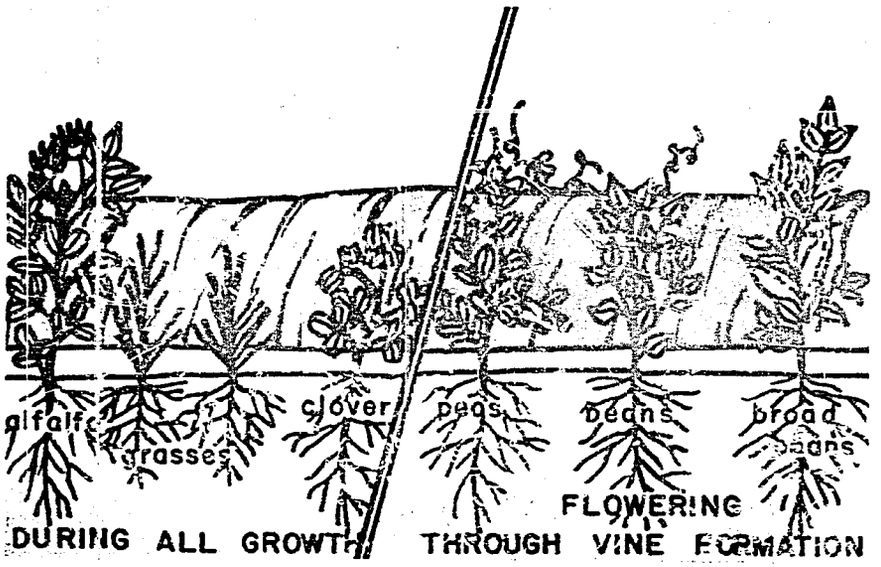
- peas
- clover
- beans
- pasture grasses
- cabbage
- turnips
- radishes
- chard
- beets

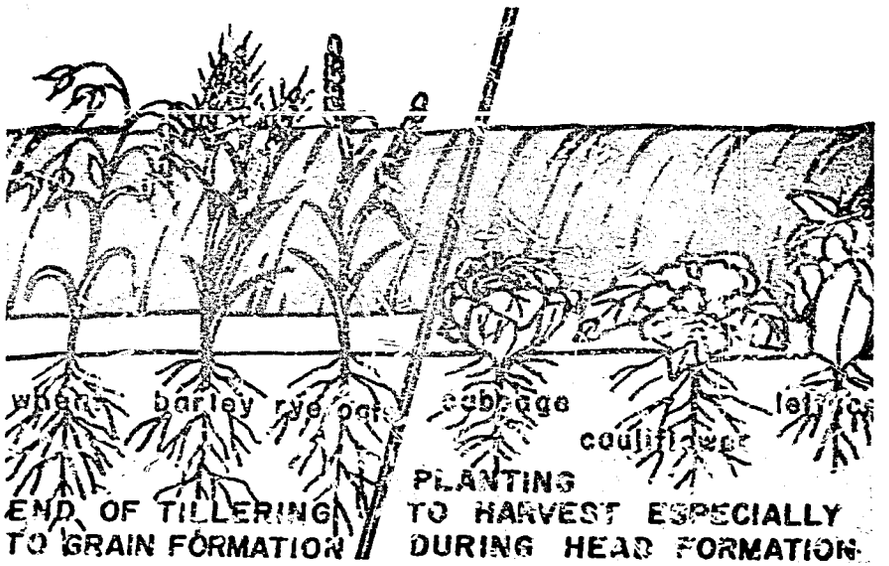
MOST TOLERANT to low moisture

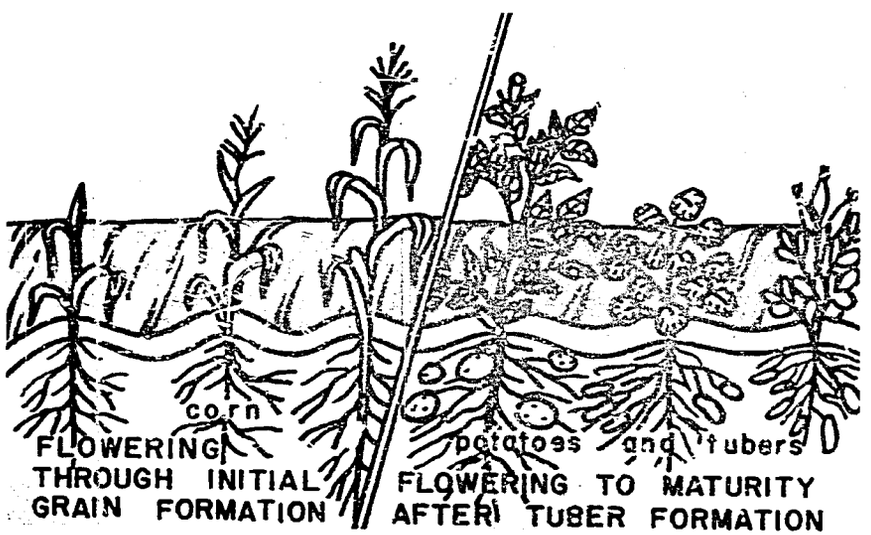
- corn
- wheat
- oats
- alfalfa
- cotton

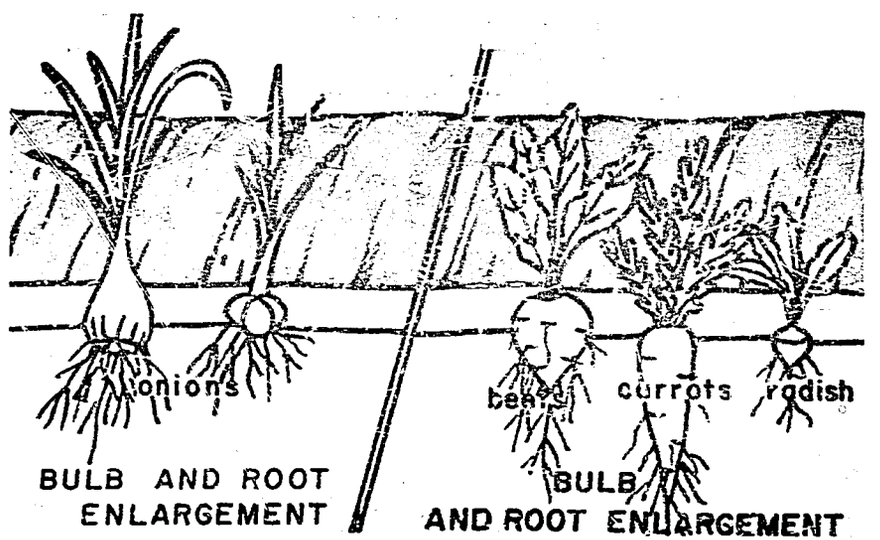
Maintain high moisture levels from flowering through grain formation on cereal crops so that yield is not affected.

Most crops have periods when a lack of water results in great reductions in yield. Make adequate moisture available, especially during these stages!!







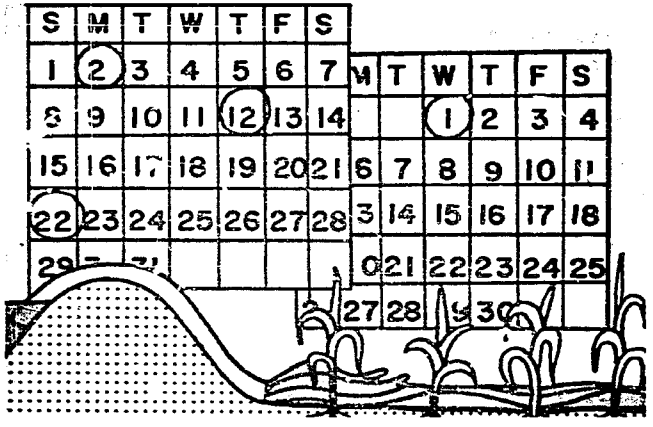


HOW DO I KNOW WHEN TO IRRIGATE?

The frequency of irrigation depends on the amount of water used by the crop and the amount of water which can be removed from the soil by the crop without stress to the plant.

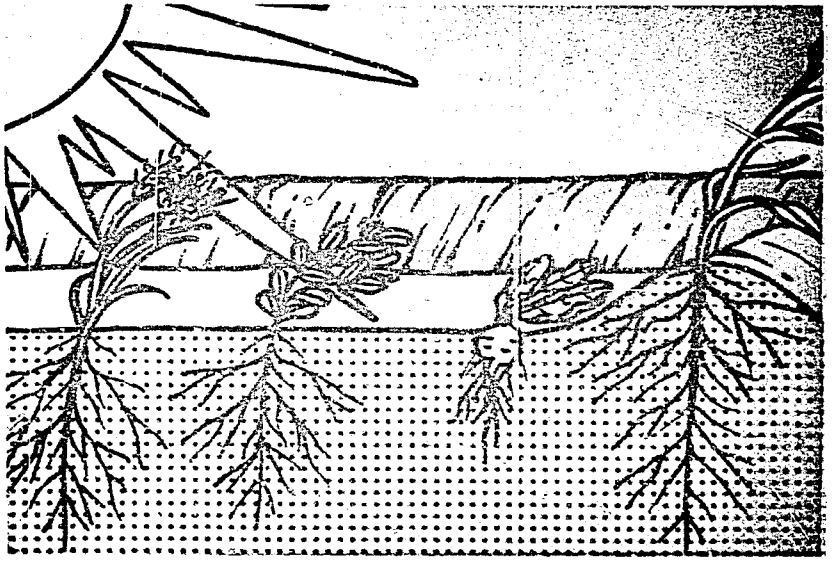
Consider the same crop and the same soil depth:

Sandy soils hold less water, so irrigations must be more frequent than on fine soils — but less water should be applied at each irrigation.

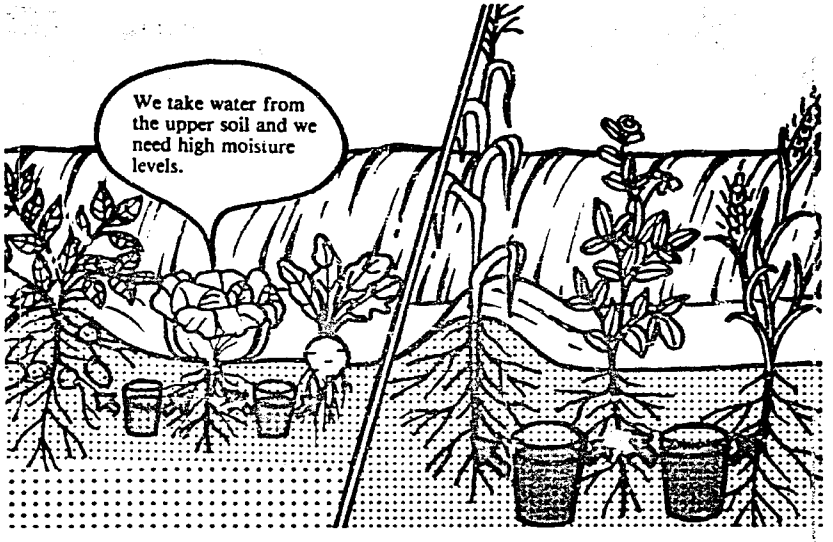


Consider the same soil and different crops:

Crops with shallow roots have less water within their reach, so the irrigations should be more frequent and lighter (less depth per irrigation) than deeper rooted crops.



On sunny, hot days, crops use more water than on cool, cloudy days and irrigations must be more frequent.



Apply only light irrigations during germination; just enough to wet the seed bed. Heavy irrigations wash the nutrients down from the upper part of the soil where they are needed for initial development.

Fill the soil profile with moisture early in the season so that you will have a reservoir for your plants to draw water from when the supply becomes deficient.

