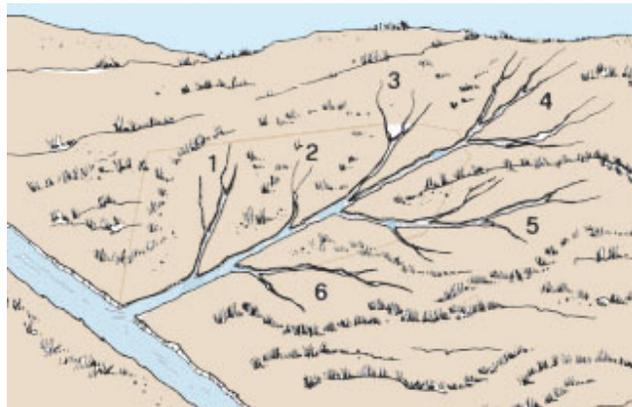


4. PROTECTING FARM STRUCTURES AND FISH STOCKS

4.0 Introduction

1. **Soil erosion has negative effects** on water quality and on the fish farm itself. You must protect your farm against erosion and its effects if you wish to maintain good levels of production at a reasonable cost. **Soil erosion** should be controlled, not only on the farm itself but also in the entire **catchment basin** upstream from it. This is usually the responsibility of the regional administration. All fish farmers involved should seek action or assistance from them if needed. However, on your own land and maybe even in its immediate neighbourhood, you should practise **soil conservation** wherever necessary. It is best if local farmers work together to achieve this goal.

A stream network with six catchment basins



Soil conservation practices may be just as important on neighbouring lands as on your own land

2. Soil conservation practices include:

- **protecting sloping land** surrounding your fish ponds against rainfall erosion ([see Section 4.1](#));
- protecting your fish ponds from **excessive winds** by establishing wind-breaks ([see Section 4.2](#));
- protecting your fish ponds against eroding **wave action** ([see Section 4.3](#)); and
- protecting your pond dikes against **damage by rain** ([see Section 4.4](#)) and uncontrolled livestock traffic ([see Section 4.5](#)).

3. Needless to say, you should also be concerned to control erosion and its effects downstream of your farm.

4. **Pest control** in fish ponds applies both to harmful animals that may feed on your fish and to plants that may harbour minute organisms responsible for diseases and infections. Animals may compete with your fish for food, and both plants and animals may reduce the production potential of your ponds.

5. For best results, **animal pests** should be controlled in fish ponds:

- **after each total fish harvest and before restocking**: for ponds that are completely drained ([see Section 4.6](#)), and for ponds that are not completely drained ([see Section 4.7](#)); and
- **during the fish production cycle** ([see Section 4.8](#)).

6. **Vegetation control** can be carried out concurrently ([see Section 4.9](#)).

4.1 Soil conservation

Introduction

1. You have already learned in a previous manual in this series (see **Water, 4**), that whenever the ground is not perfectly horizontal, **rainwater** partly infiltrates it and partly runs off over its surface. As water runs down a slope, it transports particles of the surface soil. The more water passes and the faster it runs, the bigger the particles that can be washed down the slope. This process is called **erosion**, and it can cause:

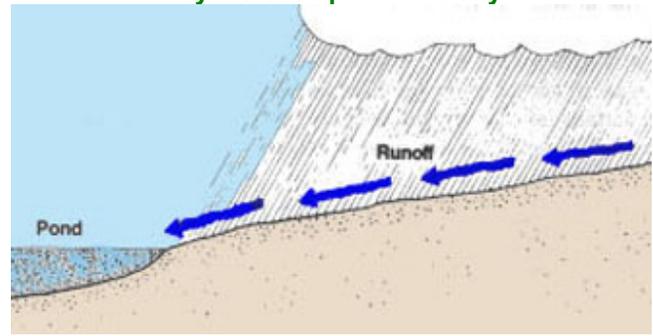
- serious degradation of the slope itself and of the soil properties, reducing fertility;
- an inflow of turbid water at the bottom of the slope and problems of soil settling elsewhere.

2. If your fish farm is situated at the bottom of a valley or even if your main water feeder canal runs across sloping ground, you should try to control soil erosion on the slopes as much as possible to prevent turbid water from running into your ponds. This practice, called **soil conservation**, can result in great benefits:

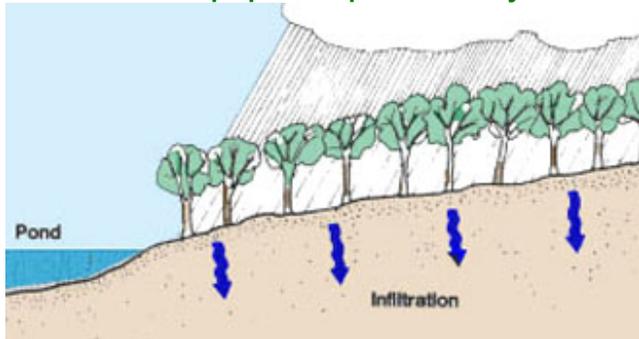
- **better soils** on the slopes and greater production of various products such as wood, fruits, fodder or food for you and your family;
- **better water quality** in your fish ponds and greater fish production.

Note: if you cannot control soil erosion in your farm watershed, you can use a **protection canal** to collect and divert turbid water. For example around a barrage pond or a sunken pond fed by runoff (see [Section 11.5, Pond construction, 20](#)). You can also improve the quality of your water supply by using a **settling basin** (see [Section 11.6, Pond construction, 20](#)). **Pond construction, 20**.

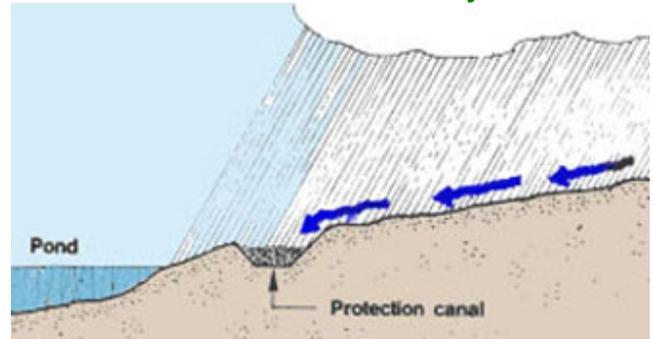
Runoff water from unprotected slopes may increase pond turbidity



A slope protected by vegetation increases infiltration and helps prevent pond turbidity



A protection canal above a pond diverts turbid water away



Kinds of erosion

3. **The erosion of soil by rain** takes place in successive phases.

4. At the beginning, the rain hits the soil surface, causing soil particles to break off and burst upwards, while water progressively humidifies the soil surface and infiltrates deeper. This is called **splash erosion**. It loosens soil but does not move it much.

Splash erosion
Falling raindrops batter the ground's surface

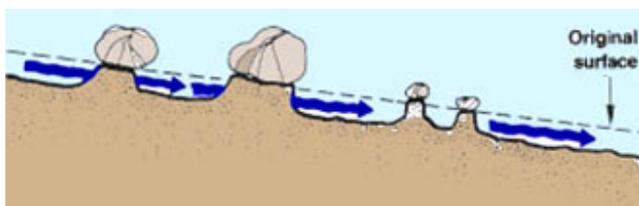


Raindrops splash and burst upwards carrying soil particles with them

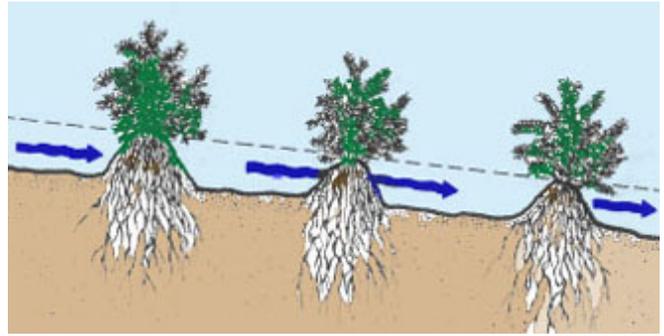


5. On flat land, as soon as the upper layer soil becomes saturated and infiltration decreases, a water layer forms over the soil surface and splash erosion stops; if the ground is not horizontal, water starts to run off the slope, transporting fine soil particles with it. This is called **sheet erosion**.

Sheet erosion

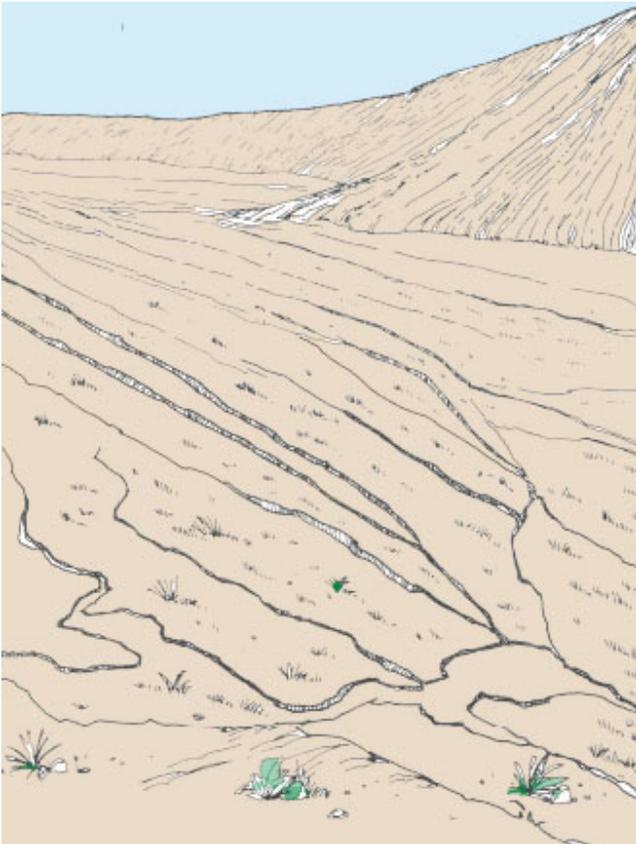


Sheet erosion can be seen when stones, pebbles or plants are left standing on small columns of soil



6. When sheet erosion remains uncontrolled, runoff cuts into the topsoil layers forming small channels. This is called **rill erosion**.

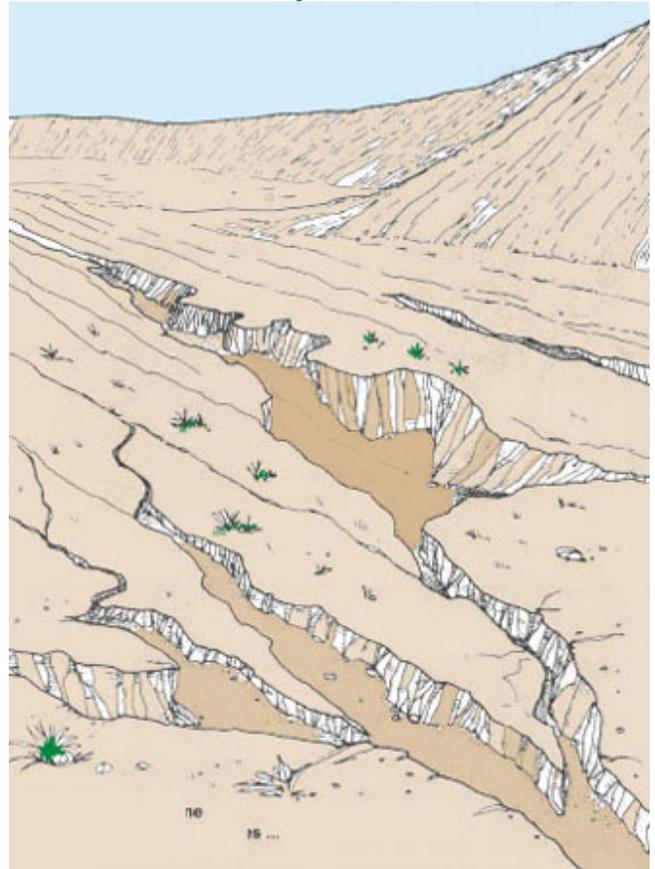
Rill erosion



Small channels or rills caused by runoff water ...

7. If heavy runoff occurs, larger flows of a water-soil mixture can gouge out deeper and deeper channels. This is called **gully erosion**.

Gully erosion



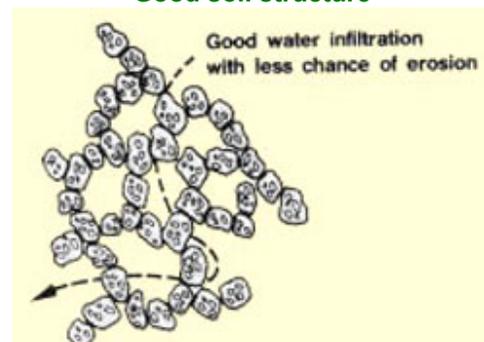
... can soon become large channels or gullies..

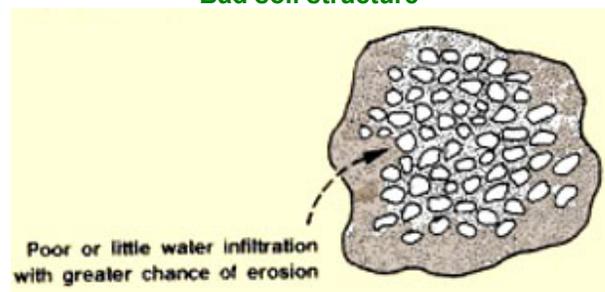
Factors affecting soil erosion

8. Soil erosion essentially depends on the following factors.

(a) **The physical characteristics of the soil**, in particular its texture, structure and permeability (see **Soil, 6**).

Good soil structure



Bad soil structure

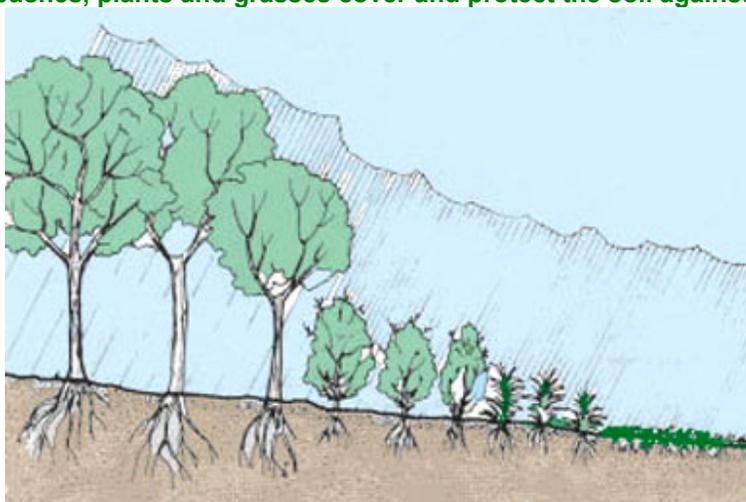
(b) **The ground slope:** as slope increases, susceptibility to erosion increases:

- flat to very gentle slope (0 to 4 percent) means little susceptibility to erosion;
- gentle slope (4 to 12 percent) means susceptibility to erosion increases rapidly;
- moderate slope (12 to 20 percent) means susceptibility is high and erosion should be controlled, especially if the slope is under cultivation;
- steep slope (over 20 percent) means that in the presence of cultivation, erosion control requires special techniques.

As ground slope increases susceptibility to erosion increases

Remember: the steeper the slope, the more important and the more difficult it is to protect it against erosion.

(c) **The vegetation present:** its cover protects the soil against splash erosion. Its roots help stabilize the soil particles and increase permeability to lower soil layers. The organic matter it brings into the soil, such as humus, increases resistance to erosion and slows down runoff. It may also help soil particles to settle down

Trees, bushes, plants and grasses cover and protect the soil against erosion

Vegetation brings organic matter to the soil which helps increase resistance to erosion

9. **To control soil erosion**, you will have to use **soil conservation practices** which modify and optimize these factors. There are several ways, including:

- management of natural vegetation;
- controlled cultivation practices;
- use of physical controls.

10. You will briefly learn about these various methods in the following paragraphs. If you plan to use any of them, it is best to ask for detailed advice from the local extension agent responsible for soil conservation.

11. By using soil conservation from the beginning, you will **prevent the formation of gullies**. Prevention is much easier than dealing with gullies once they are formed. It is most important **to stabilize any incipient gully** as soon as possible to keep it from becoming longer, larger and deeper. Otherwise it might become, if not impossible, at least extremely difficult and expensive to control. Possible methods for the stabilization of gullies are described in the FAO Conservation Guide, 13/2, FAO watershed management field manual, Gully control, 1986.

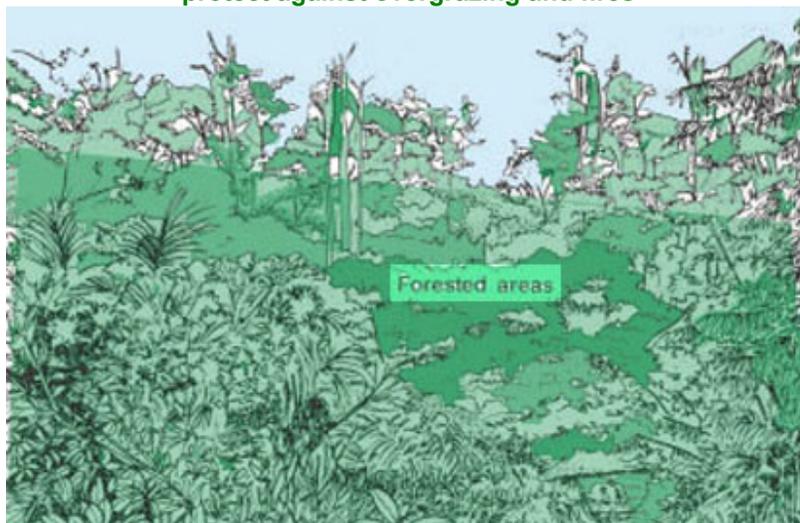
Managing natural vegetation to conserve soil

12. By managing natural vegetation on sloping ground, it is possible to ensure that the soil has a greater resistance to erosion.

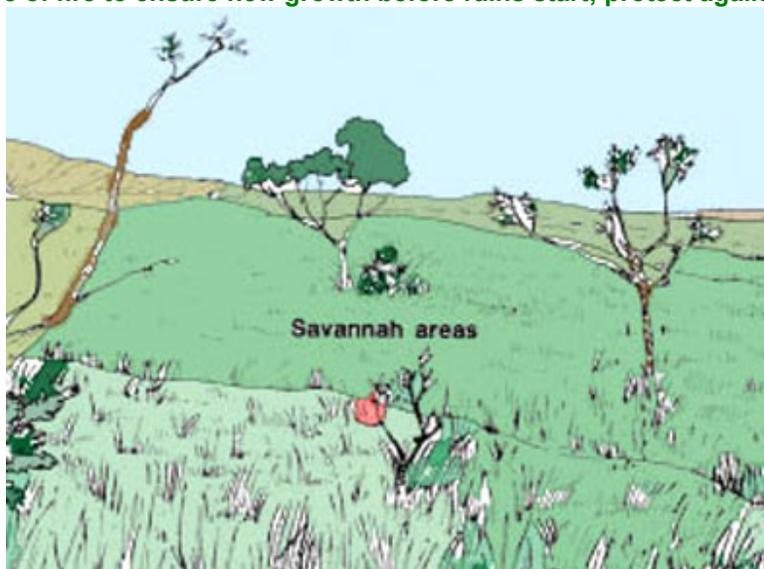
(a) In **forested areas**, maintain **the soil cover** as completely as possible by managing the exploitation of the trees and protecting the forest against overgrazing and fires. Woodlands with good undergrowth, widespread root systems and good leaf cover give the best conditions.

(b) In **savannah areas**, **control the use of fire** for the regeneration of pastures and give preference **to early fires** to ensure sufficient new growth before rains start. Avoid overgrazing, especially with sheep and goats. As far as possible, plan for **rotational grazing**.

Maintain forest cover by managing exploitation and protect against overgrazing and fires



Control the use of fire to ensure new growth before rains start; protect against overgrazing



Cultivating soil to conserve it

13. When soil is placed under cultivation, **conservation practices** may include the following.

(a) Avoid repeating the cultivation of the same crop by **rotating crops** and keeping the soil covered as long as possible, especially at the beginning of the rainy season.

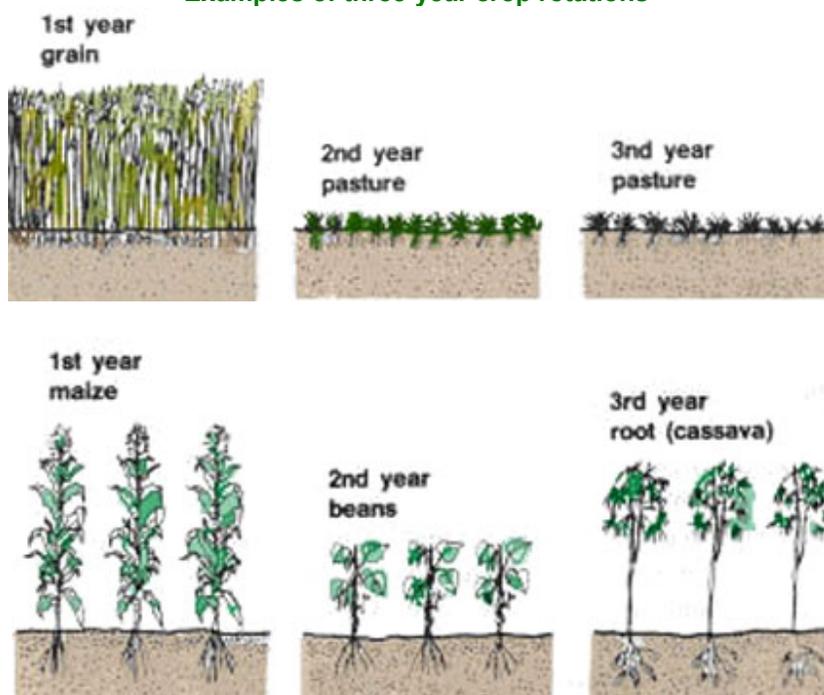
(b) Improve **the soil cover** by increasing fertilization and crop density. Plan sowing and harvesting so as to have the soil covered during the heaviest rains.

(c) Associate **several crops together** to maximize soil protection.

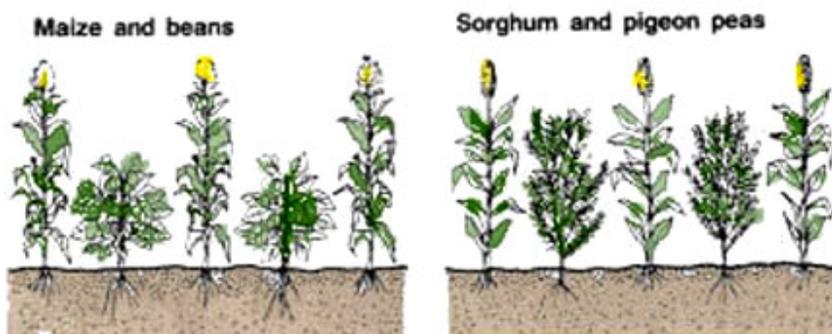
(d) Between two culture cycles, cover the soil with **a mulch*** made, for example, from the residues of the last harvested crops.

(e) Plant **cover crops**, usually legumes and grasses. Grasses are more effective and are either used alone or mixed with legumes (see [Tables 5 and 6](#)). They provide **excellent forage** for farmed livestock and even for some plant-eating fish such as the Chinese grass carp.