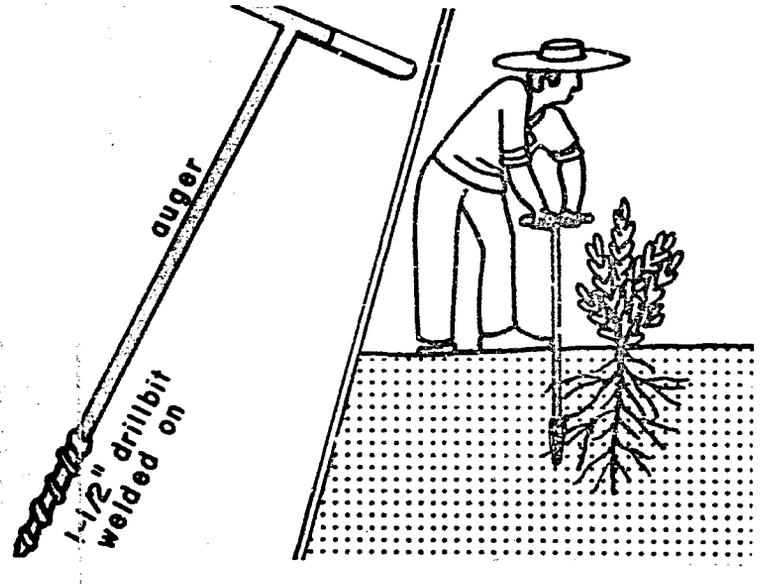
Use the following procedure to determine if it is time to irrigate.

1. Take some soil from the root zone area.

   - if the crop has 12 inches of roots, check at least to six inches, and sometimes to 12.

   - if the crop has 24 inches of roots, check to at least 12 inches, and sometimes to 24, etc.

2. Squeeze the soil in your hand.



3. Open your hand and observe the soil. Irrigate most crops when the soil gets to the following state:

Coarse or sandy soil:

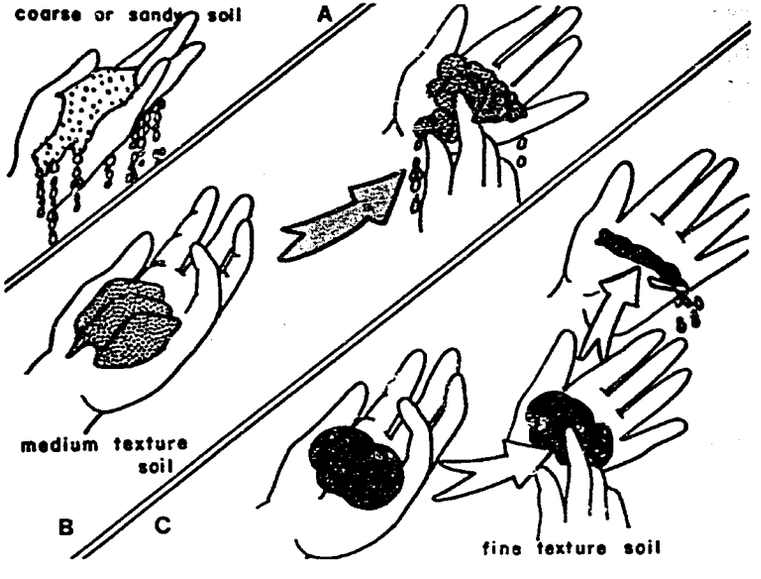
The soil falls apart (crumbles) when the hand is opened. **(A)**

Medium textured soil:

The soil retains the form of the compressed hand when opened, but crumbles when pressed by the finger. **(B)**

Fine textured soils:

The soil retains its form when the hand is opened. The ball will not crumble when pressed by the finger. However a thin cylinder cannot be formed with the soil. **(C)**



Crops which are not tolerant to stress should be irrigated BEFORE they get to the conditions indicated above.

You can determine if the irrigation has removed the moisture deficit from the root zone.

1. Dig down to the root depth:

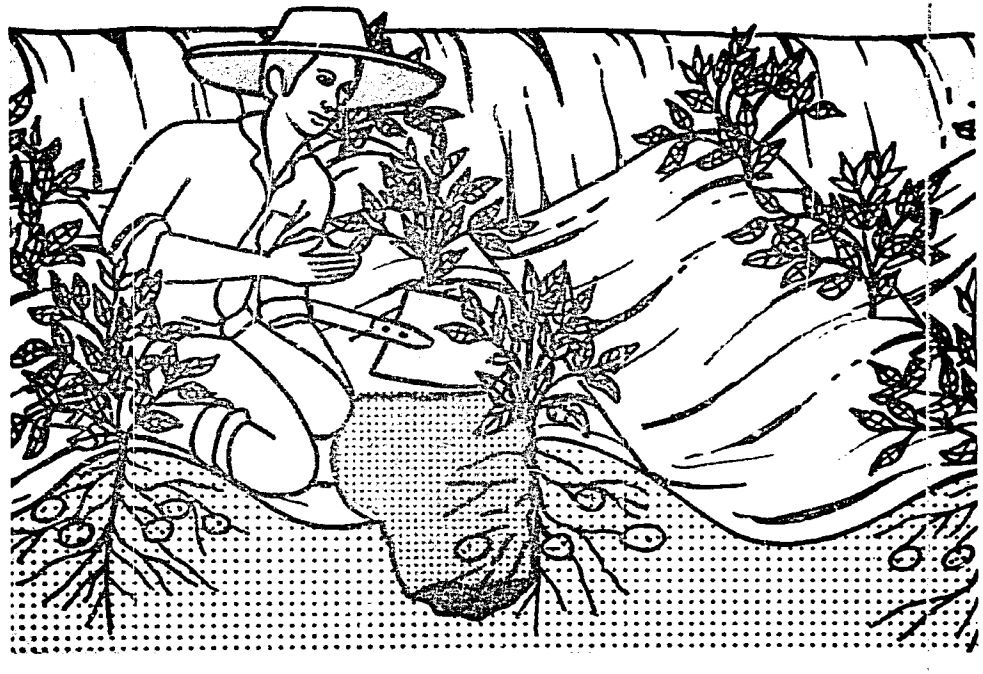
   1 day after irrigating coarse-textured soils

   2 days after irrigating medium-textured soils

   3 days after irrigating fine-textured soils

2. Check the moisture depth.

   A change in moisture will usually be obvious if the water has not penetrated enough.

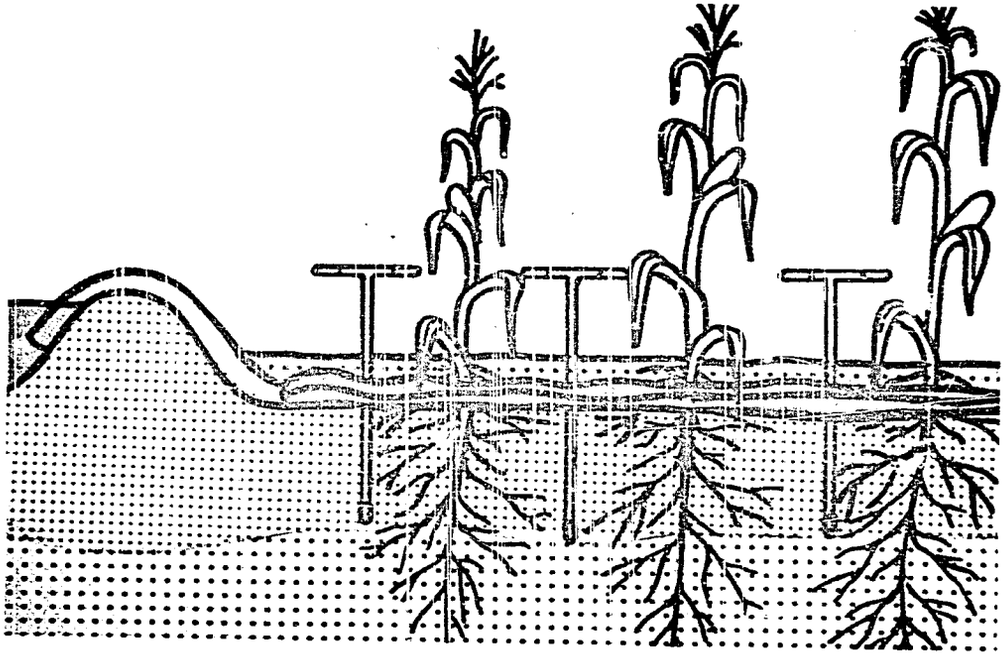


WHEN CAN THE WATER BE CUT OFF

In furrows:

Cut the water off when the round-tipped probe (see tool section) penetrates easily ½ to ¾ of the root depth along the whole run.

Water will penetrate the soil for a significant time after an irrigation. This is why it does not need to penetrate to root depth during the irrigation.

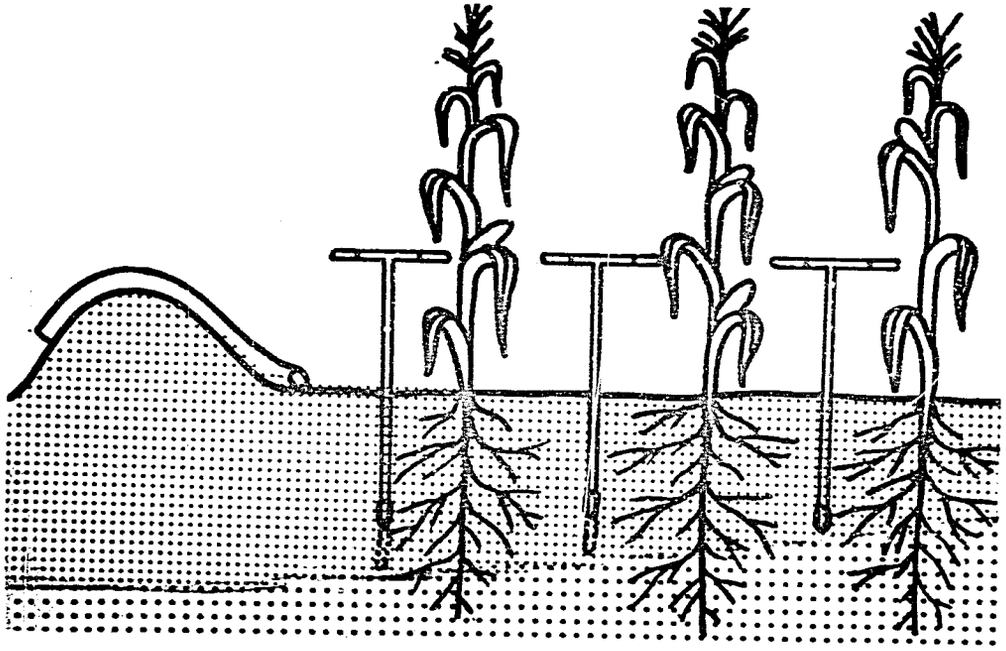


In borders or basins:

The round-tipped probe should penetrate from ½ to ¾ of the root depth, after the water disappears from the surface.

Adjust the irrigation duration, stream size, and how far it must travel along the surface before being cut off.

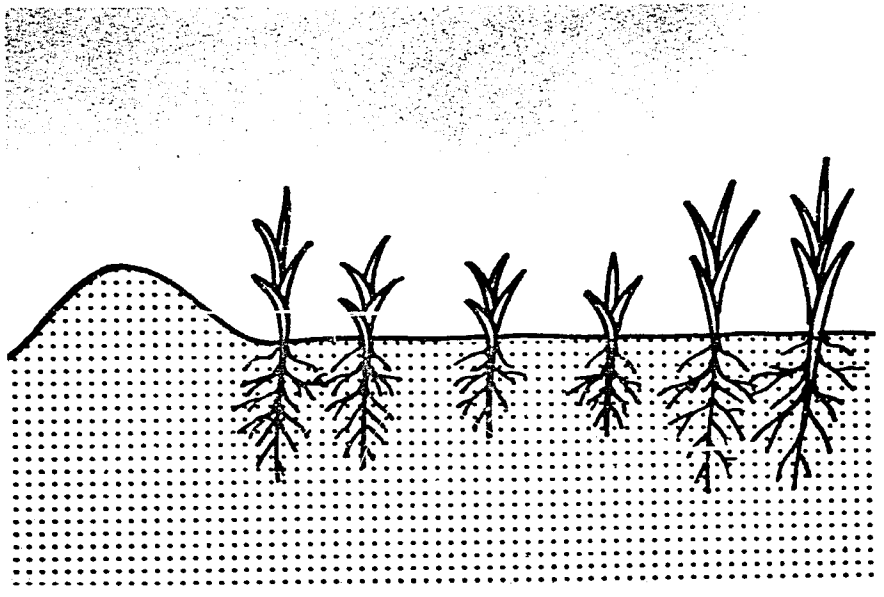
In border irrigation, the stream usually proceeds ⅔ to ¾ of the border length before being cut off.

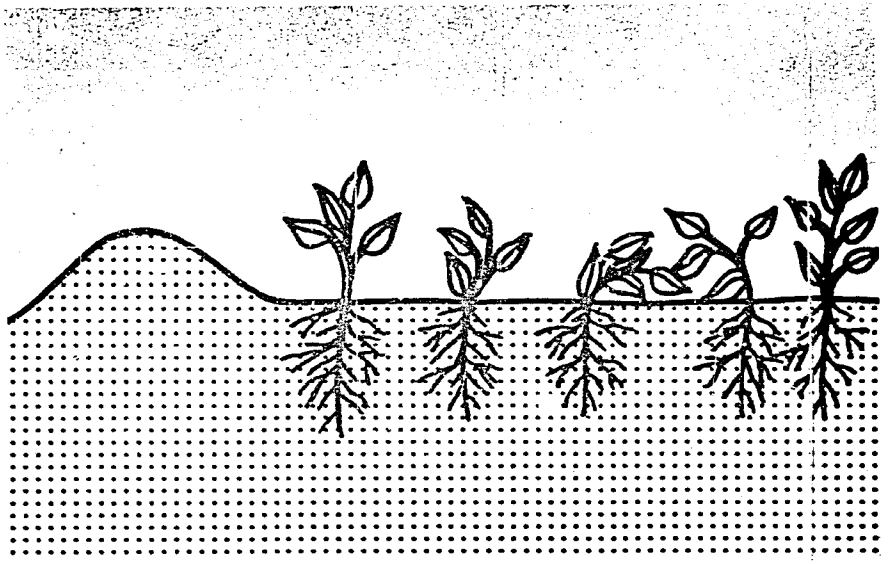


HOW DO I MAKE SURE THAT MY IRRIGATIONS ARE UNIFORM?

First, look for any of the following indicators of non-uniformity.

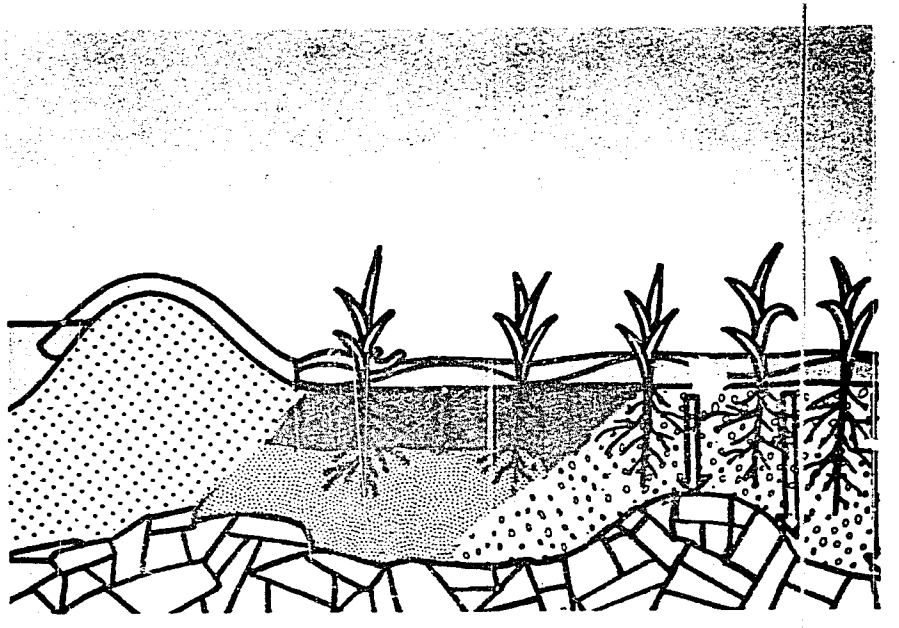
1. Variation in plant height through the field.



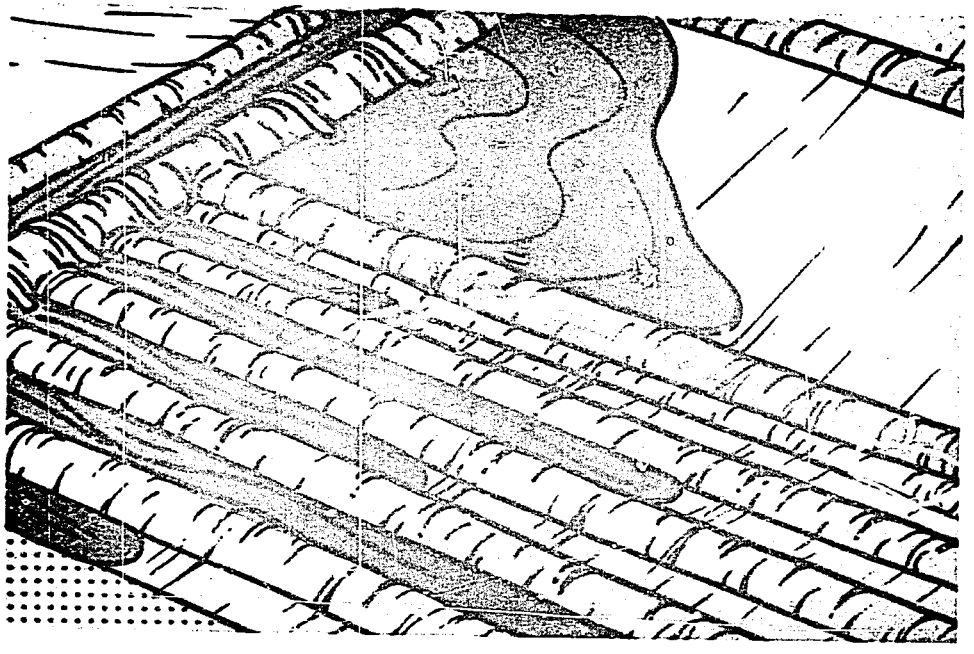


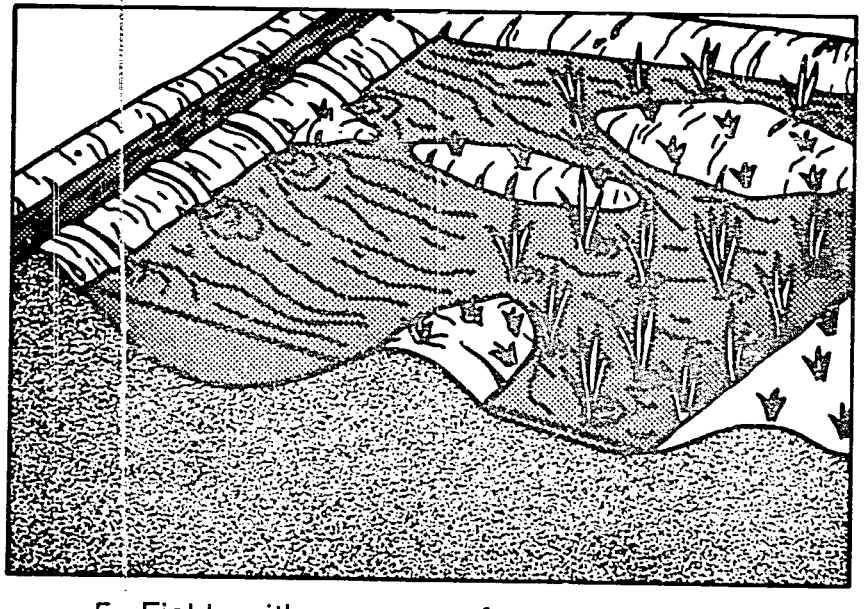
2. Plants wilting in some parts of the field and not in others.

3. Large differences in texture and depth of soil along the field.

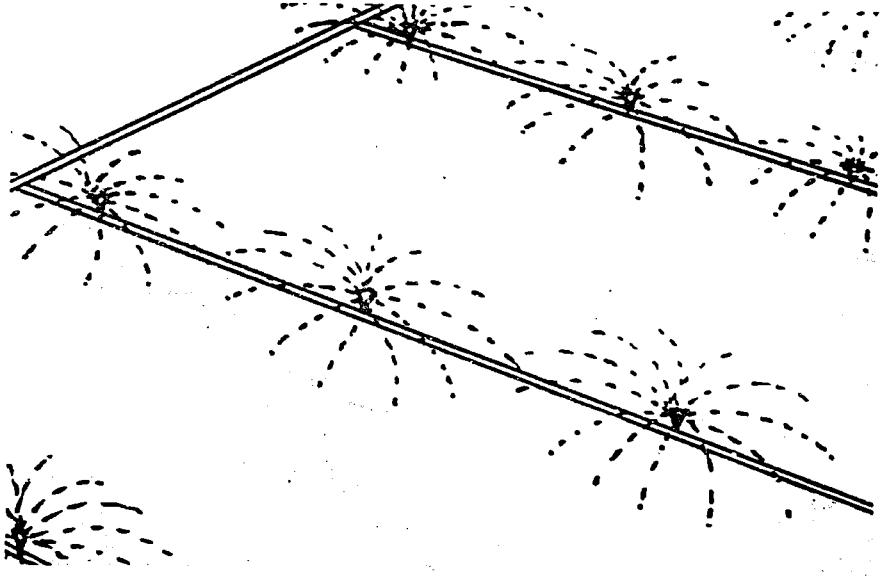


4. Large variations in the time that water remains on different parts of the field. (For example, if the water advances slowly over the field and disappears at almost the same time over the whole field, the water may have penetrated more at the head than at the tail end of the field.)





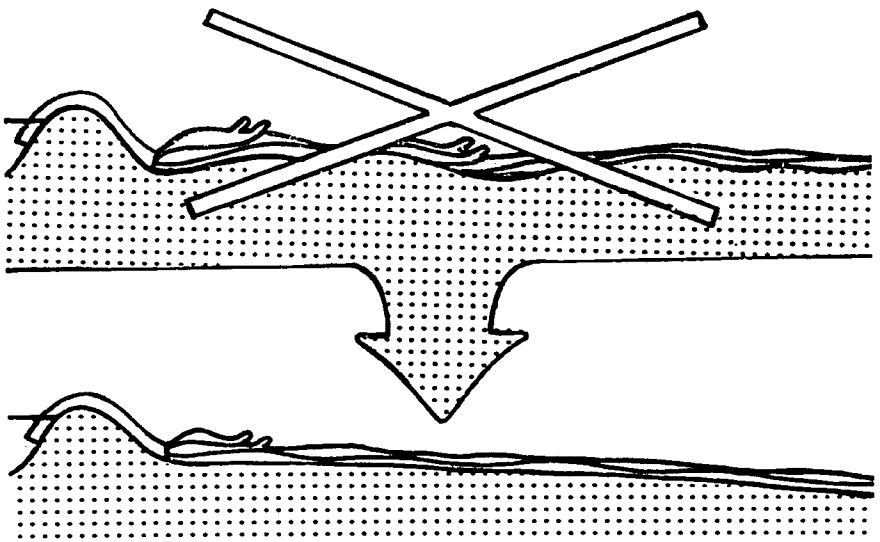
5. Fields with uneven surfaces...water ponds in low spots and high spots remain dry.