Examples of three-year crop rotations



Plant several crops together



(f) **Contour plough** the soil following contour lines (see [Topography, 16](#)). This step is most effective by itself if the soil is sufficiently pervious and if the slope does not exceed 3.5 percent.

(g) **Contour farm** following **contour lines***, instead of across or straight up and down the slopes. The steeper the slope, the more important it is to undertake all crop-raising activities along contour lines.

(h) Establish **perennial* vegetation strips** 3 to 8 m wide to separate 15 to 30 m wide **contour strips** under cultivation. You can use:

- **live fences** made of shrubs and trees ([see Table 7](#));
- **absorbent strips** made either of grasses or of grasses mixed with legumes ([see Tables 5 and 6](#));
- or a combination of these two types.

Note: you will learn more about this particular method for soil conservation at the end of this section.

An example of perennial vegetation planted on the contour to separate strips under cultivation



Plough and farm sloping land on the contour ...



... not across or straight up and down



TABLE 5
Grasses useful for soil conservation

Latin name/ common name	Origin	Vegetal cycle ¹	Maximum height (m)	Climate		Resistance		Establishment ²	Spacing (cm)		Harvesting for forage	Remarks
				Air temp.	Rainfall (mm)	Drought	Grazing		Pure stand	Mixed stand		
<i>Cenchrus ciliaris</i> Buffel grass	Africa, India, Indonesia	P	1.50	Warm	350-1 000	High	High	S 5 kg/ha RC 2-3 tilled	25 × 50	50 × 50	After 2-3 months, before flowering cut 10-15 cm above ground	—
<i>Chloris gayana</i> Rhodes grass	S.E. Africa	P	1.50	Warm to temp.	600-1 000	Medium	Low	S rows at 50 cm RC 10 cm deep	25 × 50	50 × 50	When 50 cm high, before flower- ing cut 10-15 cm above ground	—
<i>Panicum maximum</i> Guinea grass, Tanganyika grass	Trop- +subtrop. Africa	P	3.50	Warm	over 1 000	High	Low	S 4-10 kg/ha RC 10-15 cm deep	50 × 100	100 × 100	After 3-4 months, before flowering cut 10-15 cm above ground	—
<i>Phalaris aquatica</i> Phalaris, toowoomba, canary grass	S. Europe, Mediterranean	P	1.00	Temp.	430-630	Very high	Medium	S 6-10 kg/ha in rows at 50 cm	20 × 50	(no) ³	Cut 10-15 cm above ground when first flowering shoots are seen	Useful to maintain canal/ stream banks
<i>Pennisetum clandestinum</i> Kikuyu grass	High tropics, E. Africa	P	1.20	Temp.	1 000-1 600	Low	High	RC + SC	30 × 30 to 50 × 50	(no) ³	Generally grazed <i>in situ</i>	Best for steep slopes with fertile soil
<i>Pennisetum purpureum</i> Napier or elephant grass	Tropical Africa	P	4.50	Warm	over 800	Medium	High	RC + SC	30 × 50 to 60 × 60	(no) ³	Grazing when 1-1.2 m tall maxi- mum; cut before 2 m tall	—
<i>Setaria sphacelata</i> Rhodesian grass, setaria grass	Tropical Africa	P	2.00	Warm to cool	500-700	Medium	Medium	RC 10-15 cm deep S 5-10 kg/ha in rows	50 × 100	50 × 100	Cut 10-15 cm above ground before flowering	Useful in cool areas
<i>Sorghum alatum</i> Columbus grass	Argentina	P	4.50	Warm to temp.	400-900	Medium	Low	S 5-7 kg/ha in rows at 80-100 cm	80 × 80 to 100 × 100	(no) ³	Grazed from 35 cm high, cut 15- 20 cm above ground at early flowering stage	Easily established; more nutritious when young
<i>Tripsacum fasciculatum</i> Guatemala or Honduras grass	S. America	P	3.50	Warm	over 1 000	Low	Nil	—	—	—	Cut 25 cm above ground	Unsuitable for grazing Tolerates acidity

¹ P = perennial

² S = seeds, RC = root cuttings, SC = stem cuttings

³ (no) - possible under proper management

TABLE 6
Legumes useful for soil conservation

Latin name/ common name	Origin	Vegetal cycle ¹	Maximum height (m)	Climate		Resistance		Establishment ²	Harvesting	Remarks
				Air temp.	Rainfall (mm)	Drought	Grazing			
<i>Desmodium uncinatum</i> Silverleaf desmodium, Spanish clover	C. + S. America	P	—	Warm	Over 900	Good	Medium to low	S 2-4 kg/ha in rows at 50-100 cm	Generally grown mixed with grasses N fixed = 90-160 kg/ha. Seed yield: 200-300 kg/ha	Soak seeds for 24 hours Inoculate seeds with special <i>Rhizobium</i> bacteria before sowing
<i>Labiab purpureus</i> Labiab, Tonga bean, lubia, batao, wai, frijol, jacinto, dolique d'Egypte	Tropics esp. Africa	A/P	—	Warm to cool	Wide range	Good	Low	S 5-7 kg/ha in rows at 100 cm	Usually grown in association with sorghum or maize. Cut above 25 cm high. Seed yield: 1.5-2 t/ha	Up to 2 000-m altitude Fast growth but short life
<i>Macropellium atropurpureum</i> Siratro	C. + S. America	P	—	Warm to temp.	800-1 600	Good	Low	S 4-8 kg/ha in rows at 50-80 cm	Good results when sown with grasses Cut/graze high, at longer intervals Seed yield 200-300 kg/ha or more	Soak seeds for 24 hours Altitude: up to 1 600 m
<i>Stylosanthes guianensis</i> Stylo, aitailla del Brazil, tropical lucerne	C. + S. America	P	1	Warm to temp.	Over 900	High	Low	S 1-3 kg/ha in rows at 50-100 cm	Good results when mixed with grasses Cut 15 cm high after 6-8 weeks. Seed yield 100-200 kg/ha. Rotational grazing	Soak seeds over night
<i>Pueraria phaseoloides</i> Puero, tropical kudzu	S.E. Asia	P	(5-6)	Warm	Over 850	Low	Low	S in rows at 100 cm SC 70-100 cm	Good compatibility with guinea and napier grasses. High nitrogen produc- tion in soil	Prefers altitude below 1 000 m. Soak seeds in 60°C water for several hours. Slow establishment

P = perennial; A = annual; S = seeds; SC = stem cuttings

Using physical controls to conserve soil

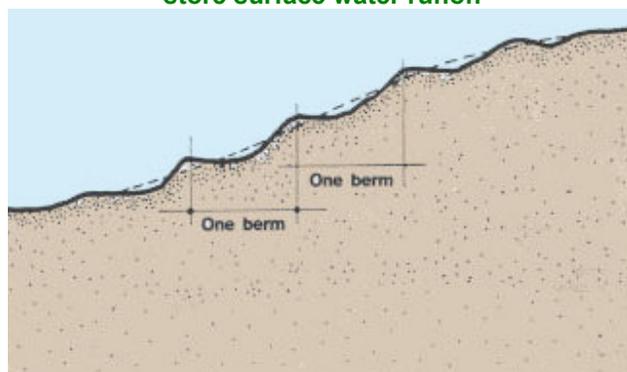
14. These controls generally involve **extensive earth movements**, often difficult to design and costly to realize. If the above practices are not sufficient to control erosion on your ground, especially if you wish to farm a rather steep slope year after year, you should look for **specialized advice from your agricultural extension agent**.

15. There are several possible physical controls, according to local conditions of slope, soil quality and rainfall characteristics. These are:

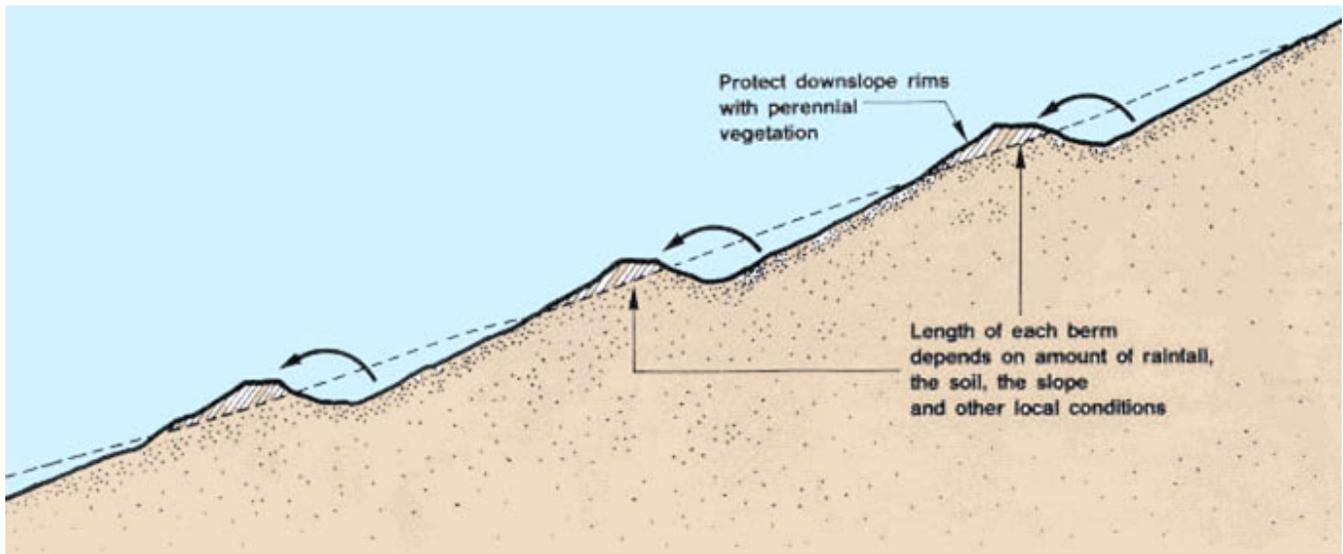
- contour berms;
- infiltration ditches;
- contour terraces;
- gulley check dams.

(a) **Contour berms** are a series of horizontal or slightly sloping ridges constructed to intercept and temporarily store runoff. The berm foreslopes may be planted with perennial vegetation to improve their resistance to erosion. Contour berms are useful in rather dry areas with considerable runoff after heavy rains, on slopes not steeper than 20 percent.

Contour berms intercept and temporarily store surface water runoff

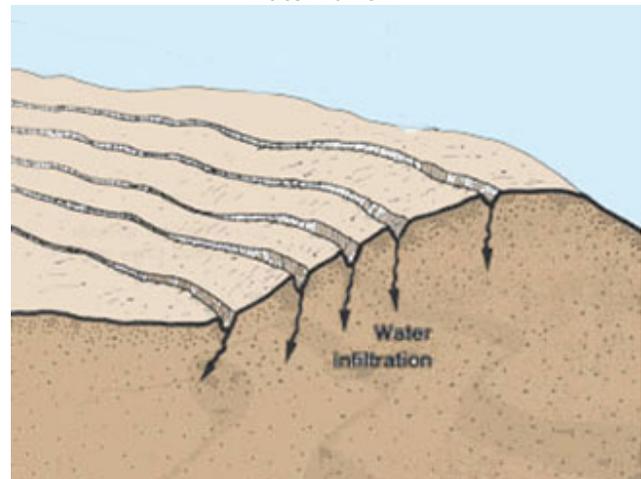


Profile showing construction of contour berms



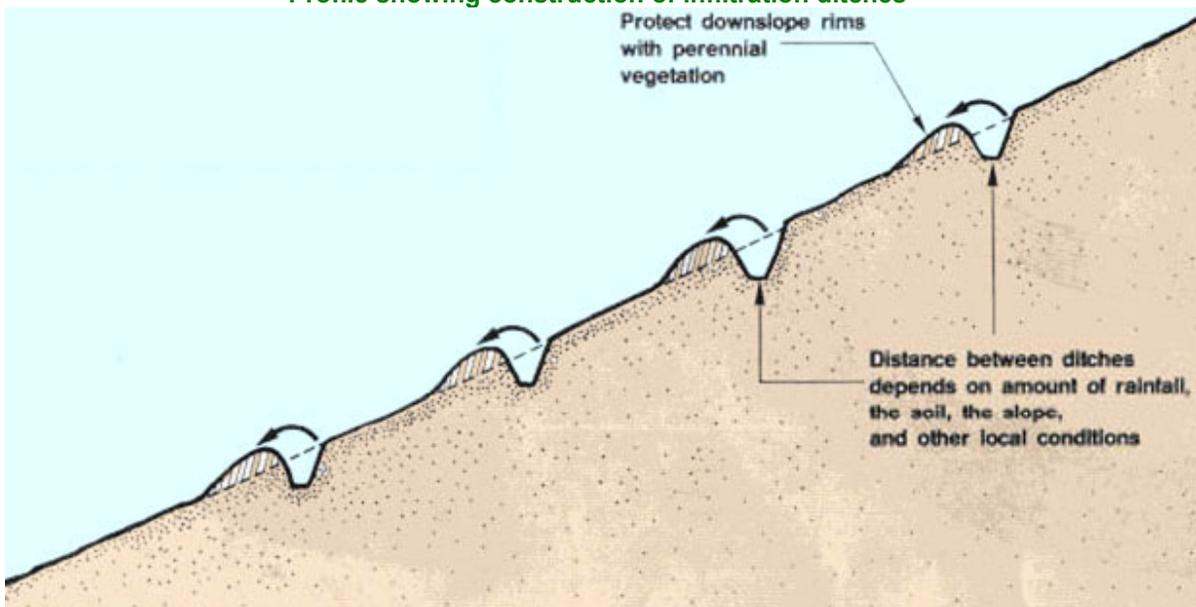
(b) **Infiltration ditches** are dug to allow surface runoff to accumulate and infiltrate the soil. They can also channel excess water to the sides of the fields where its discharge should be controlled. The downslope rims of ditches can be planted with perennial vegetation to increase their stability. This type of ditch is useful in areas with more than 400 mm annual rainfall where heavily cultivated slopes are steeper than 10 percent and soils are rather impervious.

Contour infiltration ditches collect surface water runoff



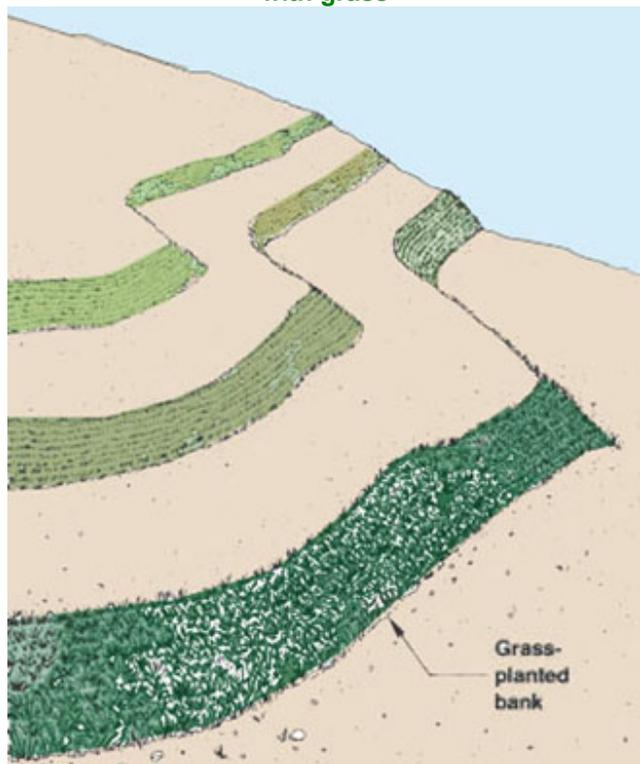
Note: ditches can also be slightly sloping to channel excess water to the sides of the farm fields

Profile showing construction of infiltration ditches

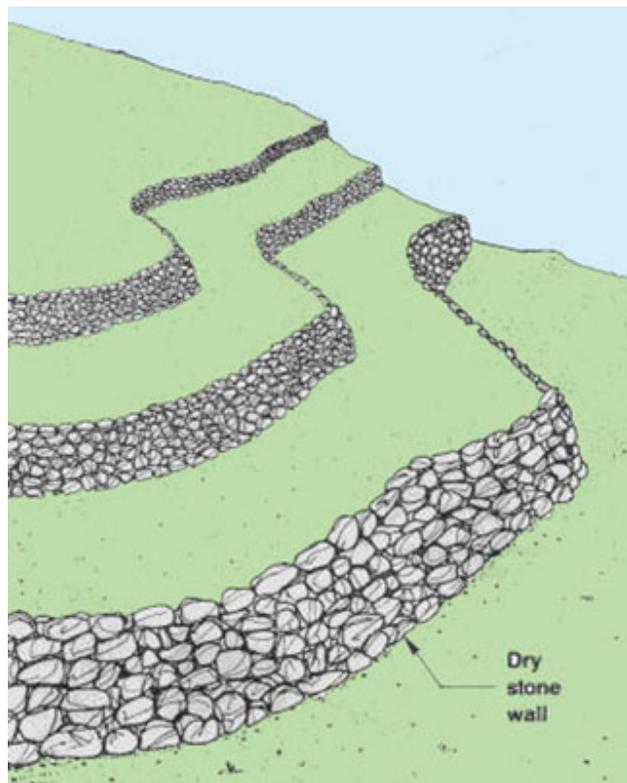


(c) **Contour terraces**, providing strips of level or near-level farmland, can be built behind steep banks protected by perennial vegetation or, if sufficient stones are available, behind stone retaining walls. Contour terraces are useful on steep slopes and on those with considerable runoff, after medium rains.

Contour terraces behind steep banks planted with grass



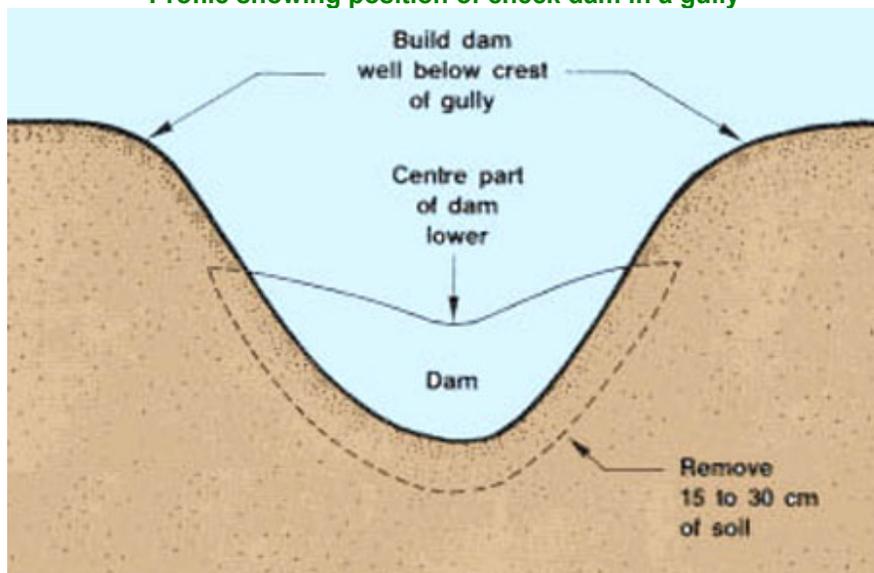
Contour terraces behind stone walls



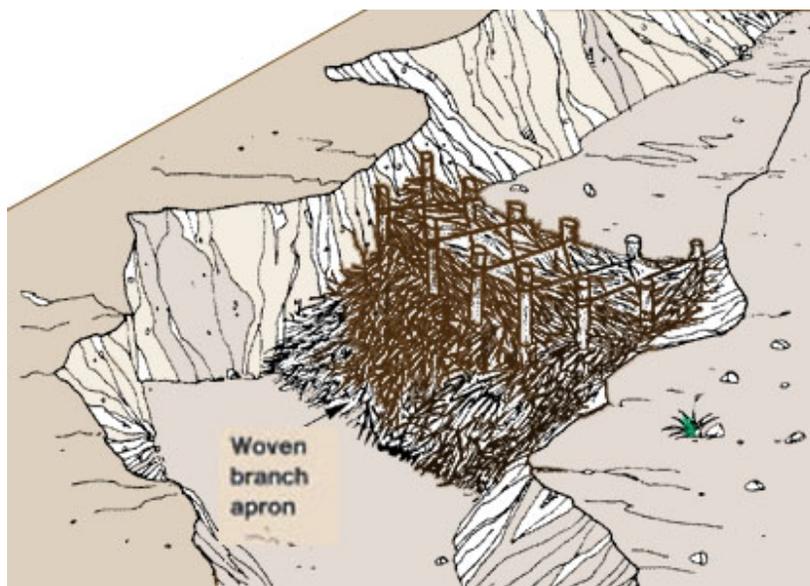
(d) **Gully check dams** are small dams built across gullies or small stream courses. They hold up runoff, limit downstream erosion and are useful in dry areas with heavy runoff and medium to steep slopes. A gully check dam may be made using a variety of locally available materials such as stone or woven tree branches lashed in place between two rows of wooden poles. It is very important that the top of the check dam be lower than the crest of the gully so that overflowing water remains in the gully.

Note: remove 15 to 30 cm of soil from the gully bottom and sides before placing the check dam and apron.

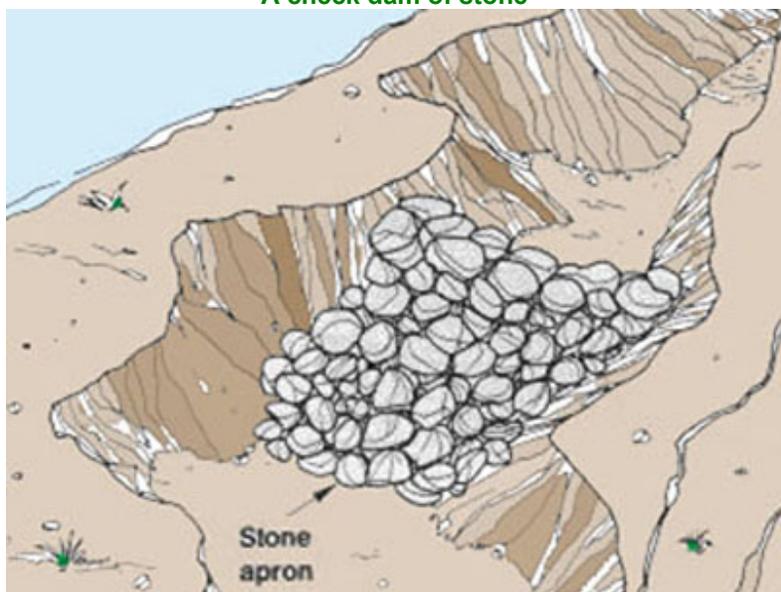
Profile showing position of check dam in a gully



A check dam of woven branches and wooden poles



A check dam of stone



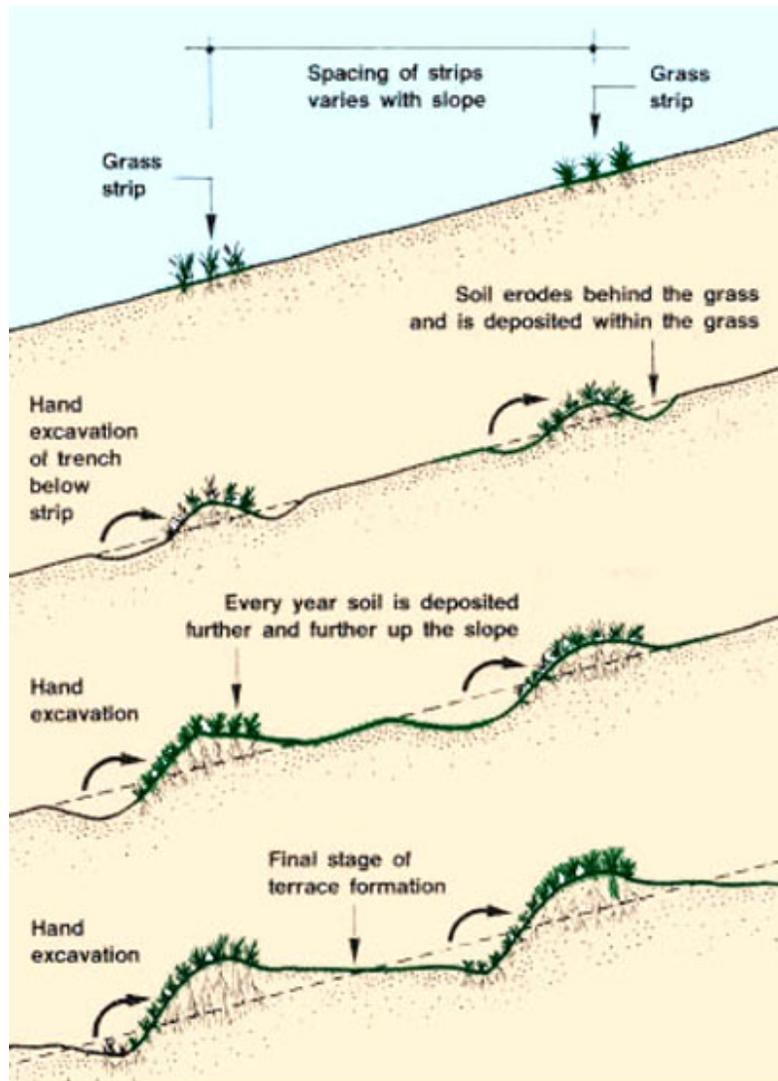
A simple method of soil conservation: the self-made terrace

16. If you plan to produce cash crops on land with **a gentle to moderate slope** (4 to 20 percent), you may use a simple method to control soil erosion, namely to encourage **the progressive build-up of nearly horizontal terraces by controlling sheet erosion itself**.

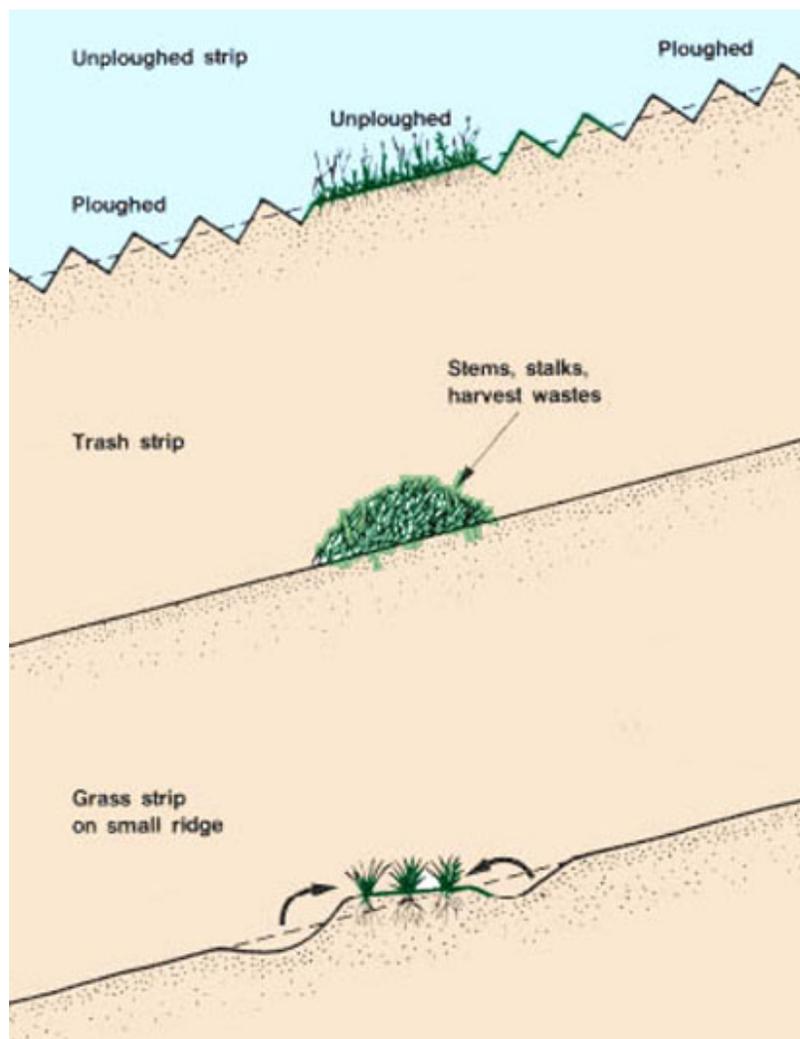
17. Narrow contour strips are planted with **perennial vegetation** fairly closely together on the slope to be protected. Generally, the steeper the slope, the more vegetation strips you will need. If necessary, **a dead filter**, made of slightly buried branches and crop residues in front of each vegetation strip, will help to stabilize the vegetation and to accelerate terrace formation. The vegetation slows runoff, resulting in the deposit of transported soil particles, first within the vegetable strips and then further up the slope. The roots of the vegetation become buried deeper and deeper as the downslope bank of the terraces builds up.

Note: as the soil is deposited within the grass, the roots are buried deeper and deeper, which helps to hold the terrace banks

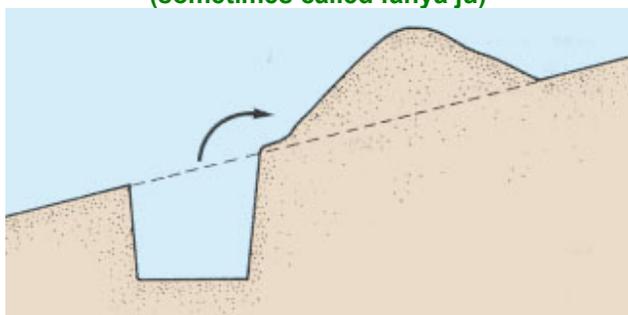
A self-made terrace formed over a number of years between strips of grass planted on the contour



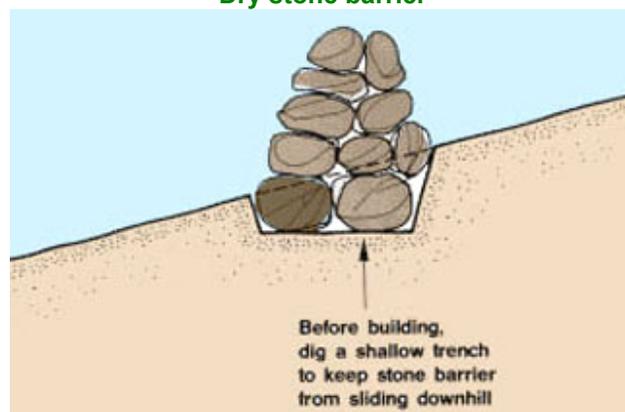
Other ways to begin self-made terraces on the contour



**Dig a ditch and throw earth uphill
(sometimes called fanya ju)**



Dry stone barrier



Note: all of the systems shown above will form self-made terraces over the years, very much like the terraces formed by grass strips shown.

Choosing a vegetation strip for a self-made terrace

18. **Perennial vegetation strips** can be made following the contour lines in several ways.

(a) **Spontaneous vegetation** can become established if you stop farming narrow strips of land.

(b) **Forage grasses** in particular **and legumes** can be planted to provide food for livestock, either under controlled grazing or as cut forage, fed fresh or dried ([see Tables 5 and 6](#) above). Similarly you could use **lemon grass, sugar cane or sisal** if a market exists for such crops.

(c) One row of **shrubs and trees could be added to this forage vegetation** to produce timber, firewood, fruit or additional fodder for your livestock. Suggested species, which should be selected according to local conditions of climate and soil, include:

- shrub and tree legumes for fodder ([see Table 7](#));
- other trees for diversified production ([see Table 8](#));
- fruit trees can be planted for the production of mangoes, avocados, pawpaws, bananas and various citrus fruits according to local demand and market potential. If possible use genetically improved varieties.

(d) **A live fence** can be made of (more densely planted) shrubs and trees (see above for suitable species).

Establishing and maintaining vegetation strips

19. Perennial vegetation strips should be established in several phases.

(a) **Determine and mark the contour lines** at regular intervals, normally spaced to provide a farmed strip 15 to 30 m wide (see [Topography, 16](#)).

(b) **Prepare the contour strips** just before the rains start.

(c) **Establish the vegetation** after some good rains have fallen, preferably by planting either seedlings or cuttings to cover the soil as soon as possible.

(d) **Seedlings** are produced in separate nursery areas and are transplanted to the contour strips after a few weeks. The nursery area should have well-prepared seed-beds. Seeds are sown in rows at about 1.5 to 2 cm deep and covered with well-preserved soil. Seeds can also be planted in small plastic bags containing soil, which help to retain moisture and control weeds.

(e) **Cuttings** should be healthy, about six months old and with at least two nodes. Small cuttings are planted at a 40° angle with one node in the soil. Long cuttings are buried in the soil about 10 to 15 cm deep.

(f) **Protect** all seedlings and cuttings **well from grazing** until the vegetation is well established. For shrubs and trees, this might take as long as three to five years.

(g) **Keep weeds under control**, especially around the young plants.

(h) **Establish the dead filter** just uphill of the vegetation by slightly burying wooden branches, crop residues or stipes of banana leaves in the soil.

20. The vegetation strip should be **regularly maintained**.

(a) **Repair and strengthen any breaches** through the strip by planting additional vegetation in the fragile zones.

(b) As the terrace builds up, place **new dead filters** uphill of the buried ones. Repair these filters as needed.

(c) Watch for **localized erosion** either of the lower lip of the terraces or of their steeper banks; immediately repair, adding vegetation.

Dealing with steep slopes

21. On slopes steeper than 15 to 20 percent, it may not be sufficient to establish perennial vegetation strips to control soil erosion adequately. The area of land suitable for farming will also be much reduced with this method, owing to the reduced spacing between vegetation strips.

22. You should therefore consider the following guidelines:

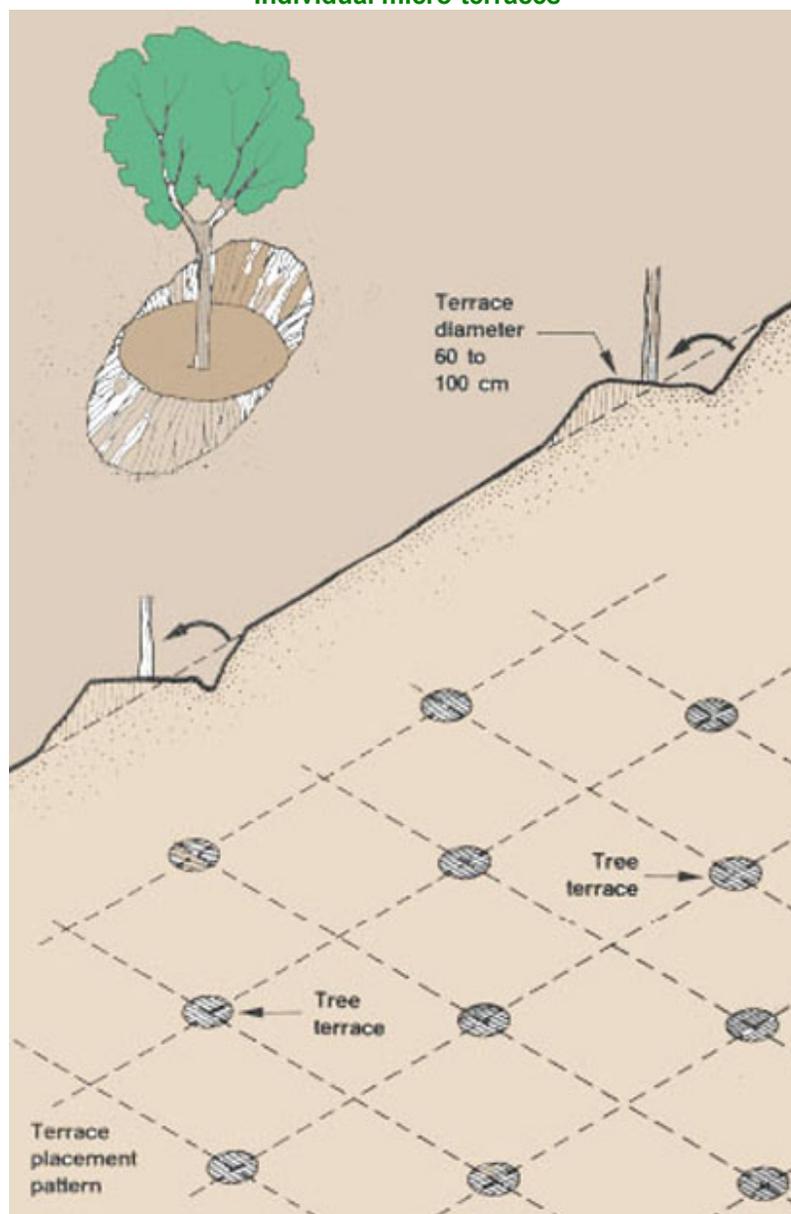
(a) Avoid farming cash crops.

(b) Limit farming to **perennial crops**.

(c) Select or encourage **shrubs and trees** that protect the soil. **A natural forest**, if well managed and protected from fire, may be the best solution.

(d) If you choose **to plant shrubs and trees**, it is best to build **individual micro-terraces** rather than using more expensive and more elaborate techniques. Protect these terraces from erosion by planting grasses and legumes at their raised edges. Protect your plantations from grazing, fires and uncontrolled cutting.

Individual micro-terraces



4.2 Wind protection in fish farms

Protecting fish ponds from wind

1. When a strong wind blows over a fish pond, it affects the environment in several ways.

(a) **It increases evaporation** at the surface of the pond, especially if the wind is a dry one, resulting in greater water losses.

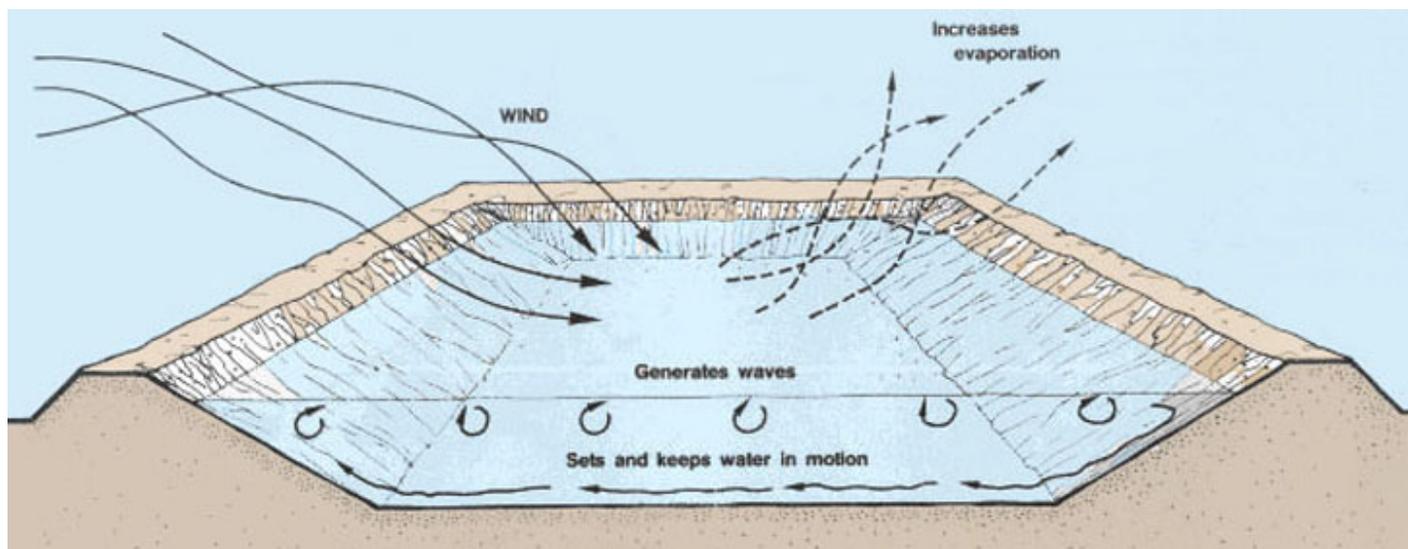
(b) **It sets and keeps water in motion**, inducing surface water currents toward the pond dike facing the wind and returning deeper currents in the opposite direction. These currents help the transfer of heat and dissolved oxygen from surface to deeper water.

(c) **It may generate waves**, which greatly accelerate the oxygenation of surface water (see Section 2.5), although wave action against the downwind dike may damage the latter through erosion.

(d) **If relatively cold**, it may delay the warming of small ponds intended for fish breeding and nursing early in the warmer season.

2. Although wind has definite advantages for fish farming, mainly keeping the ponds well mixed and oxygenated, there are **particular situations** in which you may wish to protect at least part of your fish farm:

- to **warm up early** small breeding ponds and nursery ponds when relatively cold winds are prevalent; and
- to **reduce wind velocity** and the size of generated waves over larger ponds, for easier control of dike erosion.



Providing wind protection

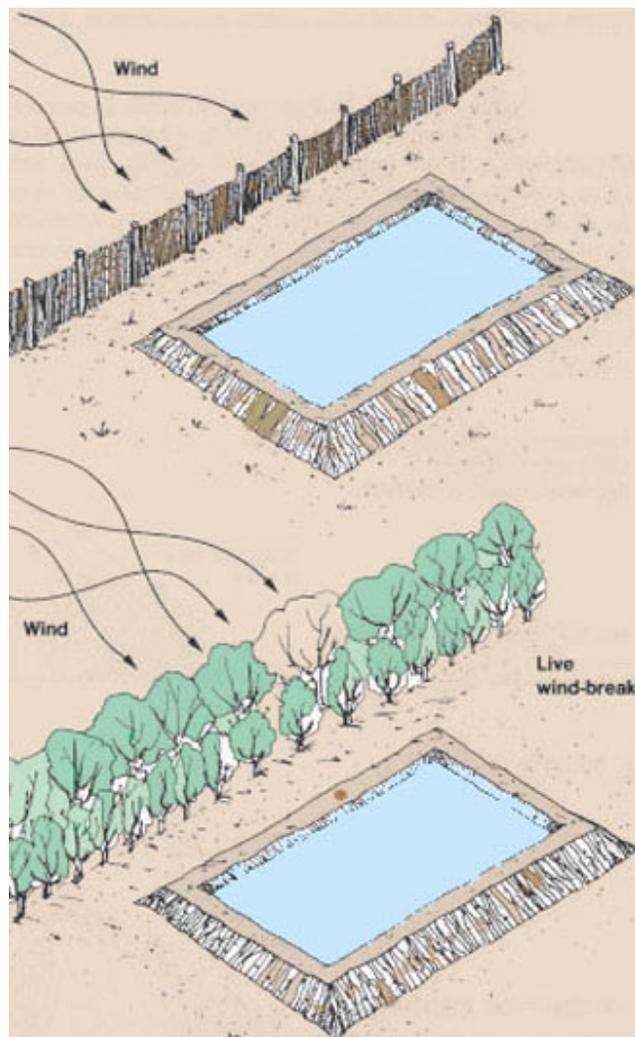
3. A simple way to provide wind protection is to build a **simple screen**, using for example canvas, plastic, or woven split bamboo stretched between vertical wooden poles. The screen has the advantage of being easily set up when and where necessary. However, it only provides protection over a very limited distance behind the screen, perhaps three to six times its height, depending on the conditions.

Bamboo screen wind-break

4. If you require more permanent protection over a greater surface area, it is usually better to establish a **live wind-break** made of perennial vegetation and designed to reduce wind velocity immediately above ground level. This kind of barrier also has some additional advantages.

(a) It provides the opportunity for **increasing the range of products** and increasing the profits of the fish farm through the production of wood for construction and fuel, animal fodder, fruit, tannin, fibres, etc.

(b) It **provides shade** not only for livestock but also for carrying out certain management tasks such as the sorting of live fish and the maintenance of equipment.



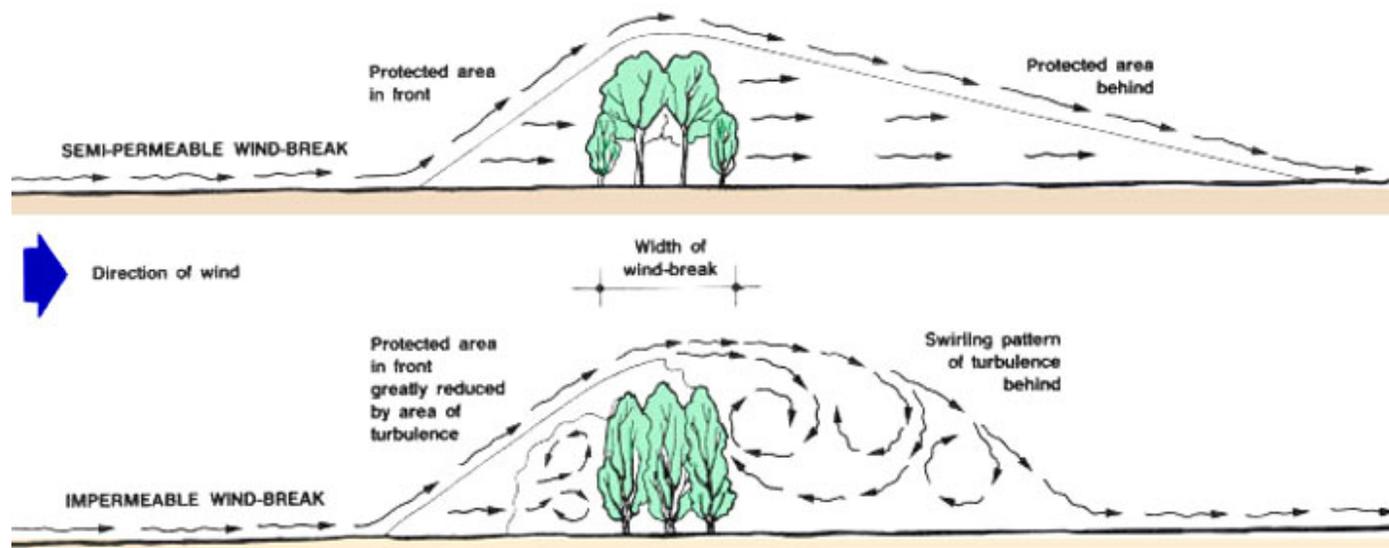
The characteristics of an efficient wind-break

5. An efficient wind-break should have certain characteristics. It should be:

- **semi-permeable** especially in its lower part, about 40 percent of its total area consisting of small openings regularly distributed (a lower permeability reduces the wind velocity more; turbulence, however, reduces the length of the protected area as only the density of the first row directly exposed to the wind modifies its velocity; an open breach in a wind-break will, on the contrary, increase wind velocity and it should be avoided);
- **relatively thin**: as the wind-break becomes thicker, its permeability to wind decreases and therefore its efficiency decreases;
- **rectangular in cross-section** to minimize turbulence in the protected zone;
- **as high as possible**, because the higher the wind-break, the longer the protected zone behind it;
- **long enough** to avoid side turbulence in the protected zone (the length of the wind-break should be equal to at least 12 times its maximum height);
- **perpendicular to the wind direction**.