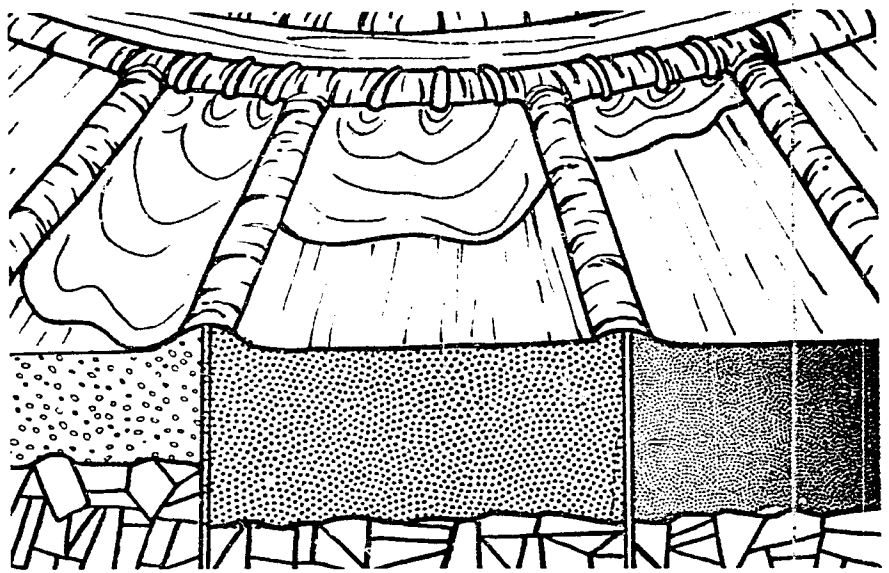
6. Sprinklers spaced so far apart that the water from one does not overlap with that of another, or does so very little.

There are usually solutions to the problem of non-uniformity.

1. An uneven soil surface can be leveled or planed.



2. Soils of different textures or structures and depths may be irrigated separately.

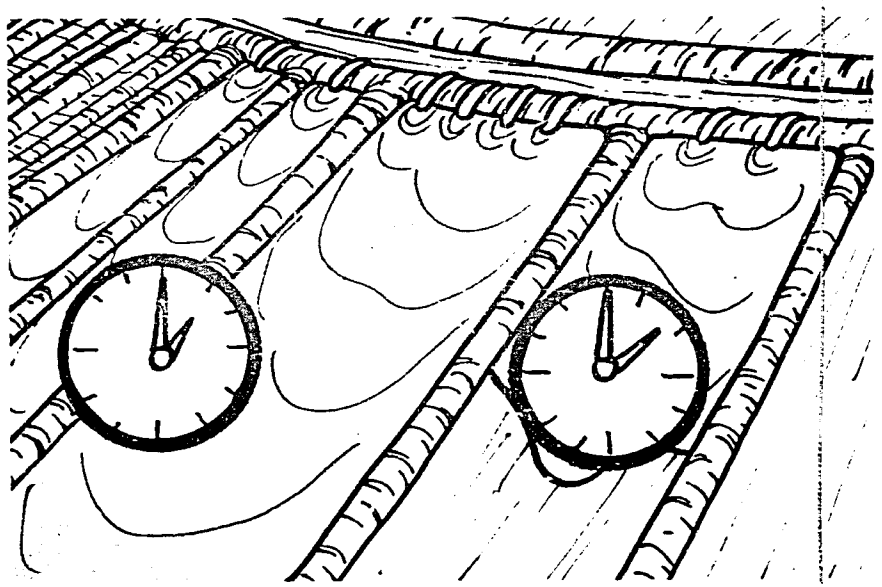


3. If the difference in time that water stands on the surface at the head and tail end of the system is great, we may be able to:

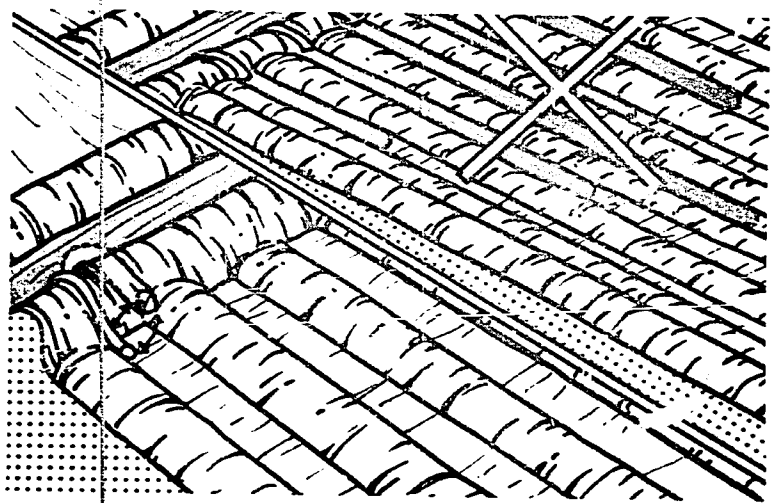
   a. cut down the length or width of furrows, borders, or basins

   b. increase the size of stream at the inlet of the furrow, border, or basin.

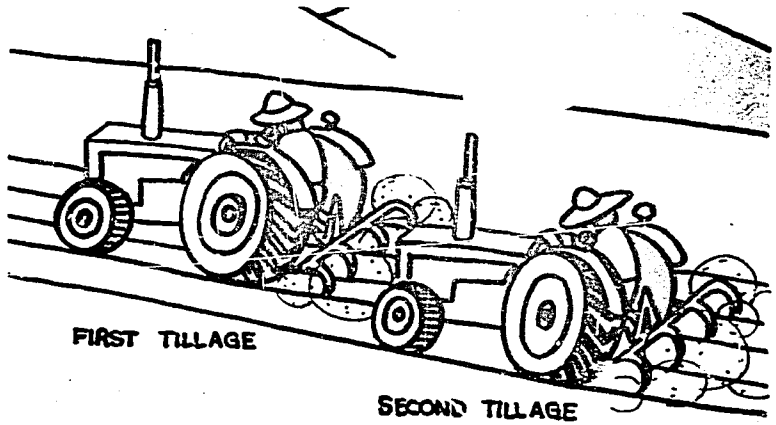
   c. increase the irrigation duration.



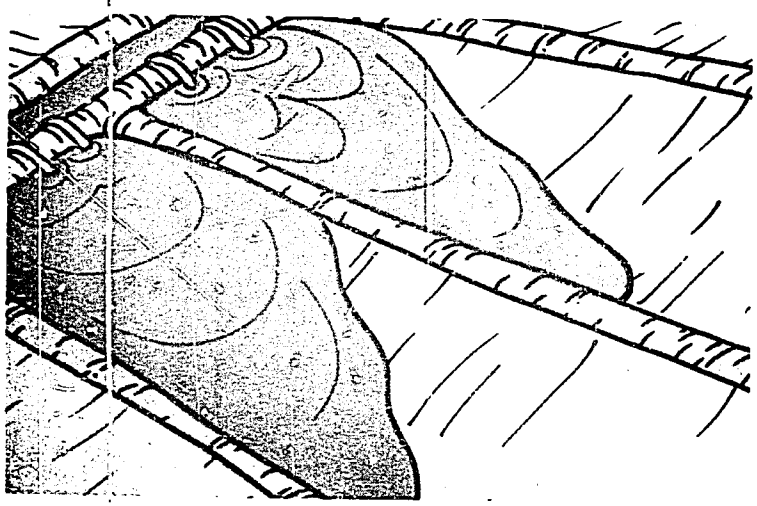
4. If the water did not advance evenly in all the furrows, you might change your irrigating tools. Use siphons and adjust them so that the necessary amount goes into each furrow.



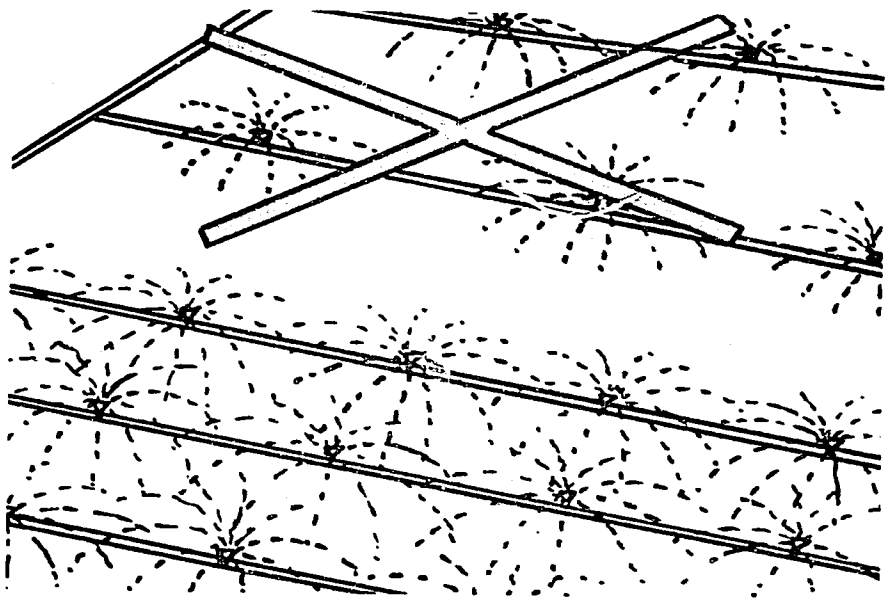
5. If some furrows are more compact than others because of tillage practices, change so that each furrow gets the same amount of tillage traffic.



6. When water in a border tends to flow along one side, there is too much cross slope. Change the direction of the borders to that of the primary slope, or level or plane each border to eliminate cross slope.

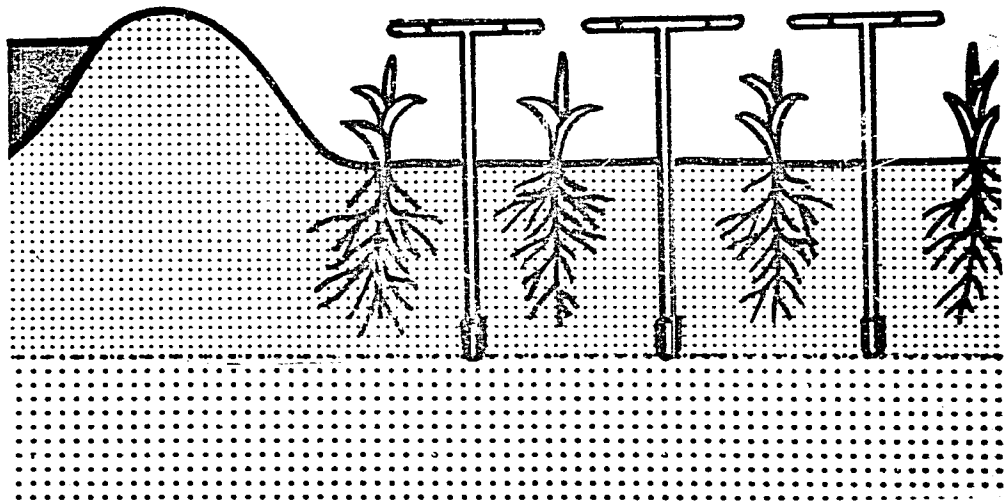


7. Decrease sprinkler spacing and/or increase pressure.

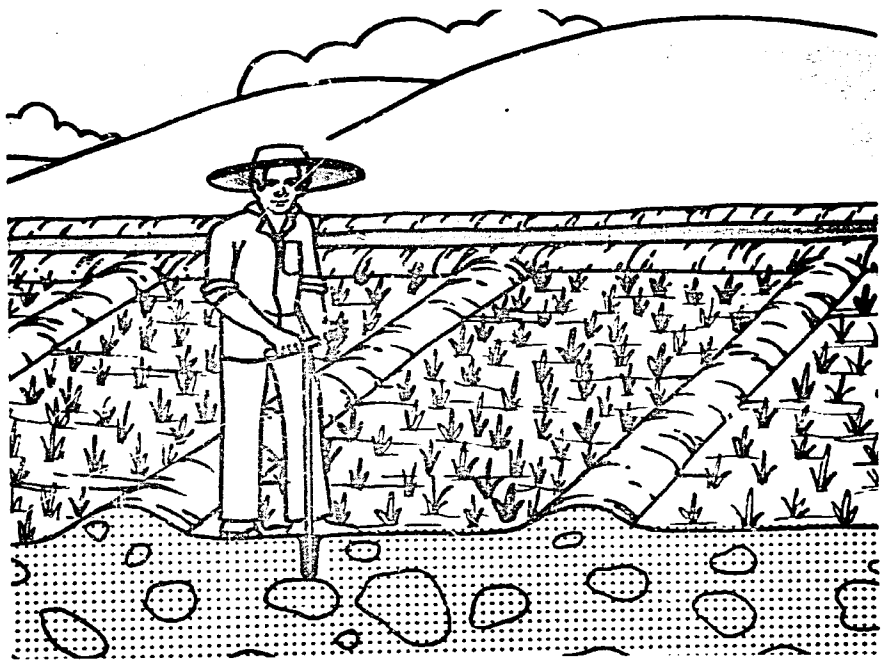


To determine definitely if the irrigation was uniform or not:

1. Introduce the long, round-tipped probe into the soil along the irrigation run after an irrigation and note at what depth it meets significant change in resistance. This is the depth the water penetrated to. Check the depth of penetration in different parts of the field and compare.