Note: carefully check on the prevalent direction of the wind against which you seek protection. If this direction is too variable, you may either increase the length of the wind-break or establish several ones in different directions.

Diagrams showing comparative protection with semi-permeable and impermeable wind-breaks



Designing a live wind-break

6. When designing a live wind-break, pay attention to the following points:

- location of the wind-break;
- use of tall trees;
- use of smaller trees, shrubs or tall grasses.

(a) Plant the wind-break at least 3 m outside the centre line of pond dikes and even further if the trees are likely to have long horizontal roots.

(b) Use at least one continuous row of tall trees. If necessary, add one or more rows of smaller trees, shrubs or even tall grasses to complete the semi-permeable screen in its lower part.

(c) The protected zone will extend slightly in front of the wind-break and much further behind, with the wind velocity being reduced in proportion to the maximum height (H in m) of the wind-break:

- by 20 percent from about $1 \times H$ in front to about 10 to $15 \times H$ behind;
- by 50 percent from about $0.5 \times H$ in front to about 1.5 to $2.5 \times H$ behind.

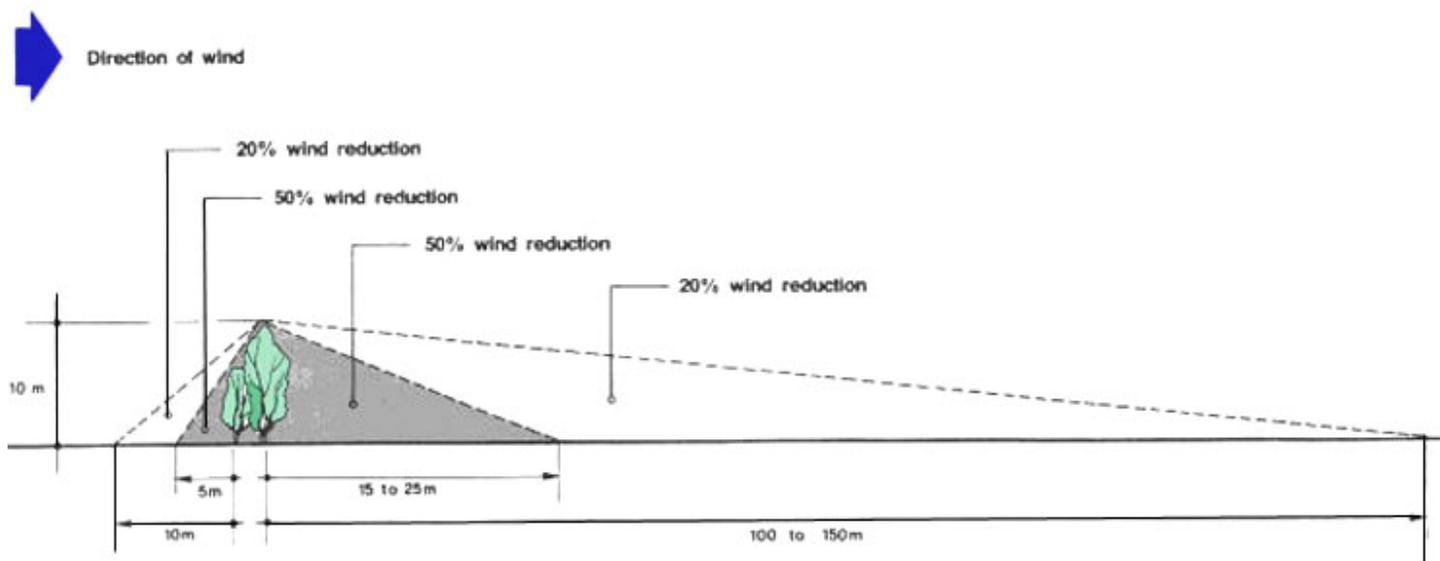
Example

The maximum height of the wind-break is 10 m. The protected zone will extend at the most from about 10 m in front to 150 m behind the wind-break.

(d) Preferably, **plant several rows of trees:**

- to avoid breaches forming in the wind-break if, for example, certain trees die from disease;
- to enable **the exploitation of mature trees** while leaving at least one row offering protection; and
- to improve **the survival of young trees**, which resist strong winds better when planted on a wider strip.

Protection characteristics possible when designing a wind-break



(e) To protect large areas, you may require **a series of wind-breaks** parallel to each other. The distance between each wind-break should be **about 15 times** their maximum height.

(f) Select **tree species well adapted** to local conditions of climate and soil. Seek advice from your forestry or agriculture extension agent.

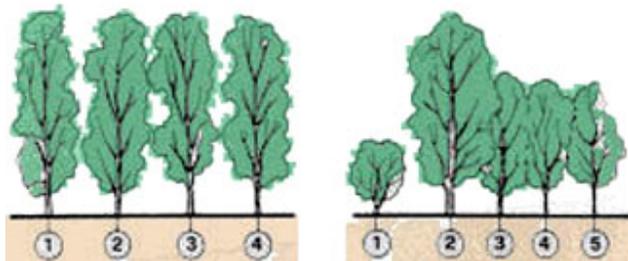
(g) **Diversify the benefits** of your wind-break as much as possible, according to your own needs and those of your community. Adapt the **volume of production** of each particular product to local demand.

(h) In addition to these last two considerations, **give preference to tree species** with the following characteristics:

- sufficient **height** for the area to be protected;
- **foliage homogeneous** from top to bottom of crown, and evergreen foliage permeable to wind;
- **fast growth** in height;
- reduced **crown volume**;
- strong **taproot** and limited horizontal root system; and
- easy **regeneration**, either naturally by seeds or by **coppicing***.

At least four rows of trees for best efficiency

Note: best efficiency has been claimed for wind-breaks made of at least **four rows of trees** occupying a strip of land 10 to 12 m wide.



Choosing vegetation to use in a wind-break

7. Very few tree species have all these desirable characteristics, and therefore it is usually necessary to **mix different species** to ensure that the wind-break has the desired efficiency and structure.

8. In most cases, you will require **tall trees** to increase the size of the protected area and to produce various wood products; depending on the local conditions you may use:

- leguminous trees such as *Acacia albida*, *A. auriculiformis*, *Albizia lebbek* or *Tamarindus indica* (see [Table 7](#)), *Cassia siamea*, *Prosopis chilensis*;
- some fast-growing but relatively short-living trees such as *Azadirachta indica* (neem), *Eucalyptus camaldulensis* (needs at least three dry months per year), or *Casuarina equisetifolia* (see [Table 8](#));
- some slower-growing but long-living trees such as *Parkia biglobosa* (see [Table 8](#)) and *Cupressus spp.*

9. You will also need **small trees and shrubs** to complete the windbreak below the crown of the tall trees. These species will mainly produce firewood, animal fodder and fruit. Depending on the local conditions, you may use some small legumes (see [Table 7](#)) or fruit-bearing trees (*Anacardium occidentale*, cashew; *Morus* spp., mulberry).

10. At the lowest level of the wind-break, you could also plant:

- perennial **forage grasses** such as *Andropogon gayanus* (Gamba grass for 600 to 1 100 mm annual rainfall with five to six dry months a year), *Chloris gayana* (Rhodes grass for 600 to 1200 mm annual rainfall with four to six dry months a year), or others (see [Table 5](#));
- **thorny shrubs** such as *Acacia* (*A. mellifera*, *A. senegal*) to protect the wind-break from being damaged by wandering animals;
- **shrubs unpalatable to livestock** such as *Euphorbia balsamifera* (dry soils) or *E. tirucalli* (humid soils).

TABLE 7
Leguminous shrubs and trees useful for soil conservation and wind-breaks

Latin name/ common name	Origin	Vegetal cycle ¹	Maximum height (m)	Climate		Resistance		Establishment ²	Spacing (cm)	Harvesting for forage	Remarks
				Air temp.	Rainfall (mm)	Drought	Grazing				
<i>Acacia albida</i> Albida, kad, haraz, winter thorn	Tropical Africa	D	30	Warm	300-600	High	Low	SD 2-5-4 months	400/ha cleared to 10 m × 10 m	Produces soft wood (10-15 years) and animal food	Soak seeds in 80°C water, cool for 24 hrs; greatly in- creases soil fertility
<i>Acacia saligna</i> Saligna	W. Australia	5-10 yrs	4-5 (coppice)	Warm	200-1 000	High	Low	SD 3-4 months	100 × 200	Harvest above 50 cm high, at long intervals; produces fire- wood, fencing, gum, animal food	Soak seeds in 80°C water, cool for 24 hrs; ability to coppice (suckers)
<i>Albizia lebbek</i> Albizia, sirs, mataraton, tbit tree	Africa, Asia, N. Australia	D	20 (coppice)	Warm to cool	Over 600	Good	Low	SD 2-5-3 months	500 × 500 to 800 × 800	Produces good timber (10-15 years), firewood and fodder	Soak seeds in 80°C water, cool for 24 hrs; ability to coppice
<i>Atriplex nummularia</i> Oldman saltbush	Australia	P	3	Warm to temp	Over 150	High	Low	SD 15-20 cm SC transplants	—	Grazing when 1.5 m high	Soak seeds in water for 2-3 days, changing water 2-3 times daily; to stabilize sandy soils
<i>Cajanus cajan</i> Pigeon pea, guando, dahl, catjang, pois d'angle	Egypt, E. Africa, India	P/D (up to 5 yrs)	1-3	Warm to temp	600-1 000	Good	Low	S 1-4 kg/ha in rows at 100 cm	30 × 100 to 50 × 100	Rotational grazing; hand har- vest at 20-30 cm in height; seed yield 1-1.2 t/ha	—
<i>Leucaena leucocephala</i> Leucaena, ipil-ipil, aroma blanco	Mexico	P/D	Shrub tree (20 m)	Warm	Over 500	Good	Low	ST < 10 cm diam. SD 3 months S 2-10 kg/ha in rows at 100-150 cm	Variable	Harvest at 50 cm in height at 10-12-week intervals before flowering; seed yield 1-1.5 t/ha; rotational grazing	May produce hardwood for charcoal; soak seed 2 min in 80°C water; wash with cold water and dry; inoculate with special <i>Rhizobium</i> bacteria
<i>Prosopis glandulosa</i> Prosopis, mesquite	S.W. USA, Mexico	D	Shrub tree (4-8 m)	Warm	150-600	High	Low	SD 3-3.5 months	5 m diam. or more	Good source of firewood, timber, charcoal, human/ animal food	Good for sandy soils; soak seeds in 80°C water, cool for 24 hrs; aggressive, invades
<i>Sesbania grandiflora</i> Sesbania, galito, cresta de gallo	Asia	P	Shrub tree (10 m)	Warm	Over 1 000	Low	Low	S 10 kg/ha in rows at 100-200 cm SD 15.2 months	—	Harvest 3-4 months after planting; produces firewood, paper, gum, human/animal food	Grows very rapidly; top the seedlings off after 1-1.5 months transplant
<i>Tamarindus indica</i> Tamarind, tamarinier	Ethiopia, C. Africa	P	15	Warm	—	Good	Low	—	—	Produces wood, good fod- der and fruit	Slow growth; drought re- sistant

P = perennial, D = deciduous
S = seeds, SC = stem cuttings; SD = seedlings; ST = stumps

¹ P = perennial; D = deciduous

² S = seeds; SC = stem cuttings; SID = seedlings; ST = stumps

TABLE 8
Non-leguminous shrubs and trees useful for soil conservation and wind-breaks

Latin name/ common name	Origin	Maximum height (m)	Climate ¹	Diversified production							Remarks
				Timber	Poles	Posts	Firewood	Charcoal	Fruit	Miscellaneous	
<i>Anona reticulata</i> Bullock heart, corazón, coeur-de-boeuf	Tropical C. America	8-10	Warm, humid	—	—	—	—	—	●	Fibres, insecticide, tan- nin, dye	—
<i>Bambusa vulgaris</i> Yellow, feathery bamboo	Pacific Islands	15	P > 1 000 mm Alt. < 1 500 m	—	●	—	—	—	—	—	Plant 4 × 4 m; clear at 8 × 8 m; selec- tive harvest, leaving at least 8 culms
<i>Butyrospermum parkii</i> Shea-butter tree, karité	Africa	9-12	P 700-1 000 mm	—	—	●	●	●	●	Shea-butter	Resists 4-5 dry months; slow growth
<i>Casuarina equisetifolia</i> Filao	S.E. Asia	High	Low altitudes	●	—	●	●	●	—	—	Excellent for sandy soils; plant 5-8- month seedlings at 3 × 3 m
<i>Colubrina arborescens</i> Wild ebony, abeyuelo, bois pelé	C. + S. America	20	Wide range	●	—	●	—	—	—	—	Fast growth in humid climate
<i>Grevillea robusta</i> Silk oak, roble de seda	Australia	25	Drought resistant	—	—	—	—	—	—	Wood for furniture and interiors	Fast growth; easy propagation
<i>Oxytenanthera abyssinica</i> Bamboo	Africa	10	Dry 900-2 000 m	—	●	—	—	—	—	—	Plant 4 × 4 m; clear at 8 × 8 m; se- lective harvest, 25% of culms
<i>Parkia biglobosa</i> African locust bean, néré, caroubier africain	Africa	10-20	P 600-900 mm	—	—	—	●	—	●	—	—
<i>Schaefferia frutescens</i> Floride-boxwood, jiba, limoncillo	C. + S. America	10	Drought resistant	—	—	—	—	—	—	Wood for furniture	Evergreen shrub/tree; fast growth
<i>Simaruba glauca</i> Simaruba, marupa, aceituno	C. + S. America	20-30	—	●	—	—	—	—	—	Food (seeds), oil	Fast growth

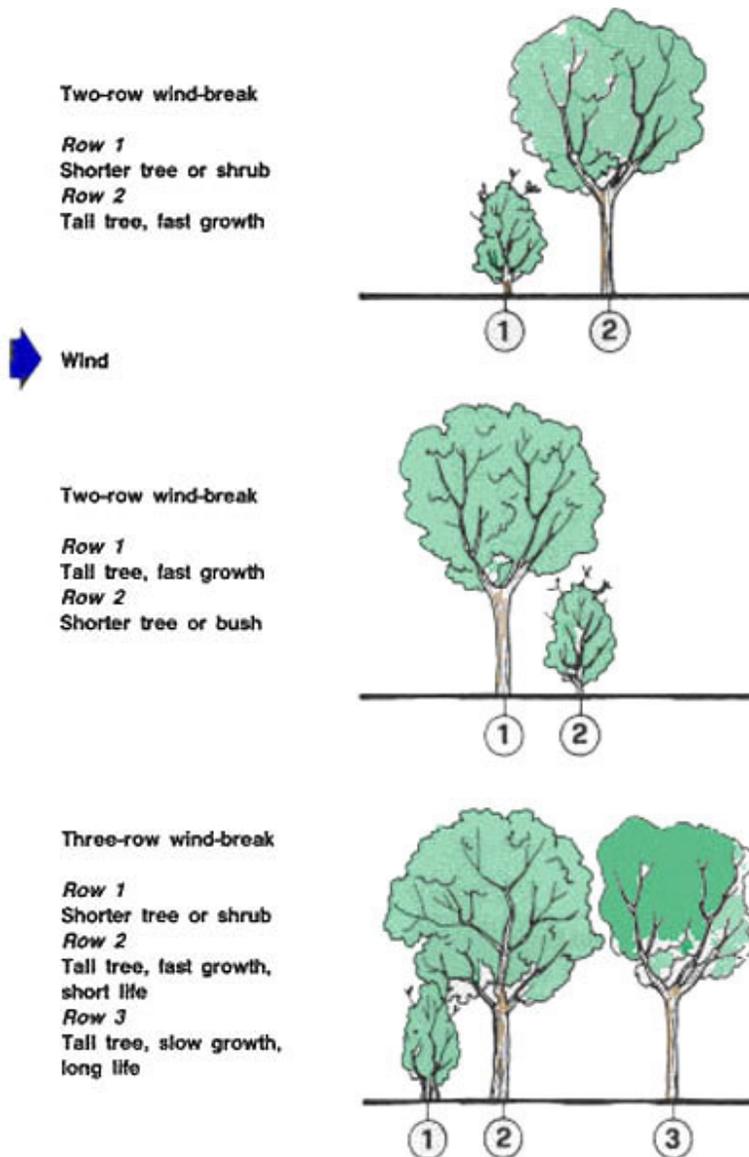
¹ P = annual rainfall

Various kinds of wind-breaks

11. Various kinds of wind-breaks can be planted, usually made of **two to six rows**, determined not only by the kind of additional benefits expected but also by the land available. Common examples of wind-breaks are the following:

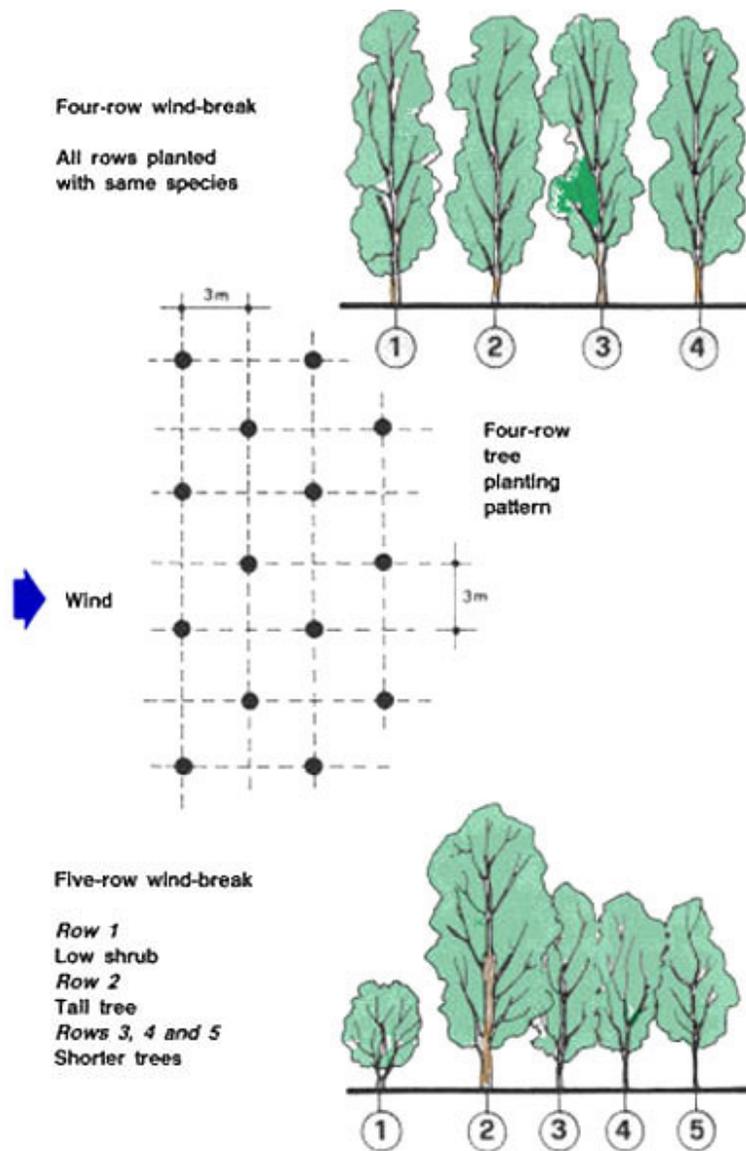
(a) **Two-row wind-breaks**: one fast-growing tree planted with a smaller tree. The smaller tree can be planted either in front of or behind the larger one, according to the resistance to the wind of both kinds of trees.

(b) **Three-row wind-breaks**: two rows of tall trees, one of which may be fast-growing but relatively short-living (e.g. *Eucalyptus* spp. or *Azadirachta indica*) and the other one may be slow-growing but long-living (e.g. *Acacia albida* or *Tamarindus indica*); and one row of smaller vegetation producing firewood, fodder, fruit, etc. Major wood production is expected from the exploitation and **even removal of the middle row** when the wind-break becomes too dense.



(c) **Four-row wind-breaks:** especially useful for additional benefits such as fodder, poles and firewood. The four rows may be planted with one tree species such as a leguminous tree. In dry locations, consider *Cassia siamea* and in wet locations, *Dalbergia sissoo*. Plant these trees in alternate rows, with about 3 m between trees.

(d) **Five-row wind-breaks:** from front to back row, the following species can be planted: *Cajanus* sp., *Casuarina equisetifolia*, *Acacia nilotica* (or two inside rows of *Cassia siamea*).



Establishing, maintaining and renewing a wind-break

12. To establish your wind-break, proceed in stages:

- (a) Obtain or produce **vigorous plants of uniform size** for the tree species you have selected.
- (b) **Prepare the strip of land well** for planting by loosening the soil to a depth of 0.6 to 0.8 m and by digging deep holes. Fertilize if the soil is infertile.
- (c) After the rains have started, **plant the young trees**.
- (d) **Protect them** from being damaged by grazing animals and fire.
- (e) **Replace** all dead plants as soon as possible.
- (f) **Water the plants** if necessary, at least until they have developed a deeper root system.
- (g) **Eliminate the weeds and loosen the soil** around the plants regularly.

13. Later, once the wind-break is established and growing fast, it should be maintained regularly, which may also provide wood products.

- (a) **Remove and if necessary replace trees** which are dead, diseased or much slower-growing.
- (b) If the permeability of the screen becomes too low or if the tree growth starts declining, **reduce tree density**.

(c) **Pollarding*** may also become necessary.

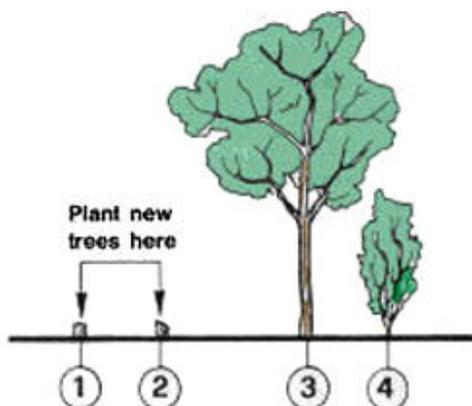
(d) Continue **to protect the plants** against overgrazing, fire and uncontrolled cutting.

(e) If necessary, improve the wind-break efficiency by adding one or more new rows of vegetation.

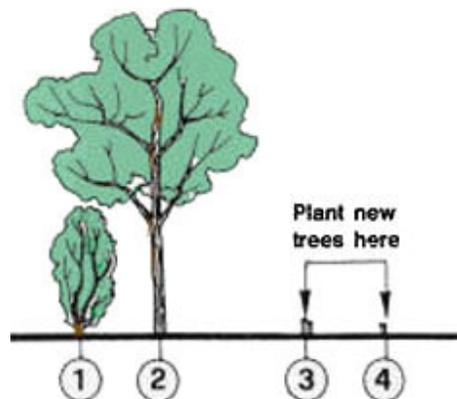
14. When the trees of a wind-break reach maturity, their ability to reduce wind velocity decreases greatly. **Exploiting and renewing** them becomes necessary. The most common practice is **to first exploit one half of the wind-break** by cutting one or two rows of trees at ground level. This vegetation is then renewed either by **coppicing*** or by planting, and the other half of the wind-break is cut down a few years later. This system is particularly easy to manage with a four-row plantation, but a similar scheme can be adopted for other types of wind-break.