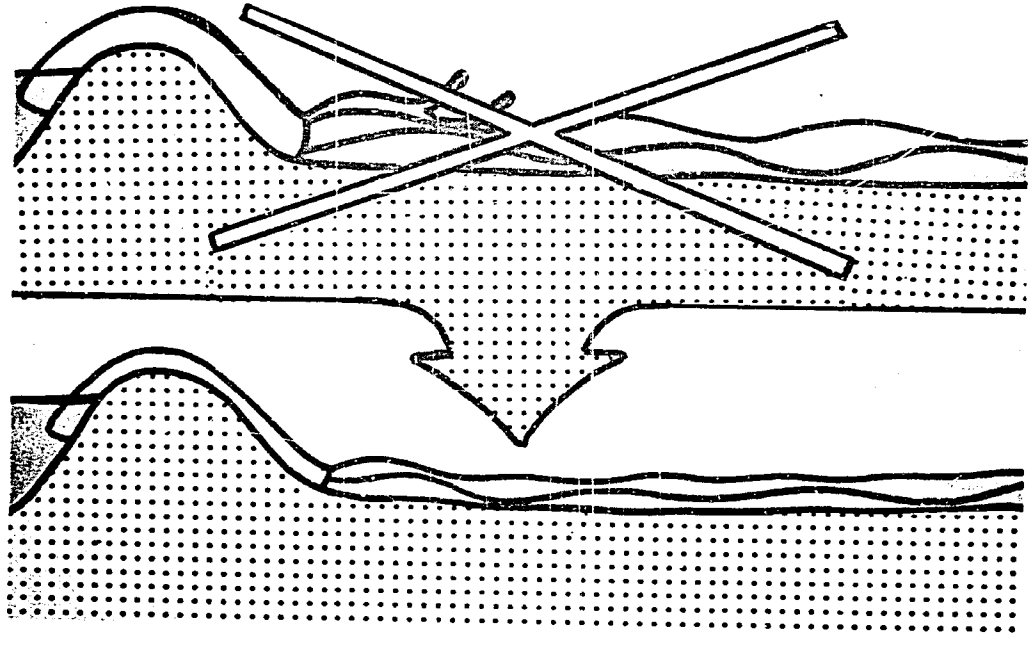


On rocky soils this probe will not work. Excavate with a shovel, soil auger or other instrument to observe the depth of penetration.



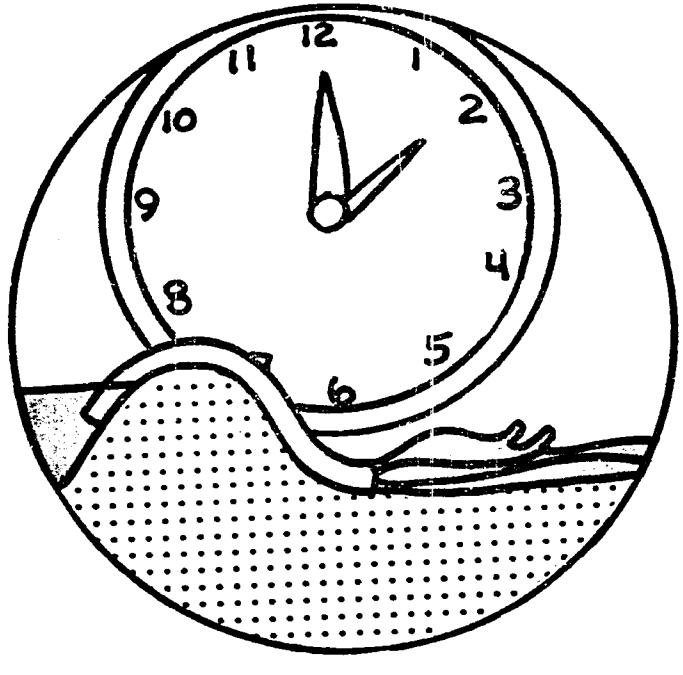
HOW CAN I KEEP MY RUNOFF LOSSES DOWN?

1. Decrease the size of the stream into the furrows, borders, and basins.

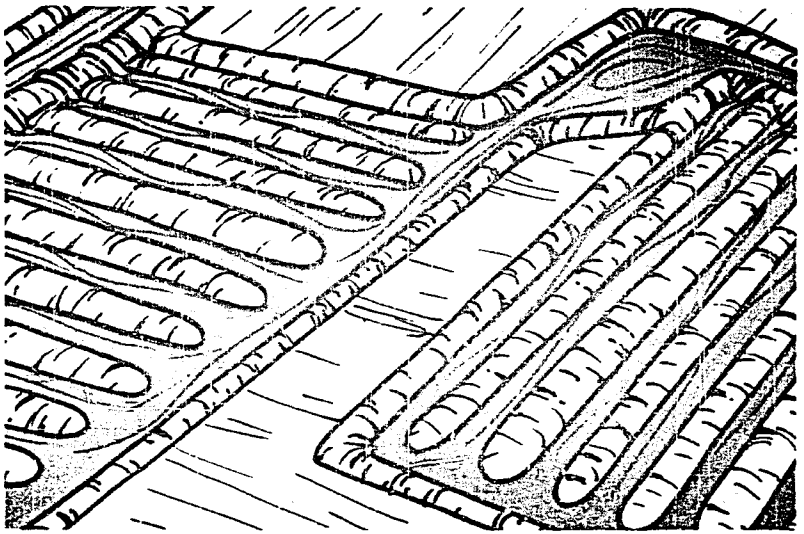


2. Decrease the duration of each irrigation. Give lighter, more frequent irrigations.

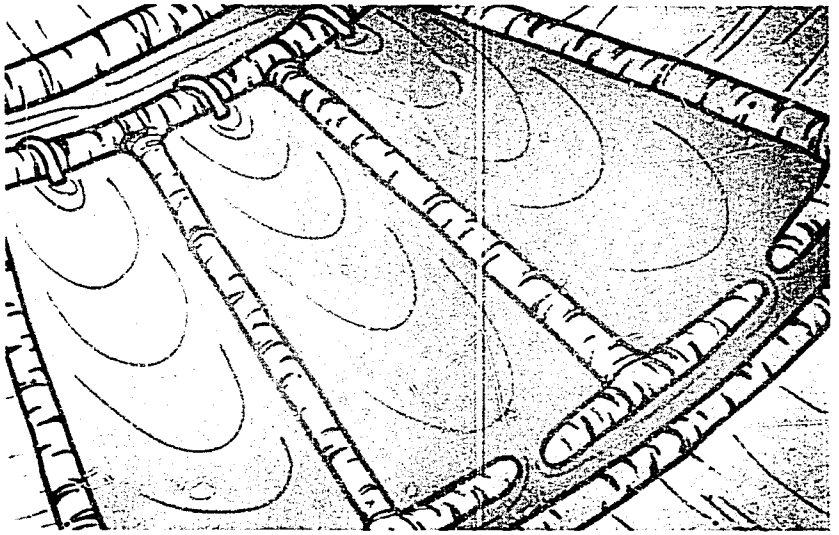
3. Reduce the inflow into the furrows when the water reaches the end.



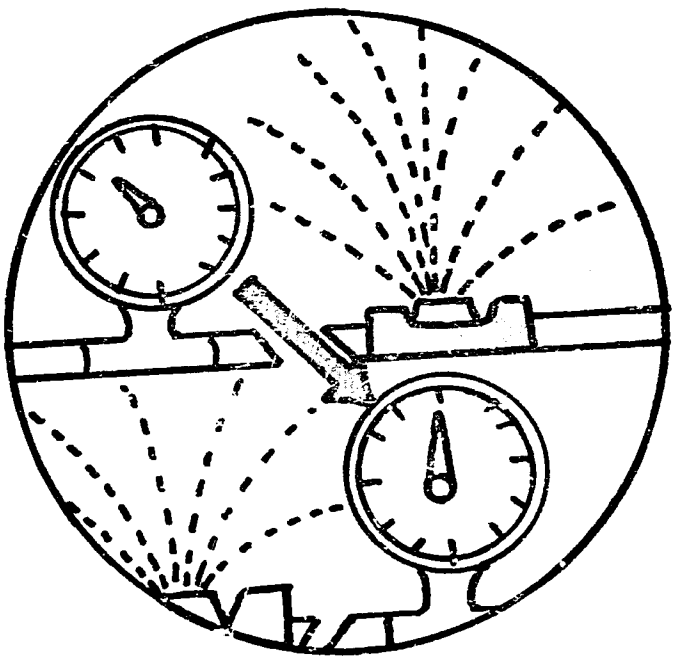
4. Gather the runoff water in reservoirs and pump it back to the head or take it to other fields.



5. With borders, build small dikes at the end (outlet) to hold some of the water back.



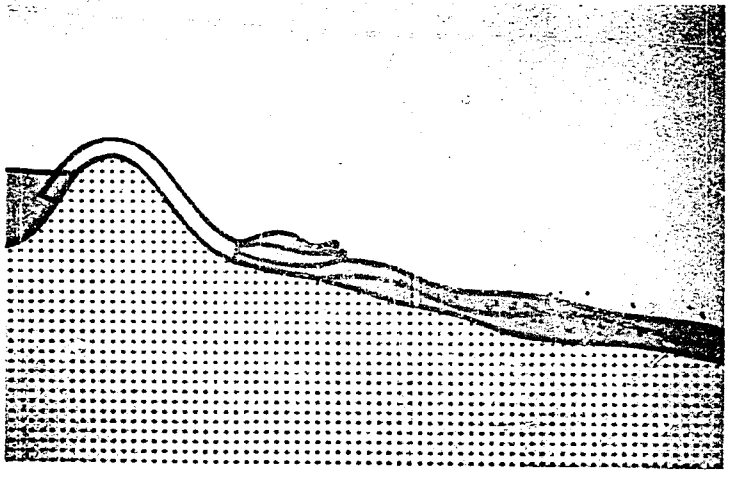
6. Increase sprinkler pressure to break up drops so the water penetrates more easily.