Examples of wind-break exploitation and renewal

Cut two rows of trees, leaving two rows as wind-break



A few years later, when the new trees have grown, cut the other two rows

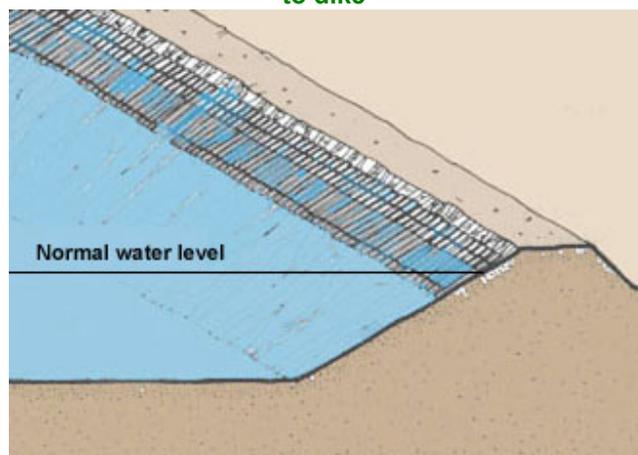


4.3 How to protect dikes against wave action

1. In ponds that are relatively large or poorly protected from strong winds, the lapping of the waves against the upper part of the dikes may cause extensive damage. Such erosion is particularly active:

- in newly constructed ponds; and
- on the wet sides of the pond dikes facing the wind.

Split bamboo, rush or fibre mats fastened directly to dike



2. **To protect dikes** against wave action, you can use one of the following methods:

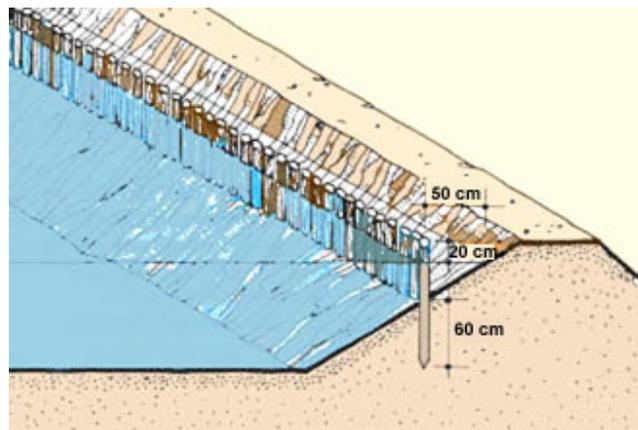
(a) Around the normal water level and over the area to be protected, lay **one or more rows 1 to 1.5 m wide of wood or bamboo poles**. Place them close to each other. Anchor each row well using wooden stakes, for example, so that the poles do not float away.

(b) You can also use **split bamboo, rush or fibre matting** laid in mats 1.5 to 2 m wide and anchored into the dike.

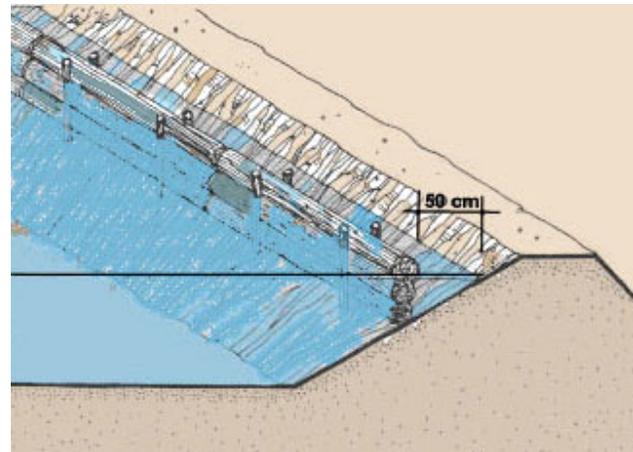
Wooden or bamboo poles driven into water off shore

They will not last so long, but are cheap and can be easily moved or replaced. Plastic sheeting or large leaves from palm or banana trees, for example, can also be used for temporary protection.

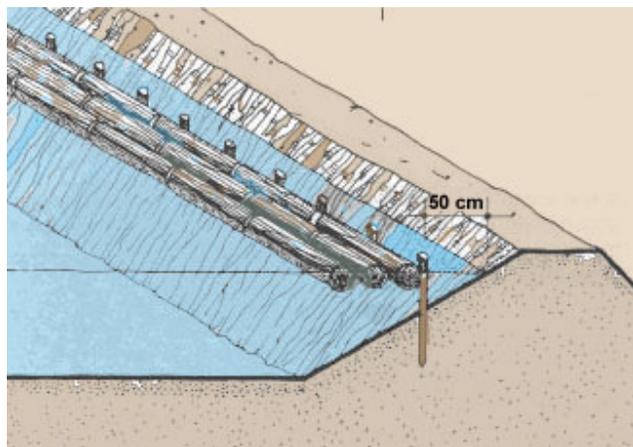
(c) Build a **fence of wooden or bamboo poles** driven side by side into the dike slope about 0.5 m from the water's edge when the water is at its normal level. To reinforce this fence, you can lace the tops of the poles together with lianas or ropes.



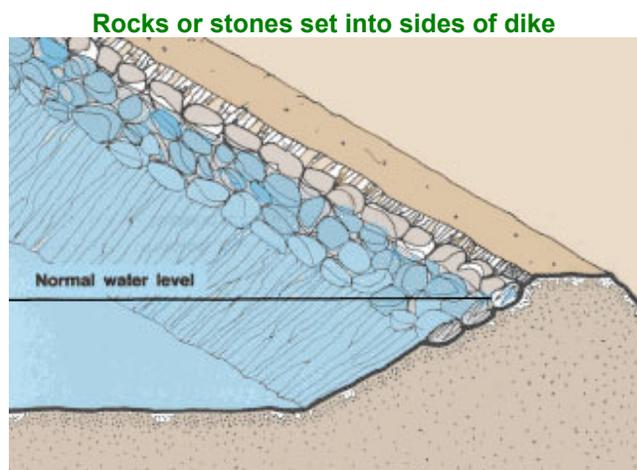
(d) A similar fence can be built with 30-cm-thick **bundles** of reeds, straw or branches stacked and tied end to end **between two rows** of stakes.



(e) **Floating bundles of straw** or **branches** may be assembled in a continuous line just in front of the dike. Make sure they extend at least 30 cm below the water level.

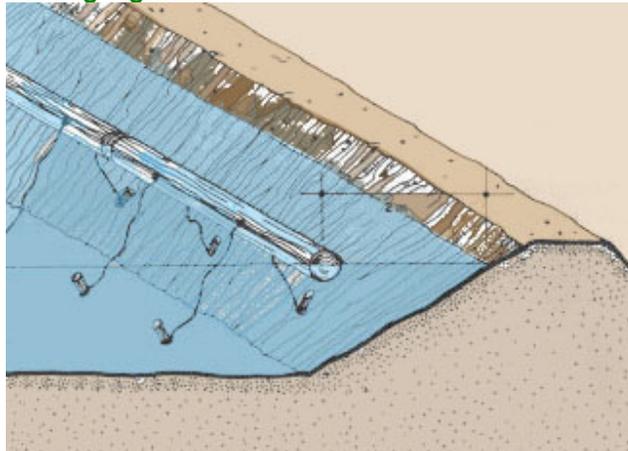


(f) More permanent protection can be made **if rocks or stones** are easily available. Use them in a layer 25 cm thick spread over a strip 1.5 to 2 m wide and extending on either side of the anticipated normal water level. Coconut shells and similar materials can also be used. In extreme cases such as for large barrage ponds, **rock rip-rap**, preferably placed by hand, might be required on top of a 25-cm-thick gravel foundation.



(g) A row of end-to-end floating logs, up to 25 cm in diameter, may be anchored about 2 m offshore. This structure is called a log boom. If the pond water level is expected to fluctuate, remember to leave some slack in the anchor lines.

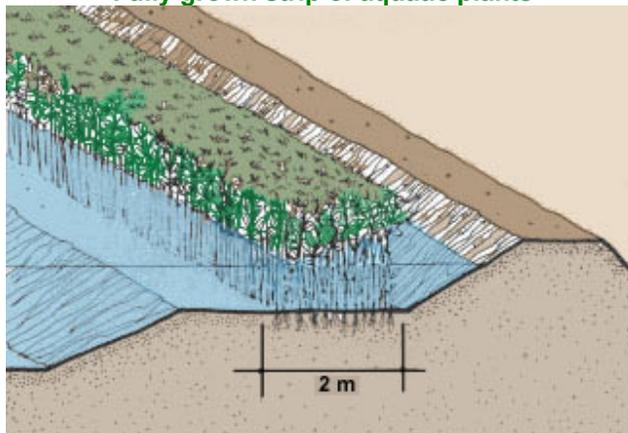
Floating logs tied end to end and anchored off shore



(h) One of the best and longest lasting methods of wave action control may be obtained from **dense aquatic vegetation**. Usually a strip 2 m wide of strong vertical aquatic plants, reeds for example, is planted in front of the dike to be protected. If you plan to use this method, **you should design the dike:**

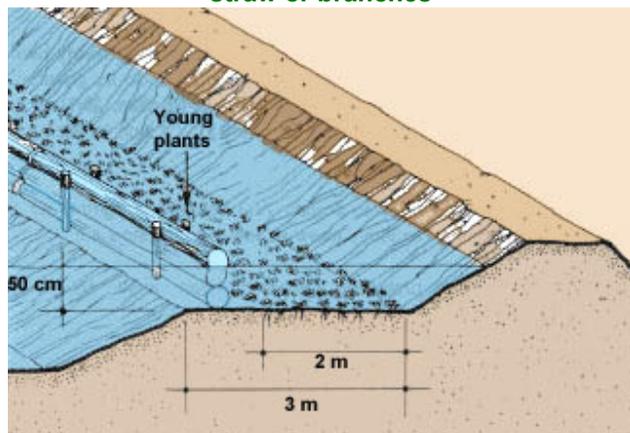
- either with **a very gentle slope** from 1:4 to 1:8 starting 0.3 m below the normal water level;
- or **with a horizontal berm** about 0.5 m below normal water level and 3 m wide.

Fully grown strip of aquatic plants



(i) To protect young aquatic plants from waves until they are grown, use bundles of reeds, straw or branches anchored in front of the horizontal berm as shown above. When the strip of vegetation is fully grown, you can remove this protection.

Young aquatic plants protected by bundles of reeds, straw or branches



4.4 How to protect dikes and canals against erosion

Protecting your dikes

1. You have already learned earlier that you should protect **newly built dikes** against erosion from rainfall, covering them as soon as possible with a thick grass cover (see Section 6.9, Pond construction, 20). You should maintain this grass cover well, cutting it regularly and fertilizing it if necessary.
2. You have also learned how to protect your fish ponds against **wind** (see Section 4.2) and the resulting **wave action** (see Section 4.3).
3. Dikes should also be protected against damage caused by **heavy livestock traffic**, as you will learn later (see Section 4.5).

4. Dike erosion can also take place **at the pond inlet** under the action of the inflowing water. Protection may be given either:

- **directly** to the part of the dike located under the inflowing water (see [Section 9.5, Pond construction, 20](#)); or
- **indirectly** through some of the water filtering devices described earlier (see [Section 2.9](#)), which absorb the force of the inflowing water.

Protecting your water canals

5. Water feeder, drainage and diversion canals are subject to erosion, particularly if **the water current** exceeds the maximum permissible velocity (see [Section 8.2, Pond construction, 20](#)). Sheet erosion during rainfall may also take place along the canal side slopes if they are not properly protected.

6. There are different ways of providing additional protection to water canals. You can do this in one of the following simple ways.

(a) First take any steps possible **to reduce water flow** in affected sections (e.g. by draining ponds carefully) **or to reduce sheet erosion** (e.g. by diverting water away from the side slopes with small trenches).

(b) You may connect the trenches with **gravel filter channels**, if you need to conduct the water safely down the canal side. These are strips of gravel 30 to 40 cm wide and 20 to 30 cm deep, which run diagonally down the side of the slope.

(c) Establish and maintain a strong short **grass cover** on the canal sloping sides, using similar grasses as those recommended for pond dikes (see [Section 6.9, Pond construction, 20](#)).

(d) Cover the sides of the canal with **lengths of wood or bamboo** driven into the canal bottom next to each other.

(e) Tied bundles of sticks or branches can also be used.

7. More expensive ways include:

- **lining the canal** with bricks, cement blocks or concrete (see [Section 8.3, Pond construction, 20](#));
- lining the side slopes with elongated half-height **gabions** (see [Section 3.7, Pond construction, 20](#)).

Note: any change in the quality of the canal walls will affect **the water discharge capacity** of the canal (see Section 8.2, [Pond construction, 20](#)).

4.5 Traffic control: fencing

1. Fencing is often used on fish farms:

- to protect the growing stocks from theft; and
- to protect dikes, structures and plantations from animals.

2. Fences may also be used as **wind-breaks** (see Section 4.3), to diversify production (wood, fruit, leaves), to provide privacy and to improve the appearance of your fish farm.

3. There are **different types of fences**. You should select the right type according to its main purpose and the amount of money you wish to invest. The chart below should assist you.

Protection given by various fences

Type of fence	Relative cost ¹	Protection from	
		Animals	Theft
Live fence	2	Yes	No
Piled fence	1	Yes	Possible
Woven fence	2	Yes	No
Post-and-rail fence	3	Yes	No

Wire fence	4	Yes	No
Wire-netting fence	5	Yes	Yes
Stone wall	2	Yes	No

¹ From cheapest (1) to most expensive (5)

Live fences

4. A **live fence** is made of shrubs and trees planted closely together as a hedge and regularly trimmed to produce a barrier to keep animals out.

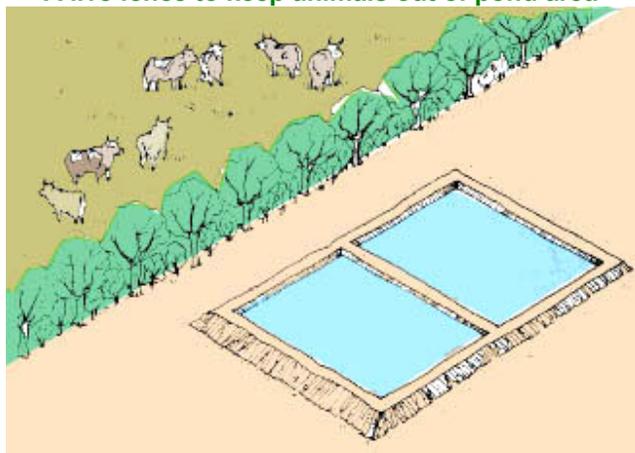
5. If planting material is readily available, these fences are quite **cheap to install**, needing only to be planted. They also have the advantage of providing **additional benefits** such as the production of wood, fruit and animal fodder as well as acting as low wind-breaks and being an attractive feature in the landscape.

6. However, before considering the use of live fences, you should be aware that:

- they usually grow quickly, **requiring labour** for regular cutting, sometimes twice a year;
- to be really stock-proof, they may require **the addition of some other type of fencing** at particular points; and
- hedges require more **space** than some other types of fence.

7. Several different **kinds of shrubs and trees** can be used to make live fences. If the availability of **animal fodder** for browsing is one of the major benefits you are interested in, you should use a shrub or tree **legume** which is fast-growing and resistant to grazing and trimming, such as *Cassia siamea* (Siamese senna) or *Gliricidia sepium* (Nicaraguan shad). For protection both from animals and theft, **a thorny live fence** can be effective. You could also use **agave** planted in alternate rows for the production of sisal (*A. sisalana*) or maguey (*A. cantala*). **Cactus** plantations are another possibility.

A live fence to keep animals out of pond area



Piled fences

8. A **piled fence** is made of a row of cut vegetal material piled up high enough to keep out animals and sometimes also people. The best way is to use **thorny branches**, but you could also use any waste from land clearing or tree felling. Tie the material intermittently to vertical posts to give it more strength.

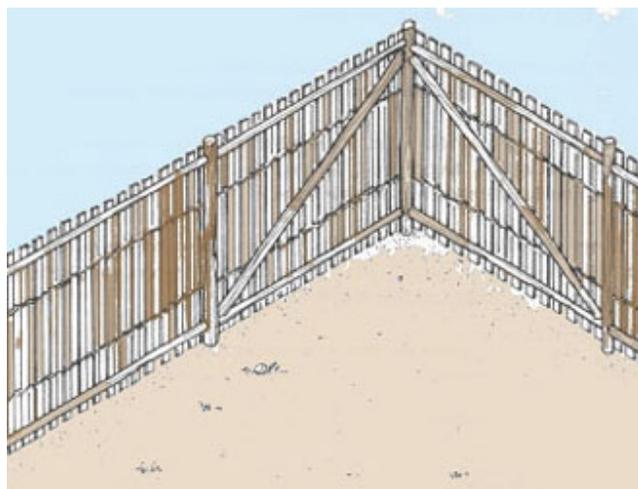
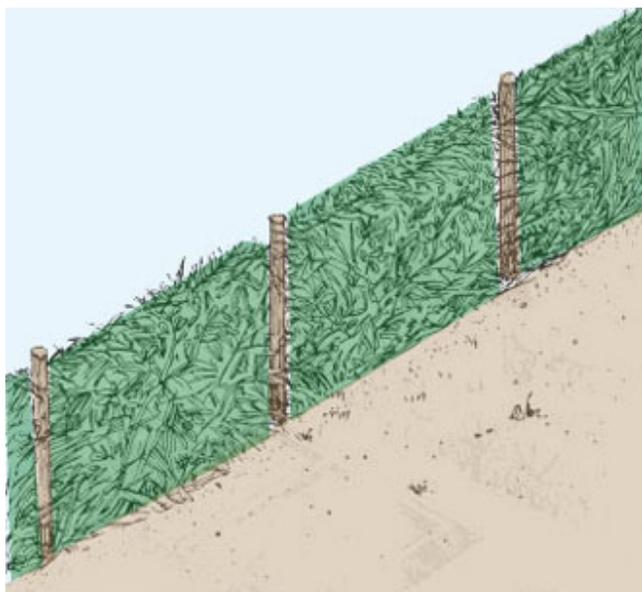
9. Usually, this type of fence can last for some years, although it can also be very susceptible to fires, rot and termites.

Woven fences

10. A simple light fence can be made using woven matting, for example, bamboo, rush or leaf matting, fixed on a framework of wood or bamboo poles, with horizontal support bars at the top and bottom. These fences should be securely braced with angled support to keep them upright.

A piled fence of thorny branches or vegetal material with intermittent vertical posts

A fence of bamboo strips with horizontal and angle supports



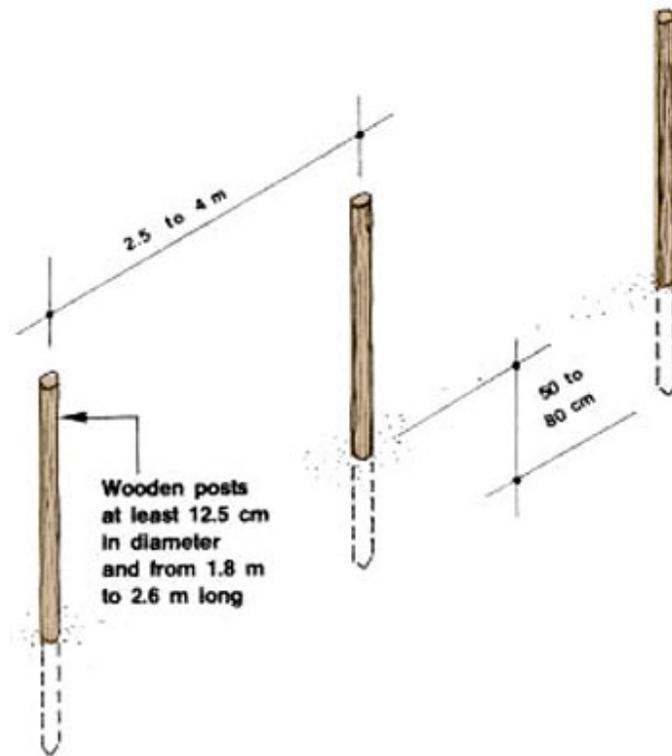
Post-and-rail fences

11. A **post-and-rail fence** consists of wooden posts strongly driven into the ground at regular intervals and joined with horizontal wooden rails. It is particularly useful in areas where wood or bamboo is available.

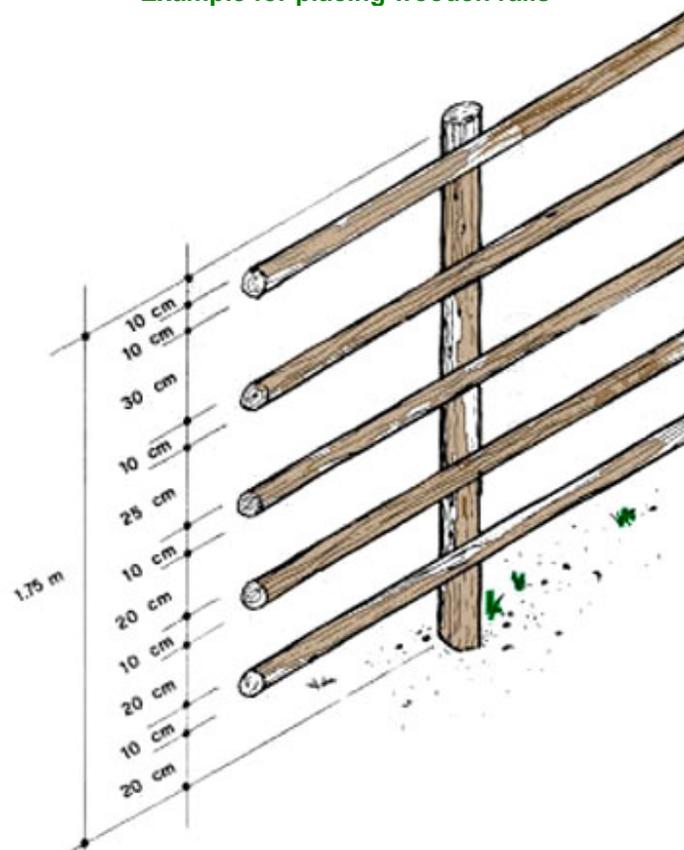
12. This type of fence is easily made as follows:

- (a) Prepare strong **wooden posts** with a diameter of at least 12.5 cm and 1.8 to 2.6 m long. If necessary, treat the wood to increase its resistance to termites and rot (see [Section 3.1, Pond construction, 20](#)).
- (b) Prepare the **wooden rails**, usually using either lengths of split bamboo or wooden poles 10 cm in diameter.
- (c) **Drive the posts vertically** into the ground to a depth of 0.5 to 0.8 m, at 2.5- to 4-m intervals. If necessary, add some angled supports to brace the posts.
- (d) **Fix the rails to the posts**, in three to five horizontal rows. Make joints of the rails only at the posts, and not all on the same post.
- (e) Install posts for gate openings. You may also want to install passes or stiles for crossing the fence (see [below](#)).

Placing the posts



Example for placing wooden rails



Wire fences

13. A wire fence is made of **several wire lines** tightly stretched between a series of **vertical posts**. Wire fencing is expensive and should be limited to areas where it is necessary and where cheaper fences cannot be established. There are two **kinds of wire**, usually **galvanized** for protection against corrosion:

- **plain wire**, which is cheaper but more difficult to place properly;

- **barbed wire**, which is more difficult to handle, rusts faster and can be a cause of serious injury to animals. It is most useful as a top wire.

Plain wire



Barbed wire



14. **Plain wire** is defined by its gauge (see [the chart below](#)), while **barbed wire quality** is defined by **three numbers** defining the gauge, number of barbs (2 or 4) and distance between barbs (8 to 11 cm); for example, "16 x 4 x 11" describes a 16-gauge wire with four barbs every 11 cm.

Plain wire gauges
Equivalence of common wire gauges (in mm)

Gauge	BWG	ISWG	USG	PG
5	5.588	5.384	5.314	1.0
6	5.154	4.876	4.935	1.1
7	4.572	4.470	4.554	1.2
8	4.191	4.064	4.176	1.3
9	3.759	3.657	3.797	1.4
10	3.403	3.251	3.571	1.5
11	3.047	2.946	3.175	1.6
12	2.768	2.641	2.778	1.8
13	2.412	2.240	2.381	2.0
14	2.108	2.032	1.984	2.2
15	1.828	1.828	1.786	2.4
16	1.650	1.625	1.587	2.7
17	1.472	1.421	1.428	3.0
18	1.244	1.218	1.270	3.4
19	1.066	1.016	1.111	3.9
20	0.888	0.914	0.952	4.4
21	0.812	0.812	0.873	4.9

Note:

BWG = Birmingham Wire Gauge (UK)
 ISWG = International Standard Wire Gauge
 USG = United States Gauge
 PG = Paris Gauge (France)

Data for Paris and Birmingham wire gauges

Wire gauge		Wire diam. (mm)	Wire section (mm ²)	Weight per 1000 m (kg)	Length per kg (m)
PG	BWG				
5	20	1.0	0.785	6.12	163.40
6	19	1.1	0.950	7.41	134.95
7	18	1.2	1.130	8.81	113.50
8	18	1.3	1.327	10.35	96.62
9	17	1.4	1.539	12.00	83.33

10	17	1.5	1.767	13.78	72.57
11	16	1.6	2.011	15.68	63.77
12	15	1.8	2.545	19.84	50.40
13	15	2.0	3.142	24.48	40.85
14	14	2.2	3.801	29.64	33.74
15	13	2.4	4.524	35.28	28.34
16	12	2.7	5.725	44.63	22.40
17	11	3.0	7.068	55.13	18.14
18	10	3.4	9.079	70.82	14.12
19	9	3.9	12.045	93.17	10.73
20	8	4.4	15.205	118.59	8.43
20	7	4.6	16.619	129.62	7.71
21	7	4.9	18.857	147.08	6.80

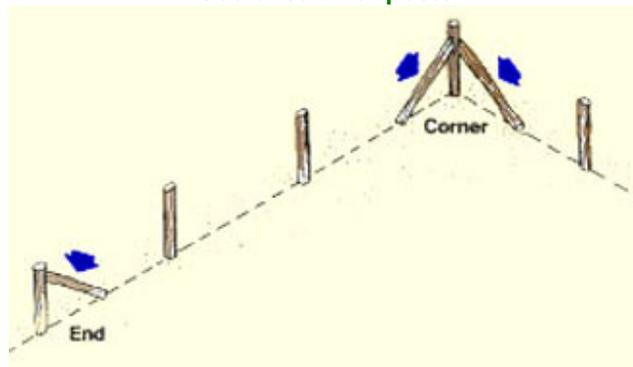
15. **Wooden posts** are generally cheaper than concrete posts but less resistant to rot, fire and termites. Select a naturally durable hardwood or treat less durable wood with a preservative ([see Section 3.1, Pond construction, 20](#)).

16. There are **two types of post** in a wire fence:

- **strainer posts**, at gates, extremities of straight lines, intermediate points on long lines and wherever the ground slope changes; and
- **intermediate posts**, at regular intervals between strainer posts.

17. The stability and efficiency of the wire fence will depend on **the strength and stability of the strainer posts**. You should therefore select and fix them with particular care.

Use of strainer posts



18. Instead of standard posts, you can also use **live posts** consisting either of trees growing on the fence line or of specially planted trees. They are cheap and long-lasting, **providing additional benefits** such as wood, fruit, animal fodder and shade. Excellent live posts are made of *Gliricidia sepium*, a tree legume widely used at low altitudes in Latin America, where it is trimmed at 1 to 1.5 m in height to be directly grazed by livestock.

Note: trees to be used as live posts should be planted well in advance to give them enough time to take root properly.

Use of trees as live posts



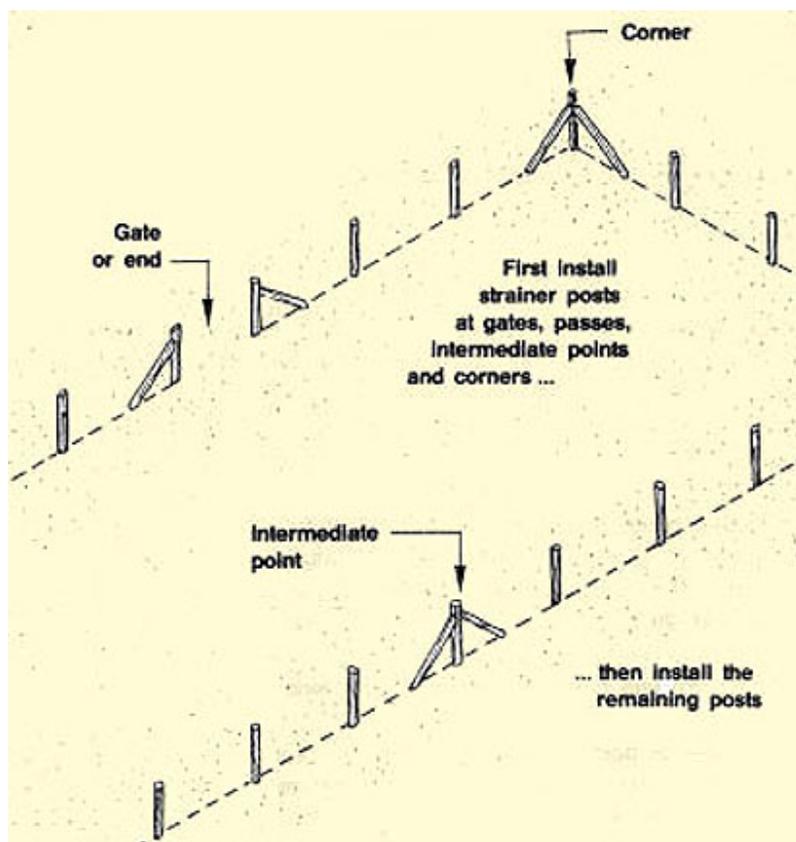
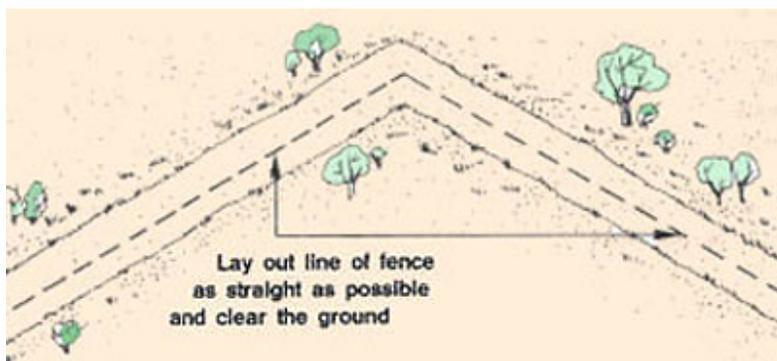
19. To make a simple wire fence, proceed as follows.

(a) **Lay out the fence line** as straight and unbroken as possible.

(b) **Clear the ground area.**

(c) **Install the strainer posts**, about 2 m long, at gates, passes, corners, top and bottom of slopes and at any intermediate point if the straight distance is over 150 to 200 m. They should be at least 15 cm in diameter and set into the ground 80 cm deep. Brace them well according to their position:

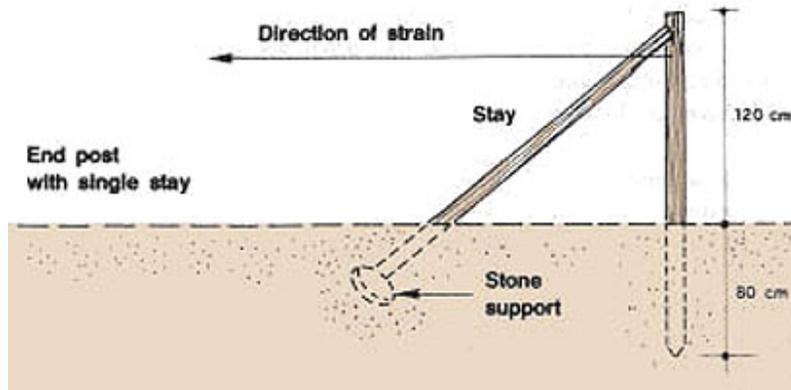
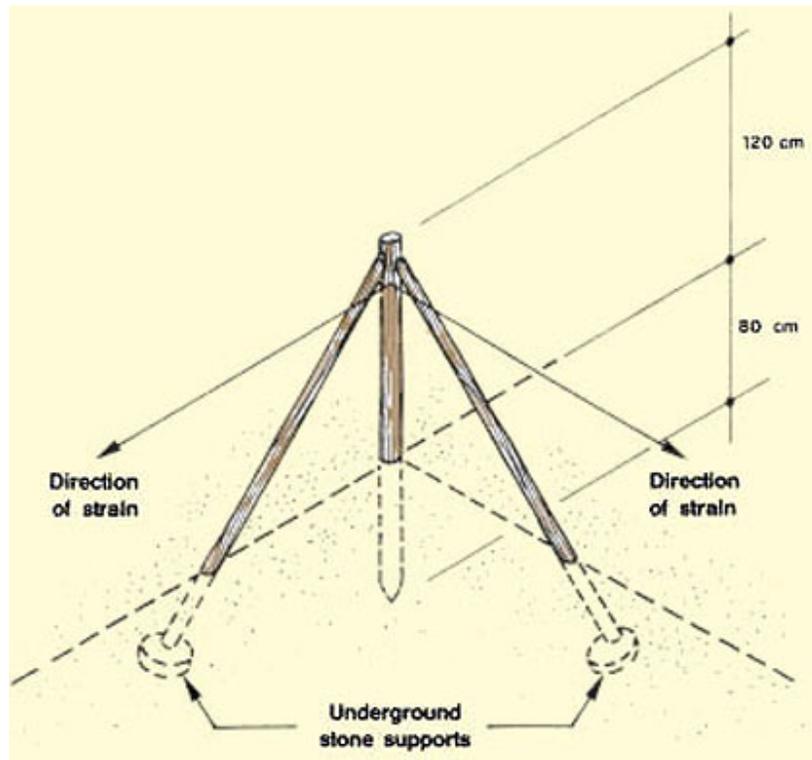
- brace **corner posts** with a stay in the direction of both fencing lines;
- brace **end or gate posts** in the direction of the fencing line;
- brace **intermediate strainer posts** at various points along long runs of fencing.



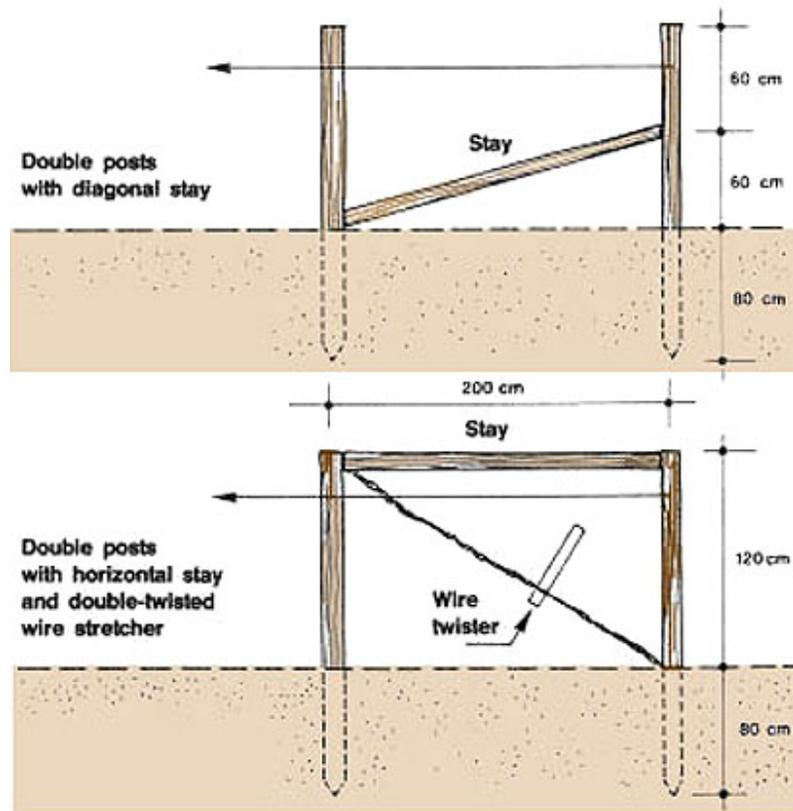
20. Different **types of stays** can be used according to soil conditions:

- single or double diagonal stays to stabilize the post by pushing against a surface or buried support at a 30° to 40° angle;
- a traditional strainer assembly with a diagonal stay between two posts;
- a strainer assembly with a horizontal stay and a double-twisted wire stretched between two posts.

Corner post with double stays



Note: posts 15 to 20 cm diam. stays 12 to 15 cm diam.

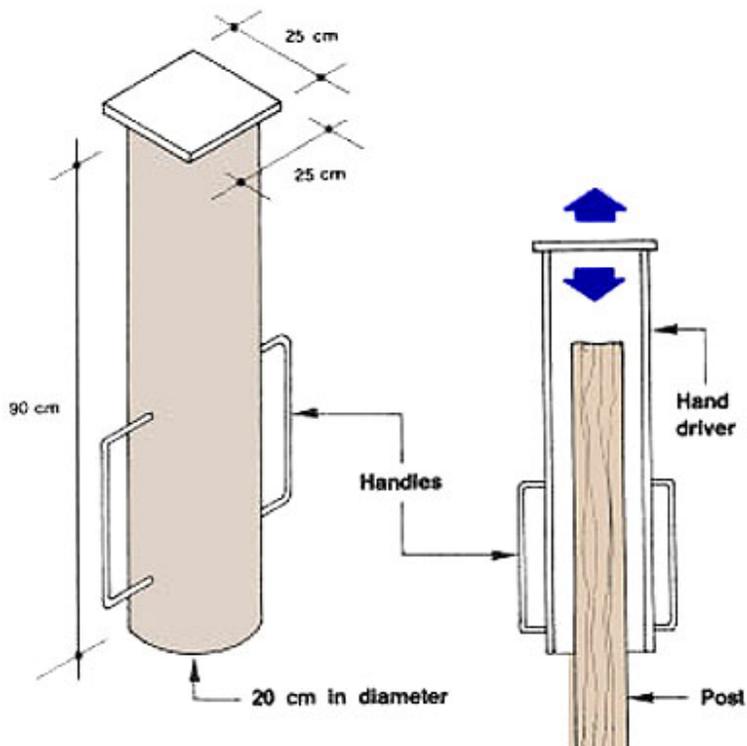


21. You can either set these posts in dug or bored holes with firmly tamped soil around them, **or you can drive pointed posts into the soil**, giving them more stability. For this, it may be useful to build **a simple hand driver** as follows:

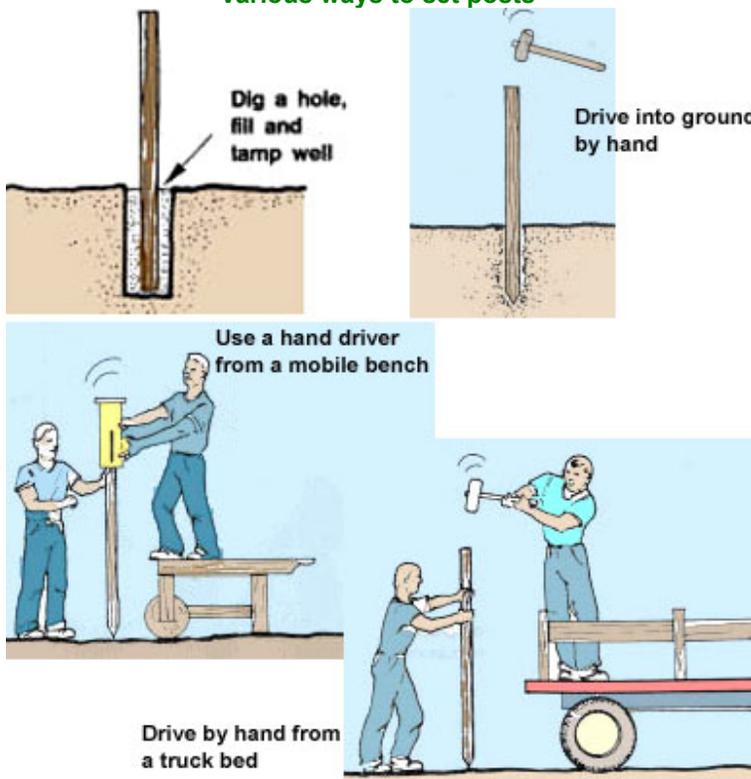
- (a) Get a steel pipe 20 cm in diameter and 90 cm long.
- (b) Close its top end by welding on a steel plate 25 cm x 25 cm.
- (c) At the other end, weld two handles.

22. The posts should be held vertically by a helper, while someone standing on a raised platform such as the back of a truck or a mobile wooden bench strikes the post head from above with the hand driver.

Build a simple pipe hand driver



Various ways to set posts

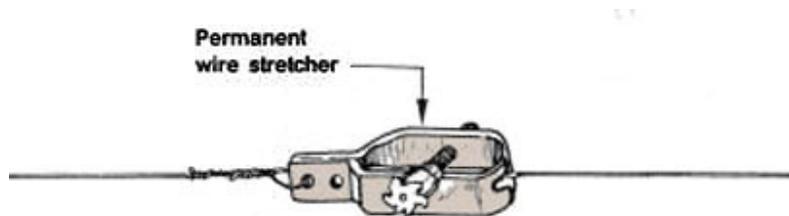


23. **Install the intermediate posts**, about 1.6 to 1.8 m long, exactly in line, at 3- to 5-m intervals. Their diameter should be 7.5 to 12.5 cm, and they should be set 40 to 60 cm deep.

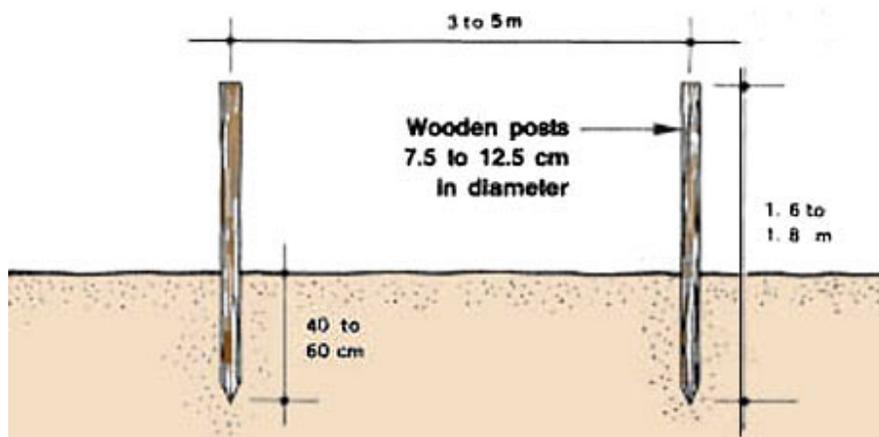
24. **Install the bottom wire** 15 to 40 cm above the ground, securing it first to a **strainer post** and leading it straight to the next **strainer post**. It is then **tightly stretched** using a wooden lever and secured to the post. Make sure that **the wire passes on the inside of all the intermediate posts**. Make one turn around any **corner post** and secure the wire by wrapping it around and stapling it to the post. **Loosely fasten** the wire to the intermediate posts by stapling.

25. **Install the other three to five wires** from bottom to top, at 20- to 30-cm intervals, as described above. The top wire should be 10 cm below the head of the posts. Then **collect** all bits of wire, nails and staples left on the ground to keep animals from swallowing them later.

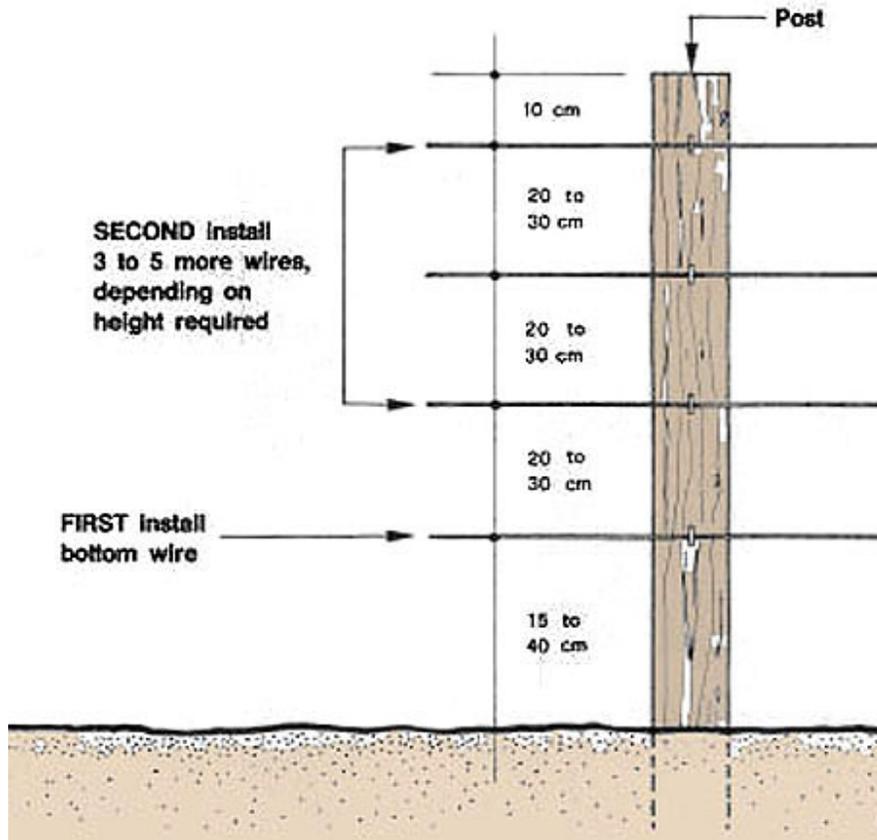
26. When all of the wire has been installed and stretched, it is time to **install gates**. Points for pond workers to cross fences, such as **passes**, should also be installed during construction. However, such crossing points as **stiles** can be placed after the fences are completed. Three kinds of gates, two kinds of passes and a stile are illustrated below.