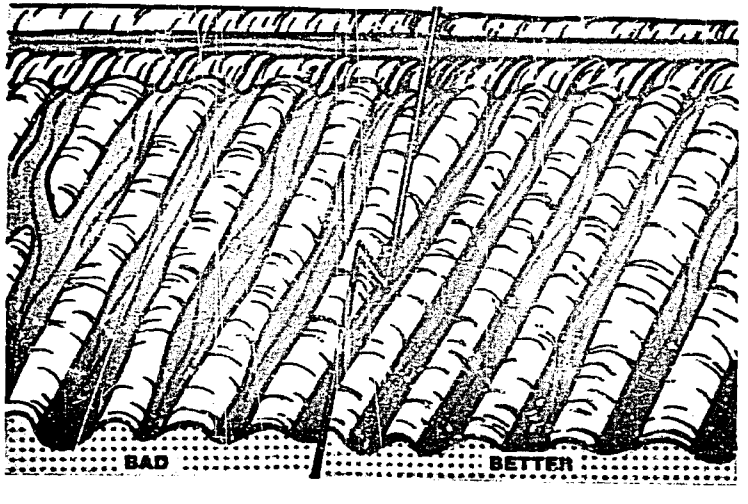
HOW CAN I STOP EROSION?

First of all observe:

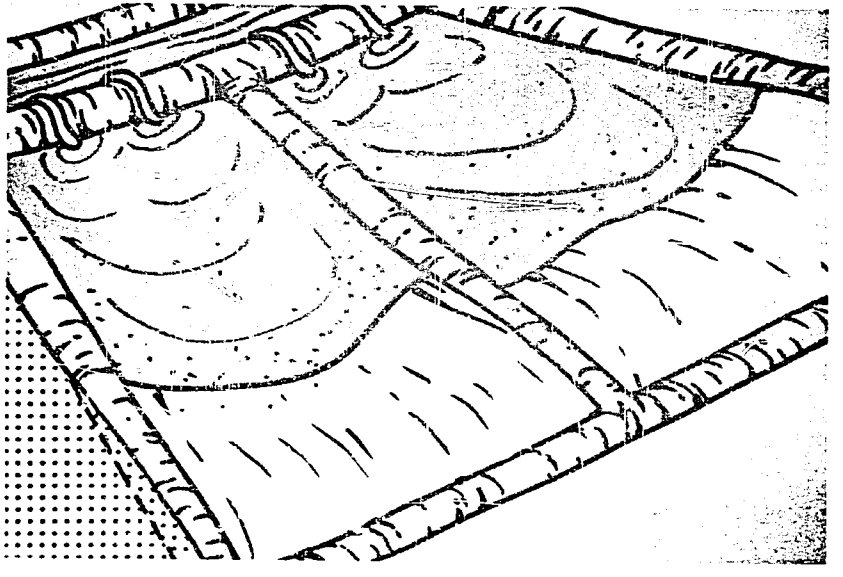
1. Does water enter the field, furrow, border or basin clear and come out looking muddy?

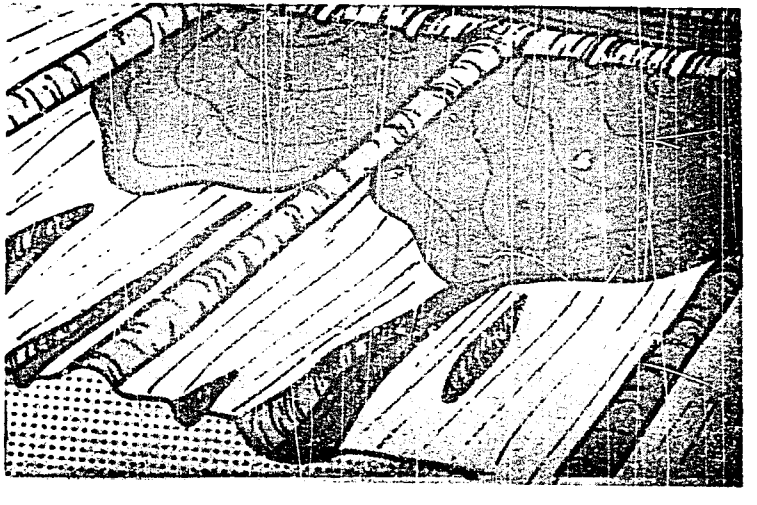


2. Do the shape of the furrows change? Are there gulleys in the fields, furrows, borders or basins?



3. Is soil being deposited at the end of the furrow, border, basin, drain or outlet of the field?

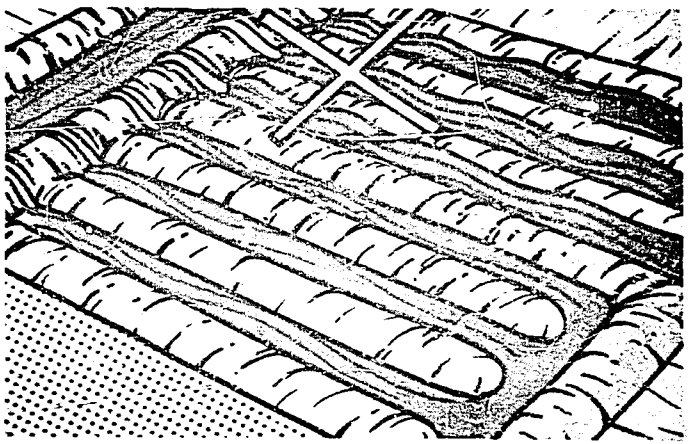




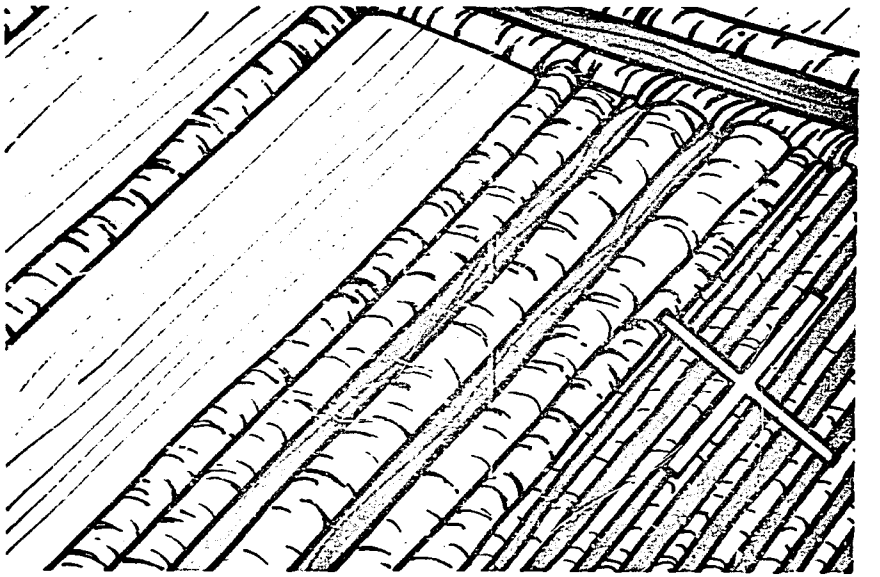
ALL OF THESE ARE SIGNS OF EROSION.

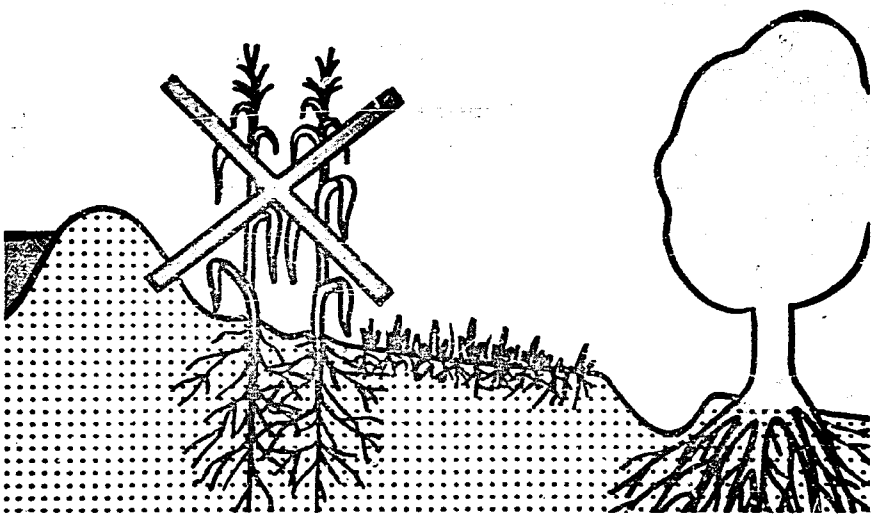
To control erosion, consider one or more of the following:

1. Reduce stream size into the furrow border or basin. You may need to cut run lengths when you cut stream size to maintain uniform irrigation.



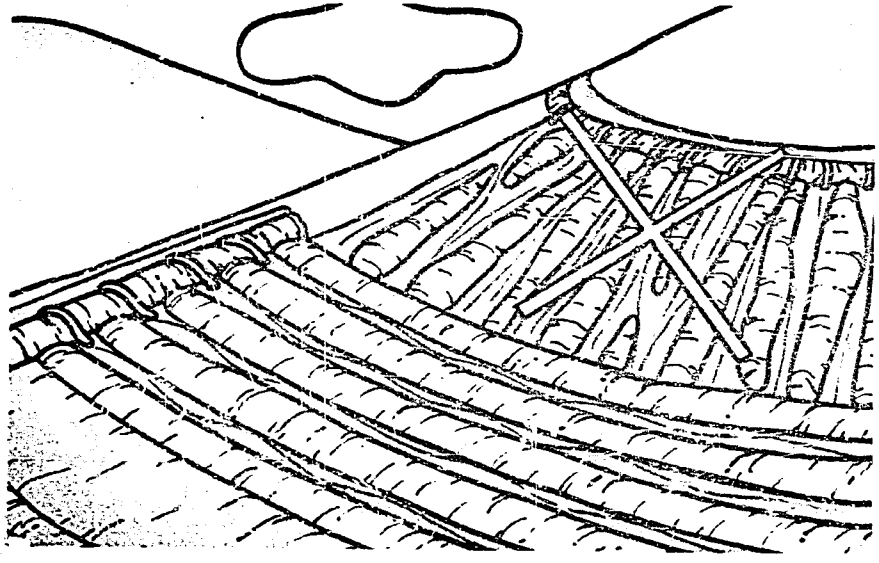
2. Make wider borders or furrows so that the stream will not be as concentrated.



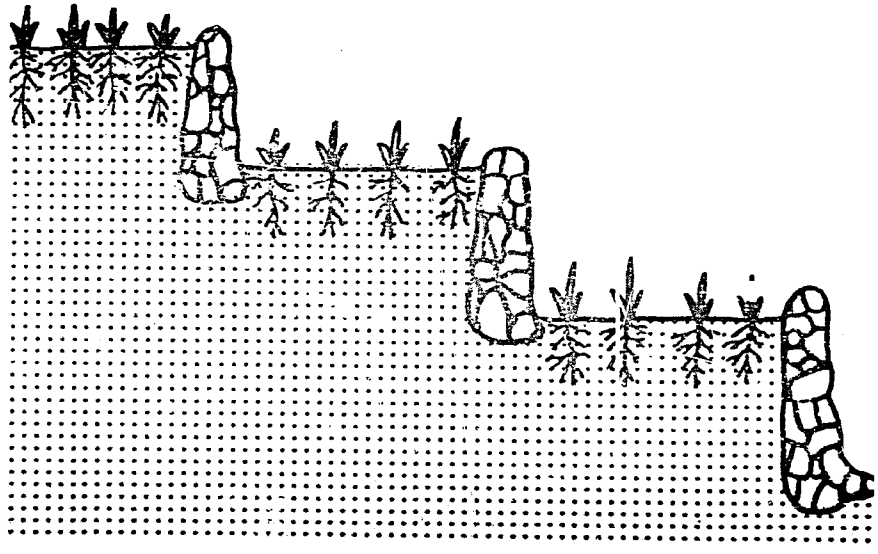


3. Plant crops which will hold the soil in place--permanent pastures, etc.

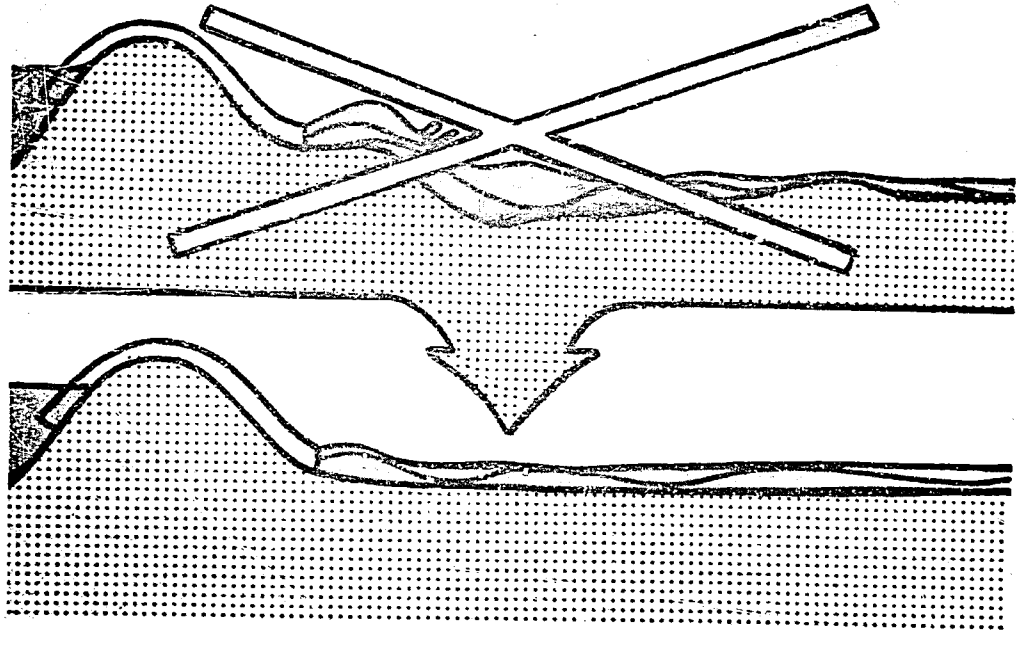
4. Change furrow slopes.



5. Construct terraces.



6. Level or plane the soils.



Especially on steep slopes, always guard against the dangers of erosion.

1. Plant crops which will fix the soil in place--permanent pastures, shrubs, trees, etc.

2. Don't pasture the hillsides constantly, as this destroys the vegetation that protects your sod. Rotate your livestock from one pasture to another.

3. If gullies start to form, eliminate pasturing totally. Plant protective shrubs and trees. You may have to place erosion barriers in the gullies.

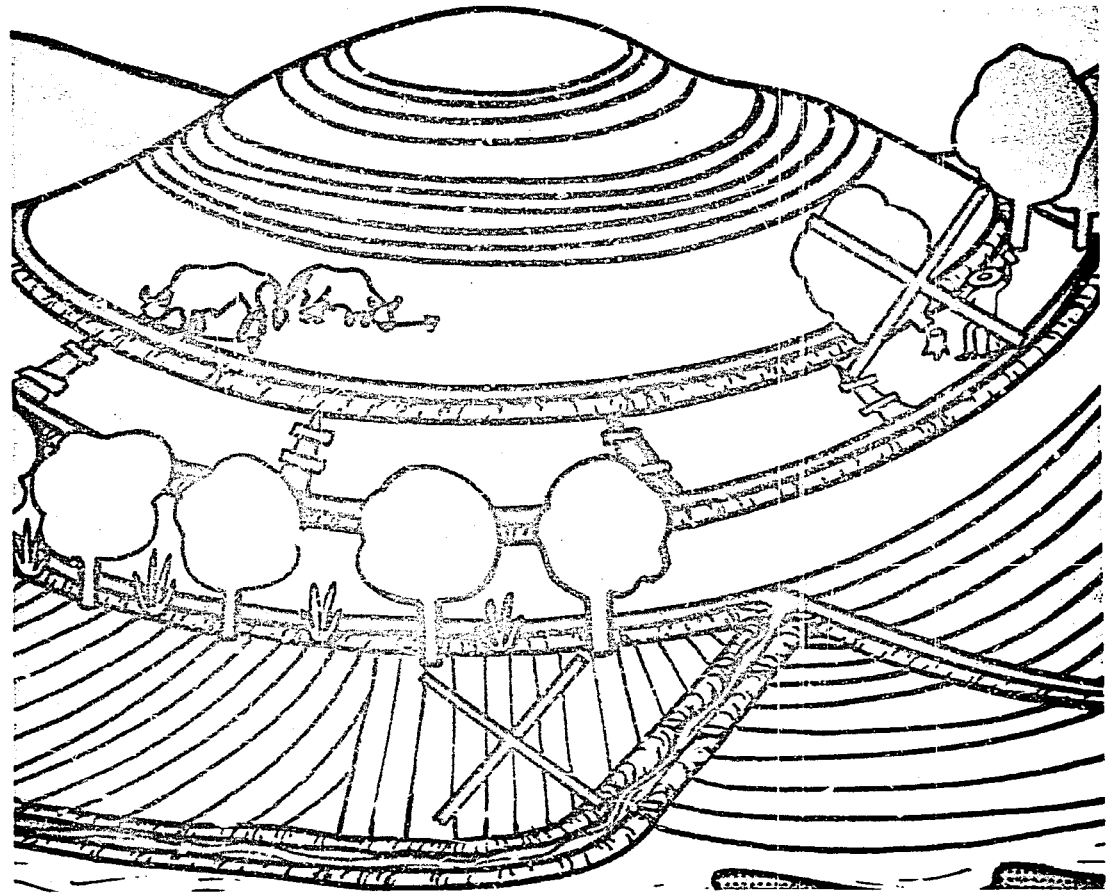
4. If you must plant the hillsides, leave strips of permanent grasses and vegetation between cultivated plots.

5. Don't plant to the edge of steep banks. Leave strips of permanent vegetation.

6. Make sure excess water from irrigation and rain is taken away to adequately protected canals and drains.

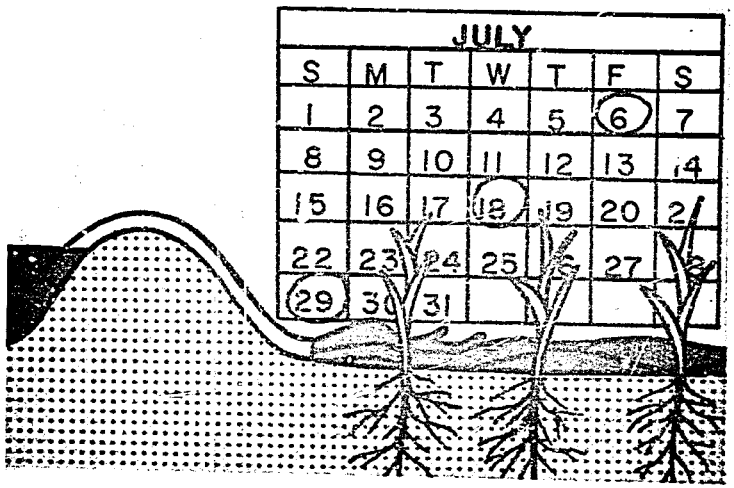
7. Do not destroy existing protective vegetation.

Take care of your soils and insure food for your children!

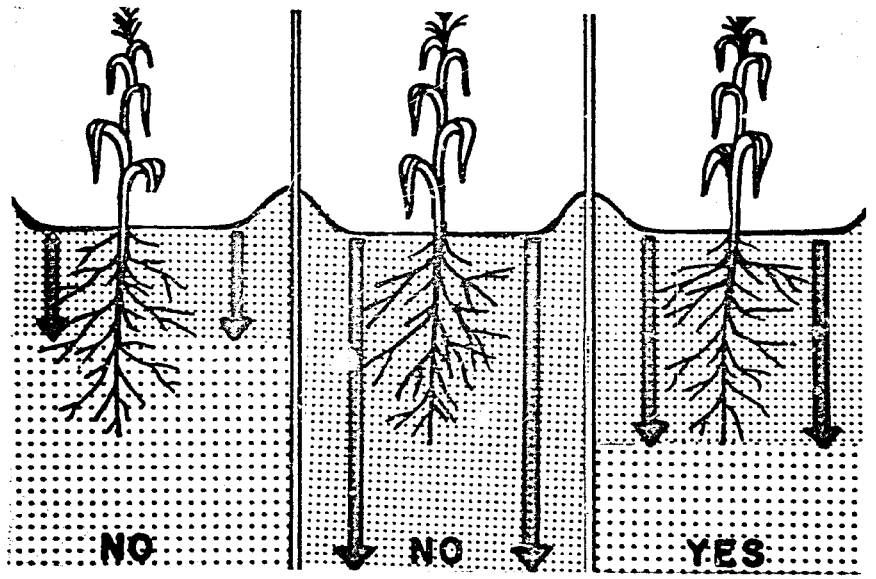


We repeat these recommendations for insuring good irrigation management.

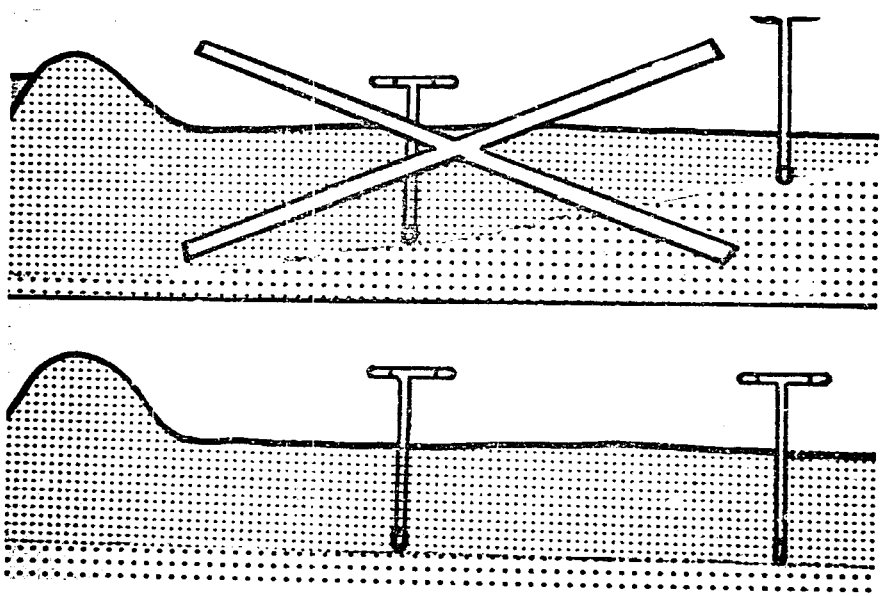
Irrigate frequently enough so that you do not hurt your crop.



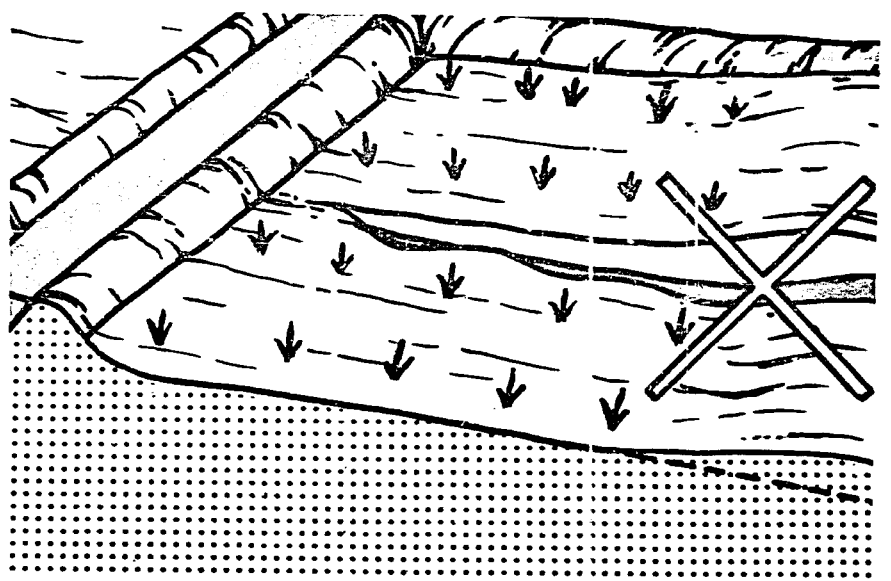
Add enough water to your soil moisture reservoir, but don't over-irrigate.