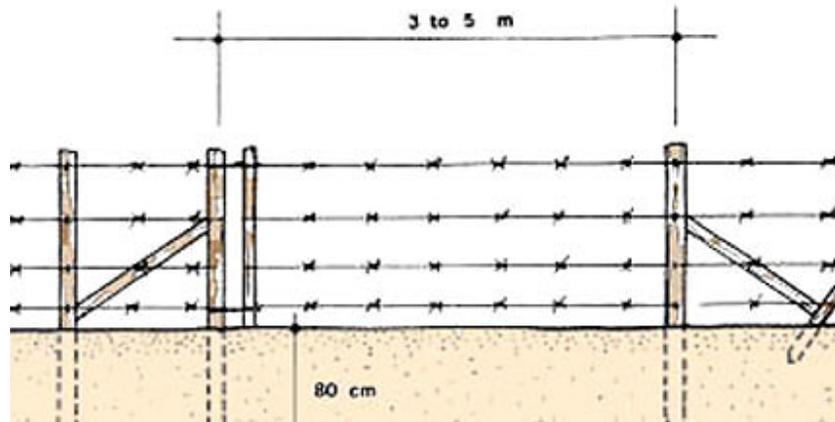
Note: it is easier to stretch the wire if **permanent wire stretchers** are installed on it every 20 to 25 m; final stretching is done after the wire has been secured at each end to strainer posts.



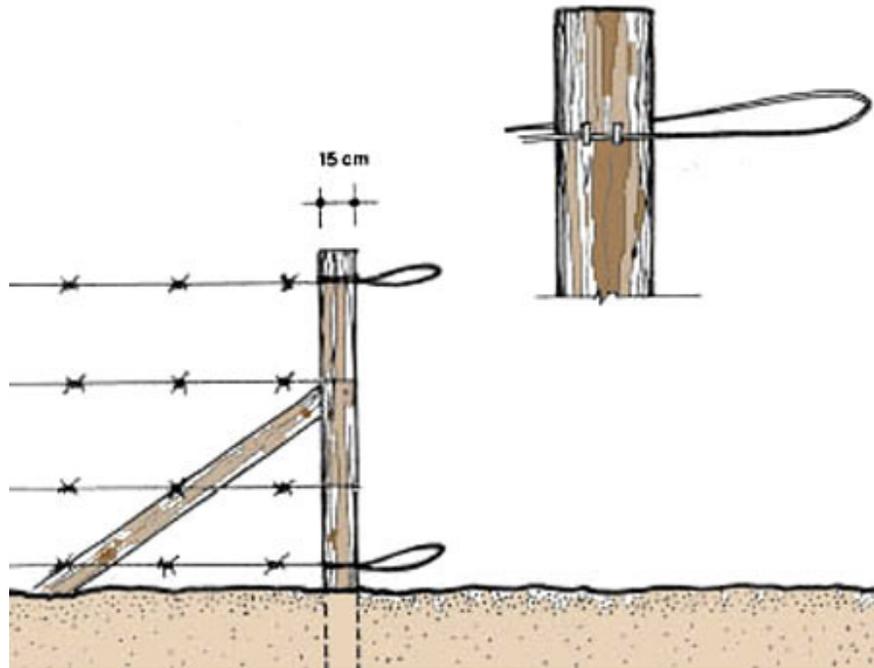
Installing posts and wire



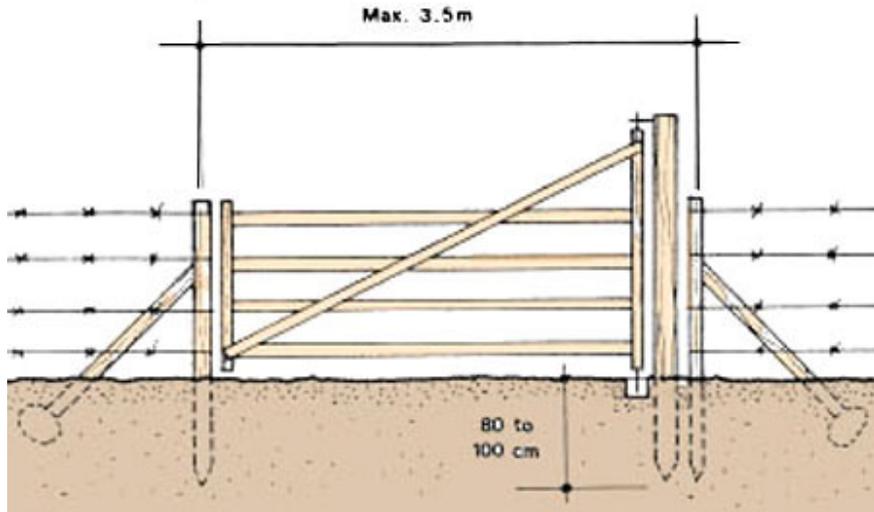
Stretched wire gate

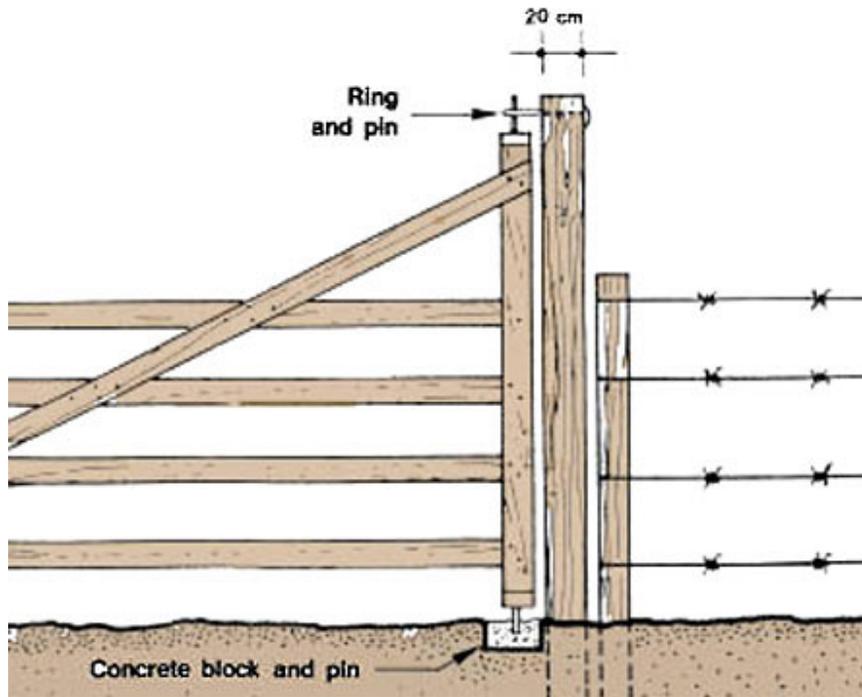


Detail of wire loop closure

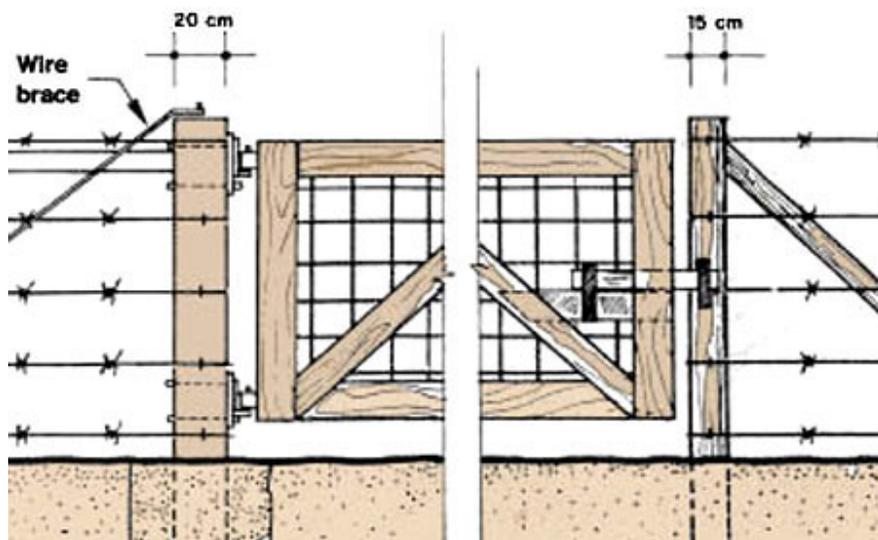
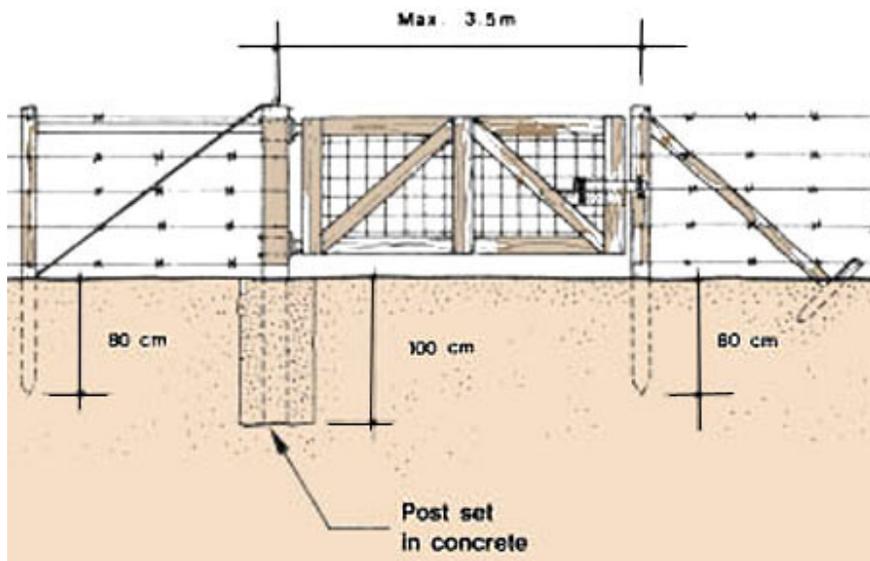


Pivoting gate

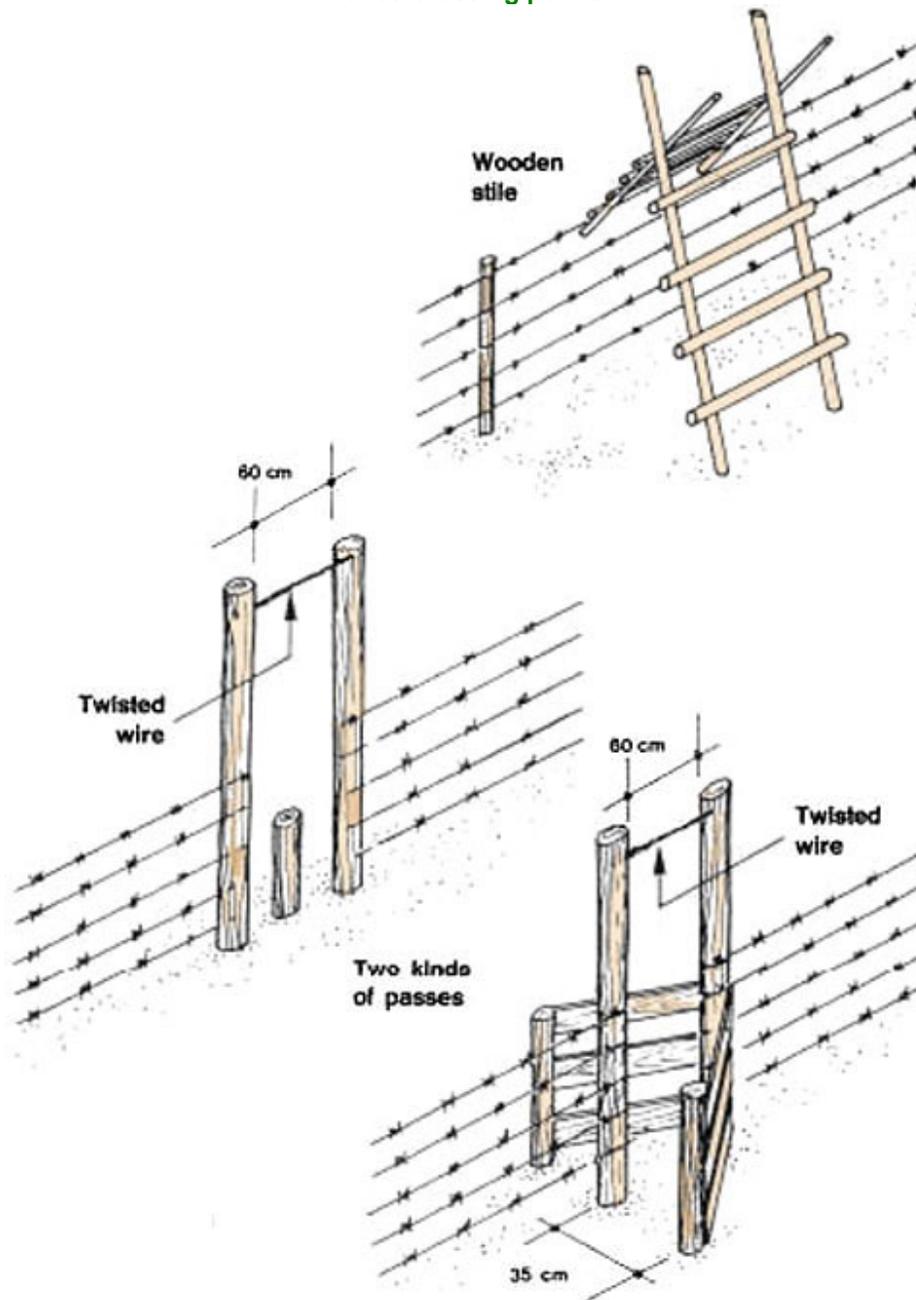




Reinforced gate



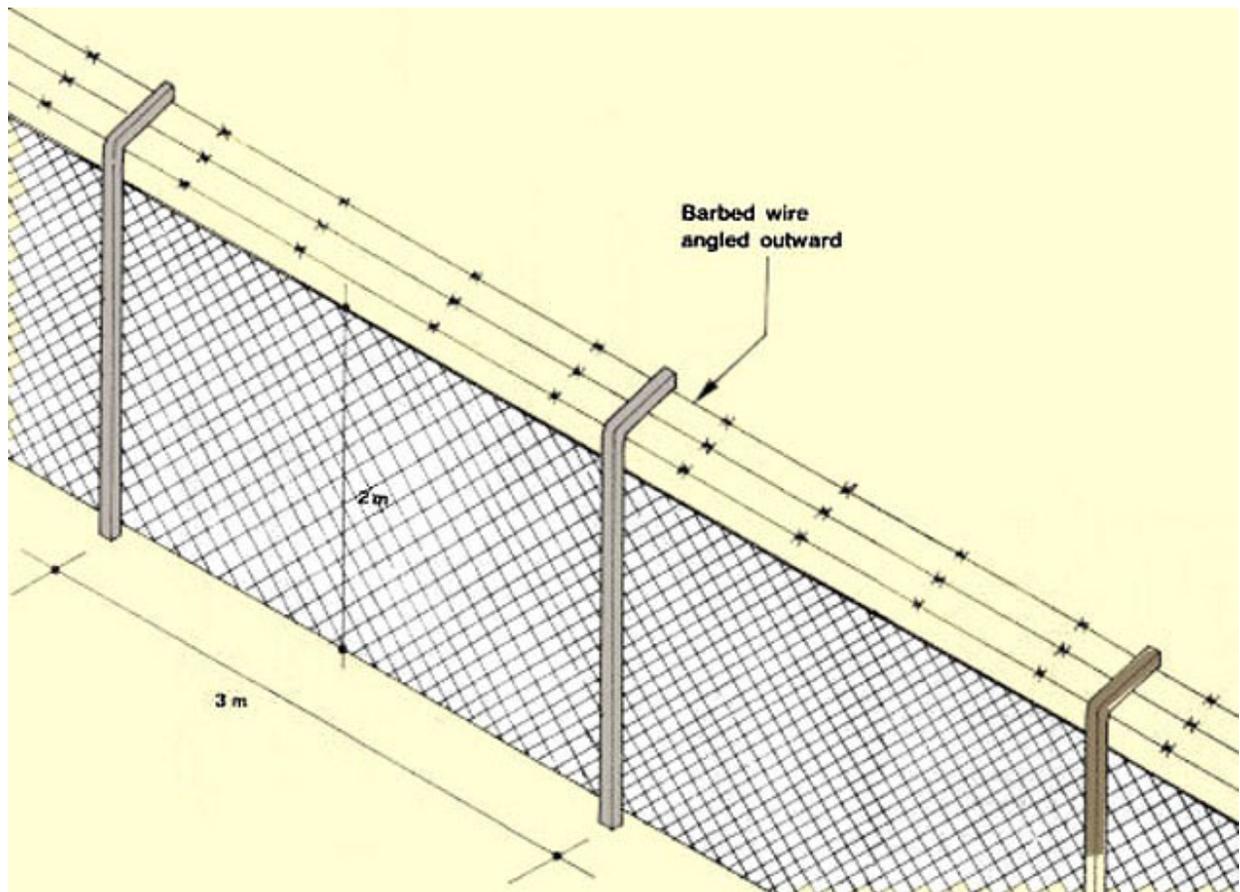
Fence-crossing points



Wire-netting fences

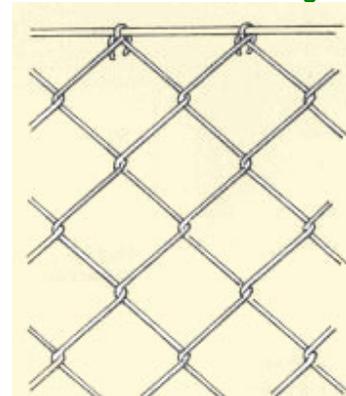
27. Wire-netting fences are primarily used on fish farms to stop intruders and to protect the fish stocks from theft. To be effective, these fences should be high, dense, sturdy and topped with barbed wire. They can be quite expensive and **their use should be limited** to enclosing particularly valuable stocks such as broodstock and heavily stocked fish kept in storage ponds before being sold.

Wire-netting fence



28. **Strong diamond-mesh netting**, about 2 m high and fixed to posts set 3 m apart, is commonly used for this type of security fence. Stays may be used for extra strength and barbed wire added at the top for increased efficiency. If possible, the barbed wire should be angled out to make access more difficult.

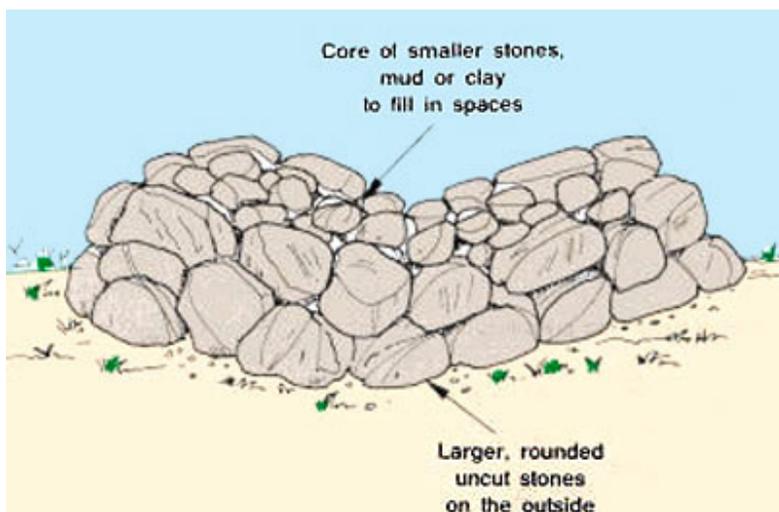
Diamond-mesh netting



Stone fences

29. **Whenever stones are plentiful**, a cheaper fence may be built by piling stones "dry" into a **wall** 0.7 to 1.2 m wide at the base. Although construction is labour intensive, maintenance costs are quite low. For extra security, short wooden posts can be built into the wall to carry some additional rows of barbed wire.

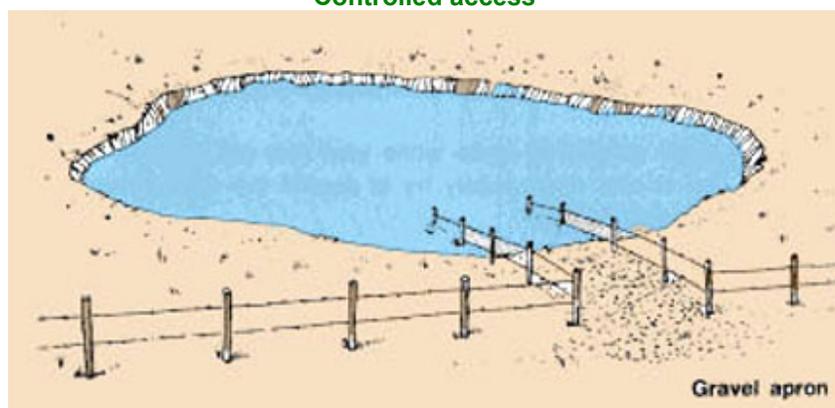
Stone wall



Providing controlled access for livestock

30. In some integrated farms, livestock should be given access to at least **one pond for drinking**. It is then best to limit access to **a small portion of the pond**, which should be well protected against erosion with gravel, concrete or asphalt. You can use fences, as described earlier, to restrict access.

Controlled access



4.6 Animal pest control in drained ponds

1. Farmed fish have many enemies and competitors, such as wild fish, frogs, insects and birds, from which they should be protected.

2. Protection is particularly important while the fish are still very small, for example still in nursery ponds. You can protect your fish in various ways.

(a) You can control the pests **after each complete harvest and before restocking the ponds**, the choice of method depending on whether:

- you **can drain** your pond completely (see this Section 4.6);
- you **cannot drain** your pond completely (see [Section 4.7](#)).

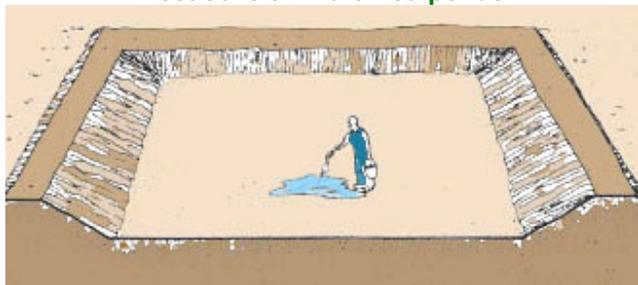
(b) **During each production cycle** while your fish are growing in the pond, you should continuously try to control the most dangerous pests (see [Section 4.8](#)).

3. Pest control in drained ponds, also called **pond disinfection**, has several objectives, namely:

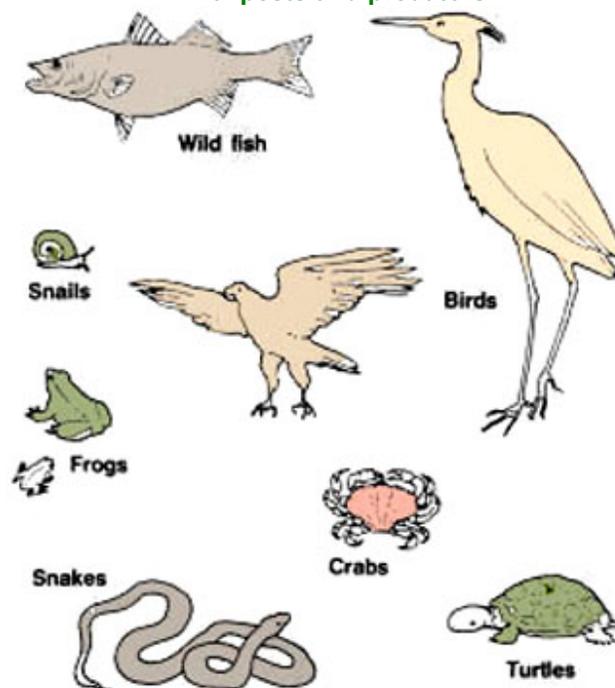
- to kill **aquatic animal predators**, such as carnivorous fish, juvenile frogs and insects left in the water puddles and in the mud, which would survive and feed on the young fish to be stocked;
- to eliminate all **non-harvested fish**, which later would compete with your new stock for space and food, especially if they reproduce without control;
- to destroy **fish parasites and their intermediate hosts**, such as snails, and thus help **control diseases** (see Chapter 15,).