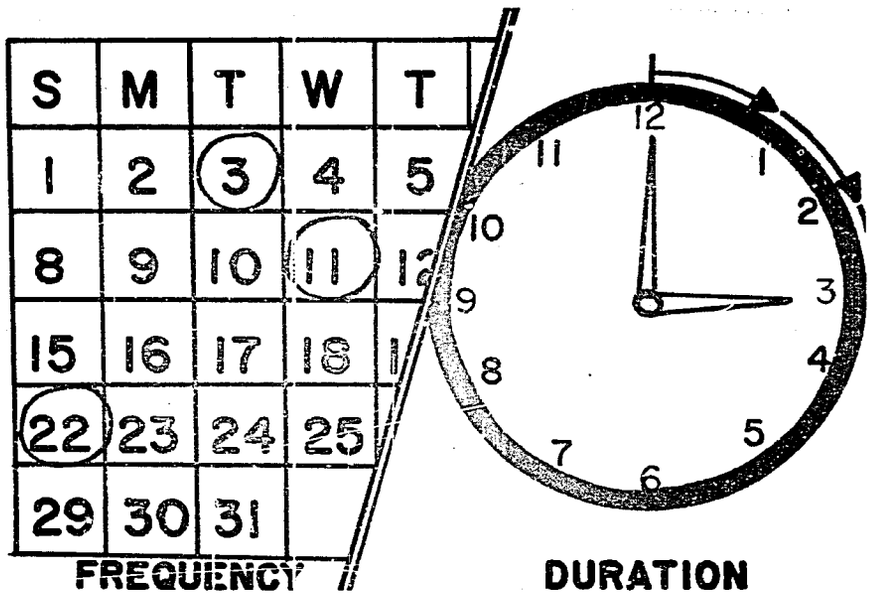
Make sure your irrigations are uniform.

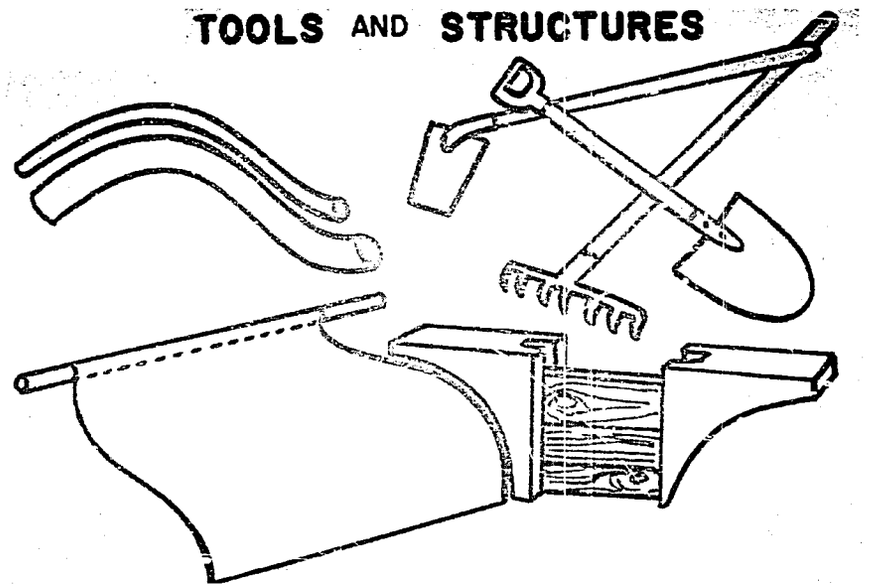


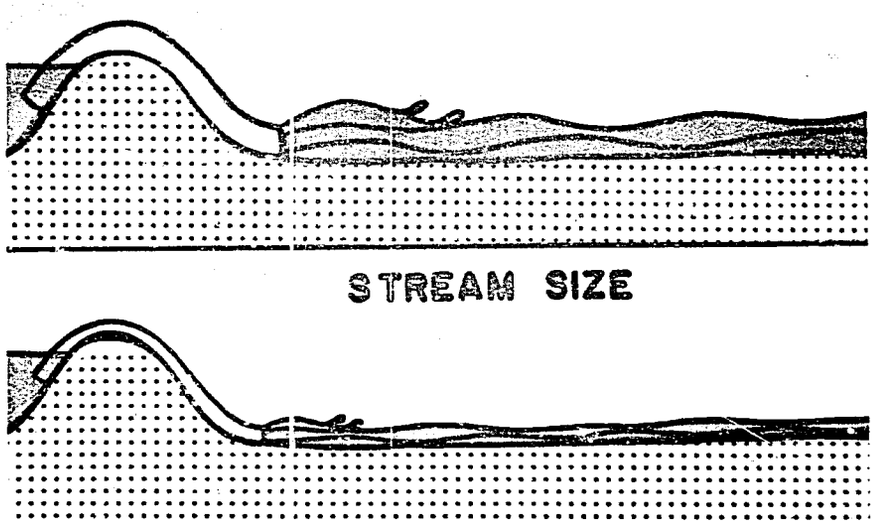
Don't erode your soils.

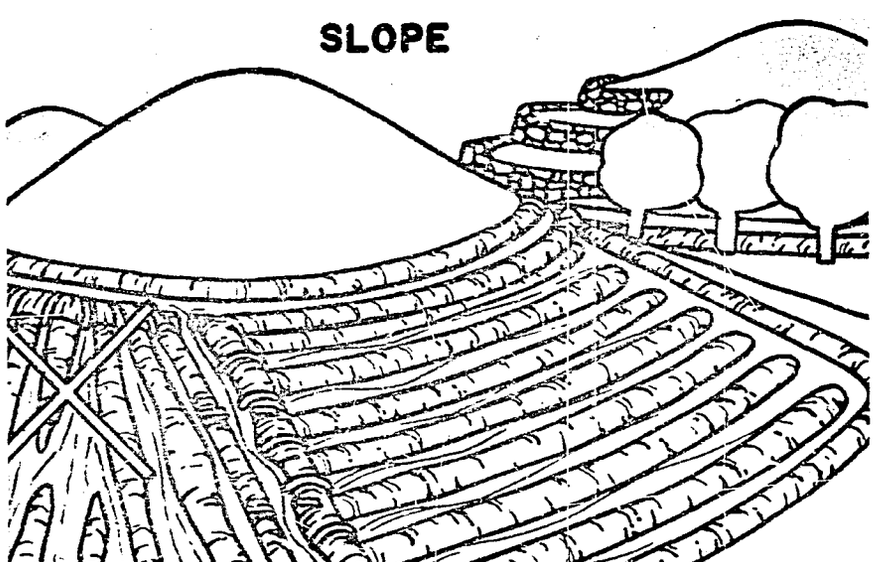


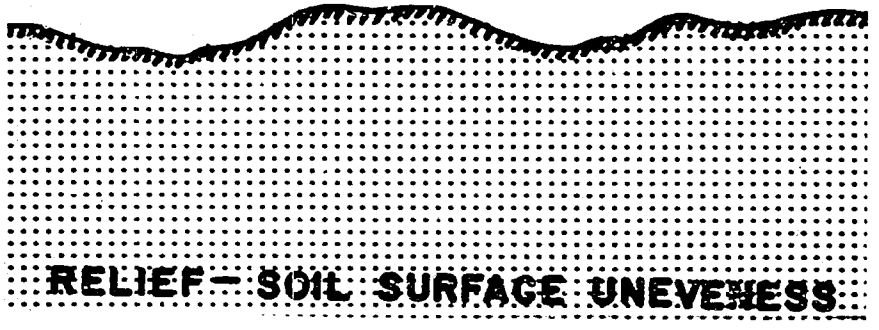
...To obtain good irrigations you can control many factors:

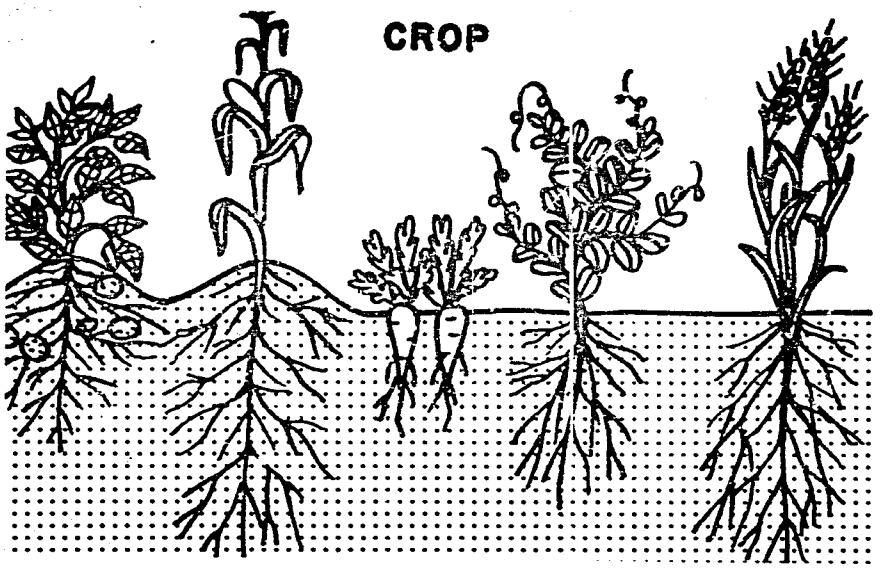


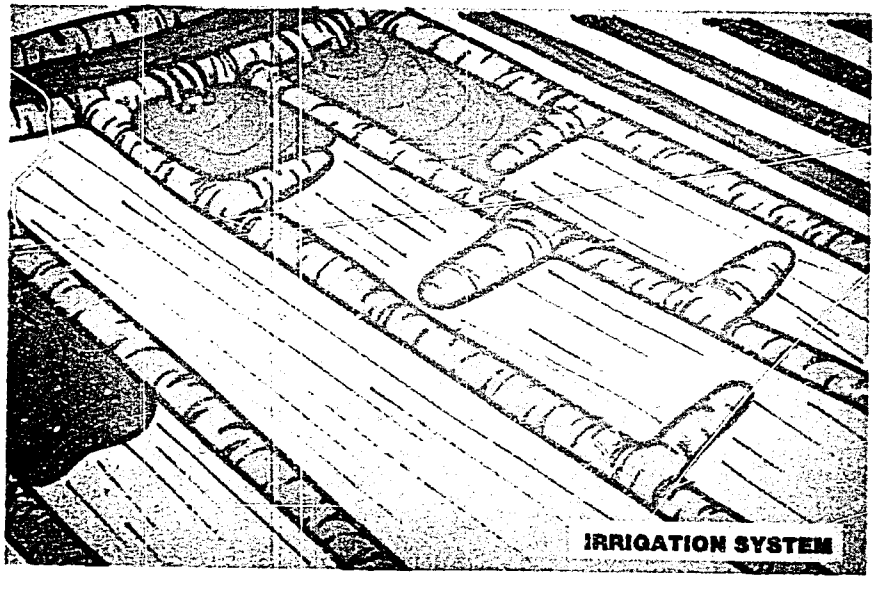












But remember, when you change one aspect of the operation to eliminate a problem, you may cause other problems. So be careful and make sure everything contributes to "good" irrigation.

Water Management on Small Farms:
A Training Manual for Farmers in Hill Areas

This guide was prepared by the staff of the Water Management Synthesis Project of the Consortium for International Development, in cooperation with the United States Agency for International Development under contract AID-DSAN-C-0058. Colorado State University and Utah State University serve as lead universities for the project.

All reported opinions, conclusions, and recommendations are those of the authors (contractors) and not those of the funding agency or the United States government.

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