4. Certain disinfection treatments have additional benefits such as improving water and bottom soil quality (see [Section 5.0](#)) or increasing the pond fertility.

Pest control in drained ponds



Animal pests and predators

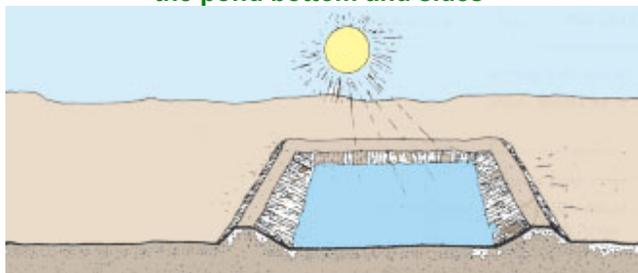


5. Earthen fish ponds are most easily disinfected **after their water has been drained** as thoroughly as possible, either by gravity for drainable ponds or by pumping for undrainable ponds. If necessary, **complete the draining** of remaining pools by deepening additional small trenches toward the main draining trench.

6. There are several ways to disinfect a drained pond. These are **usually combined** to give most reliable results.

(a) **Keep the pond dry** (preferably in warm, sunny weather). The ultraviolet rays of the sun have a powerful sterilizing effect. Depending on air temperature, keep the pond fully dry from 24 hours (at the minimum) to one month.

The ultraviolet rays of the sun help to sterilize the pond bottom and sides

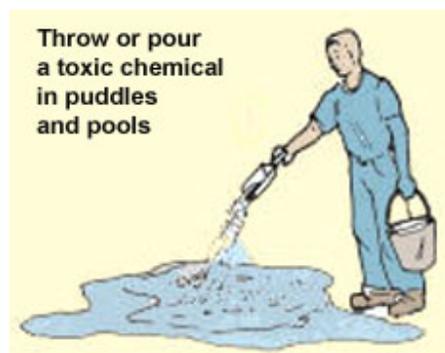


Duration of dry period according to air temperature

Air temperature (°C)	Minimum duration of dry period
30	24 hours
20	4 days
Less than 20	30 days

Note: you learned earlier how to keep a pond dry to improve water quality (see [Section 2.5](#)). Remember that **certain types of pond should not be kept dry for too long**.

(b) **Throw or pour a toxic chemical** (see below) **in water puddles and pools** remaining on the pond bottom. Let the chemical react for a few days. Common procedures are summarized in [Table 9](#).



(c) Spread **a toxic chemical uniformly on the wet pond bottom and sides**. Let the chemical react for two to three days. Slowly let just enough water flow in to cover the whole pond bottom with a shallow layer. Wait for 15 days. Then drain slowly, taking care not to cause fish to be killed downstream. Before final refilling, it may be necessary to rinse out your pond once.

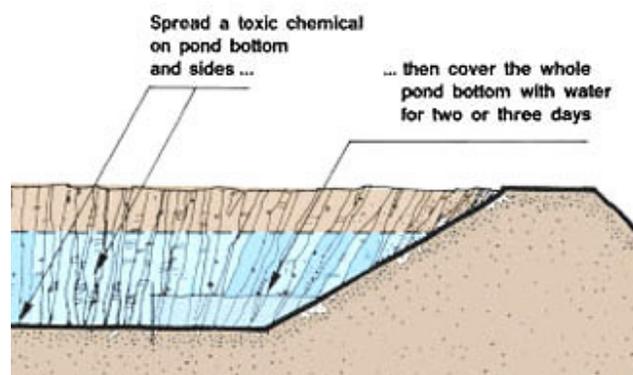


TABLE 9
Common disinfectants for totally drained ponds

	Doses		Remarks
	(g/m ²)	(kg/ha)	
QUICKLIME			Very caustic
Pond slightly muddy	100-200	1000-2000	Lumps or powder
Pond very muddy	200-300	2000-3000	Lime milk = 1 part + 4 parts water
HYDRATED LIME			Caustic, fine powder
Pond slightly muddy	160-300	1600-3000	To be freshly made
Pond very muddy	300-460	3000-4600	
CALCIUM CYANAMIDE			Highly toxic powder
Pond slightly muddy	100-150	1000-1500	Usually limited to treatment of small ponds
Pond very muddy	150-250	15000-25000	Rinse pond after use. Contains 60-70% CaO and 18-22% nitrogen
AGRO-INDUSTRIAL BY-PRODUCTS			To be used on flooded pond bottom or in puddles/pools, see Table 10 .

Note: for a thorough disinfection, it is best to treat the drained pond twice at eight- to 15-day intervals. Refill the pond ten to 15 days after the second treatment.

7. **Three chemicals are commonly used** for disinfecting drained earthen ponds (see [Table 9](#)):

- **quicklime**, CaO (calcium oxide), sold in lump or powder form; it is **extremely caustic** and should be handled with great caution (see below). Because of its lasting toxicity, **lumps of quicklime should be well crushed** before use, but uniform spreading remains difficult. **It is better to use lime milk, prepared when needed** by mixing one part of quicklime lumps with four parts of water;
- **hydrated or slaked lime**, Ca(OH)₂ (calcium hydroxide), a fine powder also to be used with caution because it contains at least 65 percent CaO (buy and use only if freshly made);
- **calcium cyanamide**, CaCN₂, a powder containing 60 to 70 percent CaO and 18 to 22 percent nitrogen; it is highly toxic for several months after its application. Particular care should be taken when draining the solution from the pond to avoid killing fish downstream. Rinse out the pond well before final refilling.

8. **Some agricultural by-products** can also be used to disinfect drained ponds cheaply whenever they are locally available, for example **rice bran** (400 to 1000 kg/ha), **crude sugar molasses** (400 to 500 kg/ha) and **tobacco dust** or tobacco **shavings** (300 kg/ha). Spread the required amount of by-product over the pond bottom. Flood with 5 to 10 cm of water for ten to 15 days. It is best not to drain the pond but to fill it up, so as not to lose the fertilizing effect of the organic disinfectant. Before stocking fish, check carefully on the dissolved oxygen content (see Section 2.5).

Note: before applying **tobacco dust or tobacco shavings**, it is best to **soak the sacks in water overnight**. This step will prevent the dust being blown away by wind during spreading on the pond bottom.

Taking precautions when handling dangerous chemicals

9. When using caustic and toxic chemicals, you should be very careful on your own behalf and on that of other people. Take the following precautions.

(a) Whenever possible, choose **a day without wind** to apply the chemical. If you have to do it on a windy day, progress in the direction of the wind, avoiding chemicals being blown over you or over others.

(b) **Fully protect skin and eyes** from contact with chemicals by using impermeable clothing, boots, goggles or glasses and a hat.

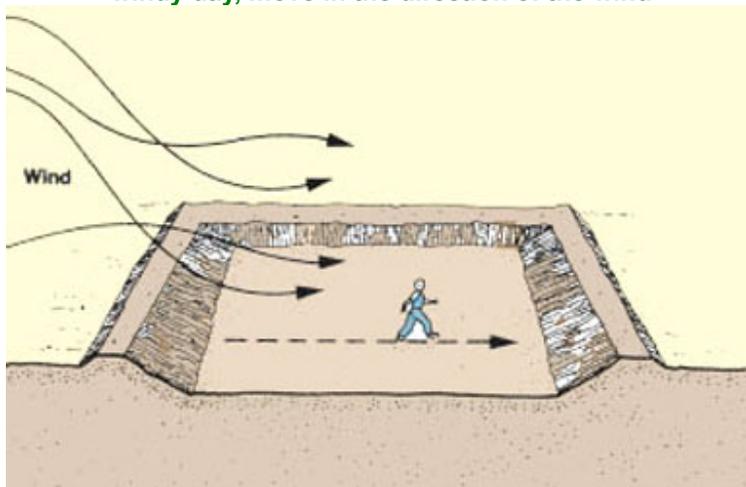
(c) **Avoid inhaling chemicals**. Protect mouth and nose with a piece of cloth.

(d) Thoroughly **wash your hands** before touching any food.

(e) Thoroughly **clean all equipment and clothing** when you have finished treating the pond.

(f) **Store all chemicals** so as not to present any danger to animal or human life, children in particular.

**When using caustic or toxic chemicals,
try to choose a day without wind but if you must do it on a
windy day, move in the direction of the wind**



4.7 Animal pest control in undrained ponds

1. **If the fish pond cannot be completely drained**, for example if it is undrainable or if there is no water available to refill it for the next production cycle, pests such as wild fish, frog eggs and tadpoles and snails should be controlled after harvesting the fish **by treating the water left in the pond**. In **nursery ponds**, voracious insects and even some **zooplankters*** should also be destroyed before restocking.

Controlling pests by treating the water

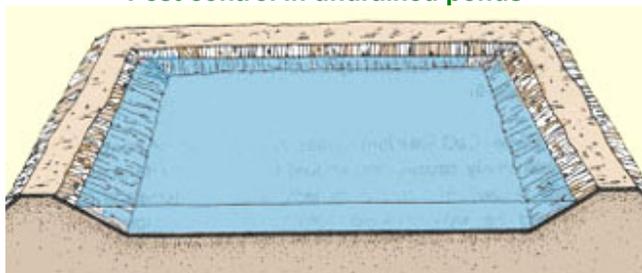
2. After harvesting your fish, proceed as follows to control the pests.

(a) **Lower the water level** as far as possible, keeping in mind that you will thereafter need water to refill the pond.

- (b) **Estimate the volume** (in m^3) **of water** present in the pond by multiplying its surface area (in m^2) by its average depth (in m) (see [Section 2.0, Water, 4](#)).
- (c) **Treat the water** with one of the products suggested in [Table 10](#), ensuring that it completely mixes with the pond water. It should kill all fish, frog eggs and tadpoles, snails and most insects.
- (d) After ten to 12 hours **collect the dead fish** with nets.
- (e) **Wait ten to 15 days** for the organic poison to break down and disappear.
- (f) **Stock a few fish**, preferably keeping them in a submerged net or a small cage to be able to watch them carefully.
- (g) If these test fish survive well and do not show any abnormal reactions, your pond is **ready for stocking**.

Note: Similar procedure is also used in addition to netting as a means of harvesting fish from undrainable ponds ([see Section 11.1](#)).

Pest control in undrained ponds



Applying powdered oilseed cake in an undrained pond

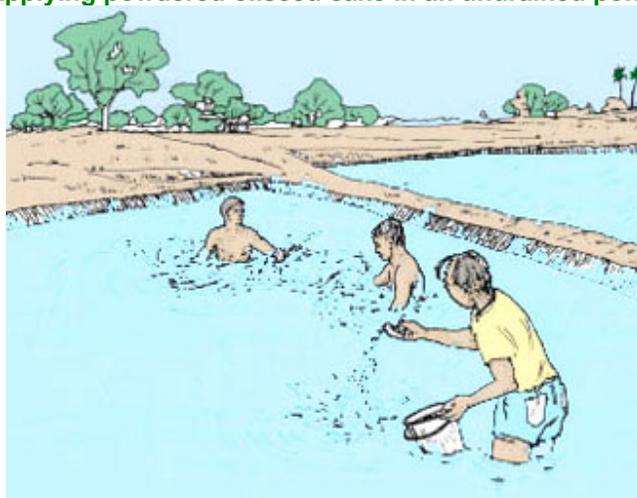


TABLE 10
Underwater pest control in ponds

Product	Doses
Quicklime	
little water in pond ¹	500-900 g/m ³
full pond ¹	200-250 g/m ³
Rotenone powder: usually 5% rotenone from <i>Derris</i> roots	20 g/m ³ ²
Saponin, pure glycoside from plant	2-5 g/m ³
<i>Derris</i> root: from <i>Derris</i> spp., tuba; roots contain rotenone	20-40 g/m ³
<i>Tephrosia</i> leaves: leguminous tree; leaves contain rotenone	500 g/100 m ²
<i>Barringtonia acutangula</i> : powdered seeds	20 g/m ³
<i>Croton tiglium</i> : powdered oilseed cake	5 g/m ³
<i>Milletia pachycarpa</i> : powdered roots	5 g/m ³
<i>Walsura piscidia</i> : powdered bark	10 g/m ³
<i>Bassia latifolia</i> : oilcake; mahua (India) ⁴	250 g/m ³
<i>Camellia</i> spp.: teaseed cake; 10-13% saponin ^{3,4}	50-70 g/m ³

- ¹ Additional benefit: liming of water, see [Section 5.1](#)
- ² Equivalent to 1 g pure rotenone
- ³ Makes pond water acid; best if followed by quicklime treatment (15 g) to improve water quality, see [Section 5.1](#)
- ⁴ Additional benefit: organic fertilization

3. Some of the products listed in [Table 10](#) require **processing before being used** in the pond:

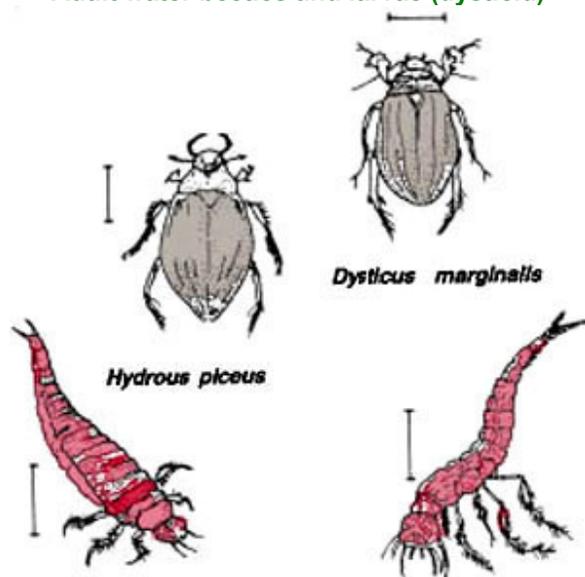
- (a) **Derris root**: select fresh, small roots. Cut into small pieces. Soak in water overnight. Pound, crush and squeeze to extract rotenone; dilute and mix with water in pond.
- (b) **Teaseed cake**: dry and finely grind the seeds. Let them soak in lukewarm water for 24 hours. Dilute and mix with water in pond.
- (c) **Rotenone or saponin**: mix the total required amount in water. Treat the pond while keeping this solution well mixed.

Controlling insects and zooplankters in nursery ponds

4. Several **aquatic insects** such as water beetle adults and larvae, dragonfly nymphs and adult water bugs can attack and destroy many fish fry in your nursery ponds. Most aquatic insects are also competing for the food necessary for your small fish to grow. Some of the largest **zooplankton species** may also harm very young fish fry. You should protect them from these enemies by:

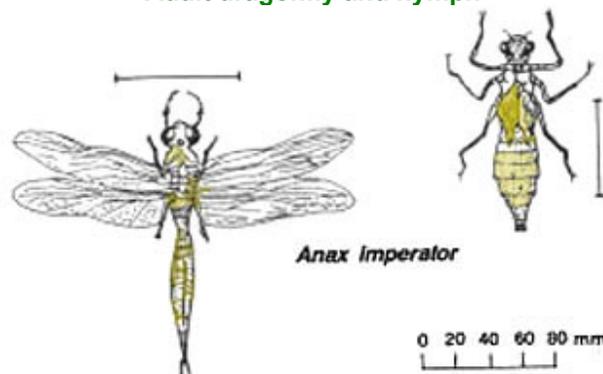
- keeping grassy **ditches clean** in the farm neighbourhood;
- **refilling your nursery pond with water** not more than two weeks before stocking, if it has been drained completely;
- **treating the water** of the nursery pond to eradicate insects and sometimes zooplankters, as described in items 5 and 6 following.

Adult water beetles and larvae (dysticid)

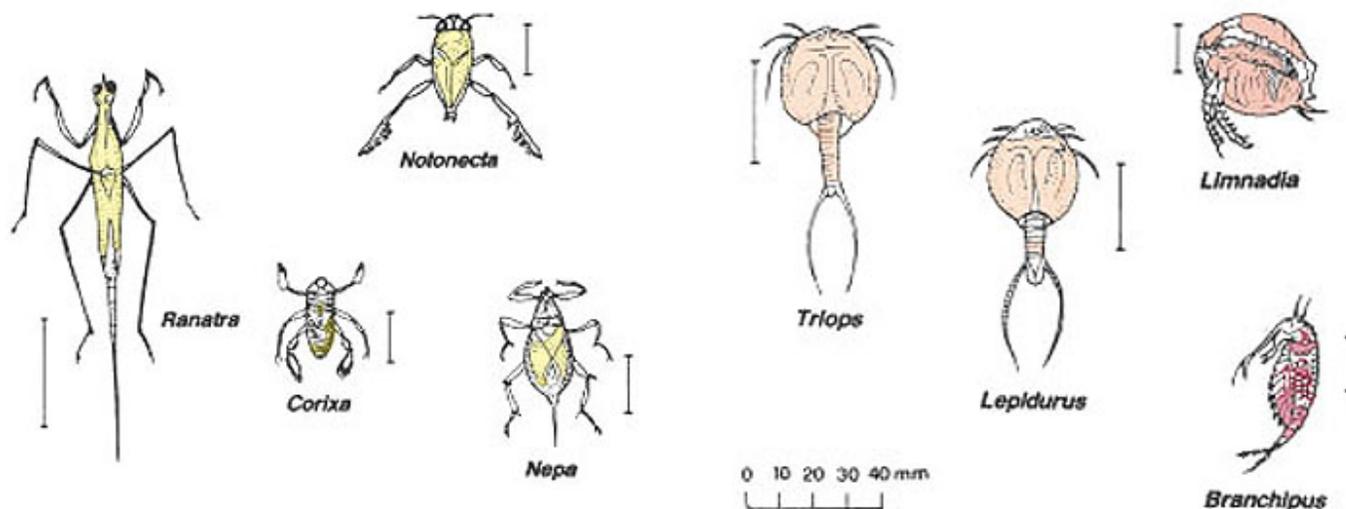


Adult water insects

Adult dragonfly and nymph



Small crustaceans (zooplankton)



5. To eradicate aquatic insects which have to come to the water surface to breathe air, such as the most harmful *Notonecta*, *Nepa*, *Ranatra* and dysticid species, proceed as follows.

- (a) Clear all the vegetation from the pond. Cut the grass short on the wet dike slopes.
- (b) Three to four days before stocking, slowly drag a fine-mesh net through the water to capture as many insects as possible and destroy them.
- (c) Preferably on a calm, dry day but 12 to 24 hours before stocking, spread a thin layer of an oily substance on the water surface (see Table 11).
- (d) Keep this layer undisturbed for at least two hours. If necessary, keep spreading more oily substance so as to keep the layer unbroken over the whole pond surface.

Note: the more wind there is, the more oily substance you will require and the less effective the treatment might be.

Dysticid larva and adult breathing at water surface

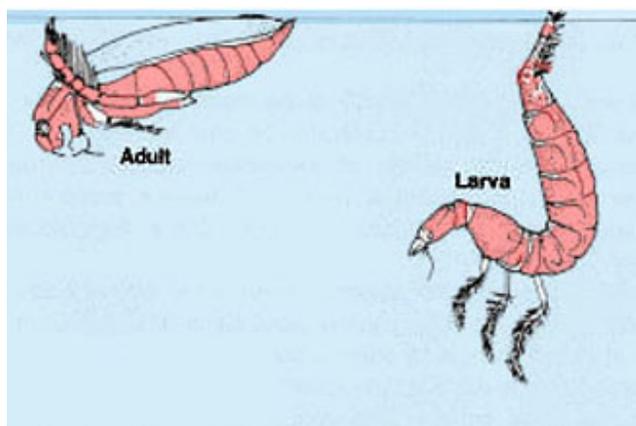


TABLE 11
Control of surface-breathing aquatic insects

Substance	Average dose per 100 m ²
Diesel oil, high-speed quality	250-500 ml
Mixture 5:1 of diesel oil/used motor oil	250-500 ml
Mixture 4:1 of diesel oil/cottonseed oil	250-500 ml
Paraffin oil, kerosene or kerdane	200-400 ml
Mixture 3:1 of mustard oil/soap powder ¹	750 g
Mixture 3:1 of coconut oil/soap powder ¹	750 g

¹ Detergent or soap powder strengthens the floating layer

6. **To eradicate all aquatic insects together with large zooplankters**, you will have to buy special agricultural chemicals. Most of these are organophosphates, **commercial insecticides** such as Baytex, Dipterex, Dylox, Flibol, Fumadol, Masoten and Sumithion. The last is particularly useful as it is toxic to insects, copepods and cladocerans but is not so toxic to small zooplankters such as rotifers ([see Section 10.1](#)), the natural food of very young fish. Proceed as follows.

- (a) Calculate **the volume (in m³) of the water** present in the nursery pond. The pond should preferably be only half full.
- (b) Measure **the total quantity of insecticide required** for treating the water volume. According to the kind of chemical you are using, the amount can vary from 0.25 to 3 g/m³. Check the calculations of water volume carefully.
- (c) **Dissolve** this weight of insecticide into 10 to 20 l of water.
- (d) **Apply this solution evenly to the pond** either directly from the banks if it is small enough, or from a boat if it is larger.
- (e) **Wait four to five days** before stocking the pond with young fry. This will give time for the small-sized zooplankters to develop well again.

4.8 Animal pest control in stocked ponds

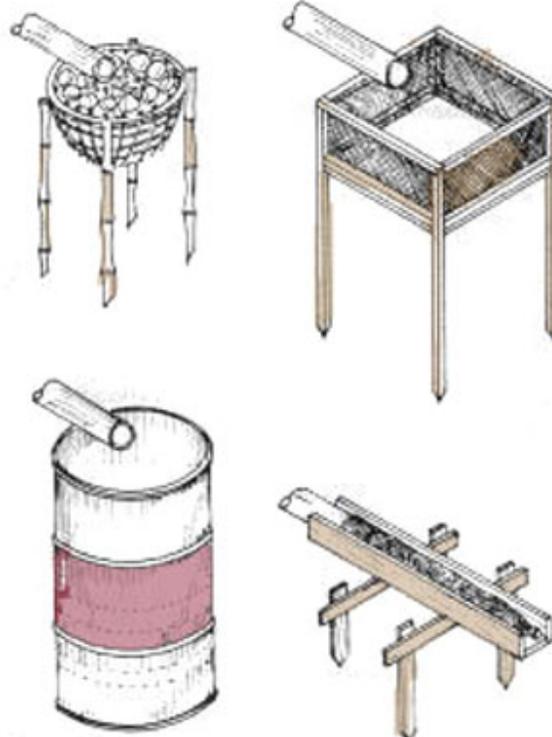
1. Once fish have been stocked in ponds, they should be protected as much as possible against **predators** such as carnivorous fish, frogs, turtles, snakes, birds and mammals. **Theft of fish** by people may also require preventive measures.

Controlling wild fish

2. Once a pond has been treated for the extermination of all unwanted fish (see Sections 4.6 and 4.7), it should be protected from being reinfected through the water supply, through the use of one of the filtering devices described earlier ([see Section 2.9](#)).

3. These filtering devices are particularly important for breeding and nursery ponds.

Water filtering devices



Trapping water turtles

4. Build a simple turtle trap as follows:

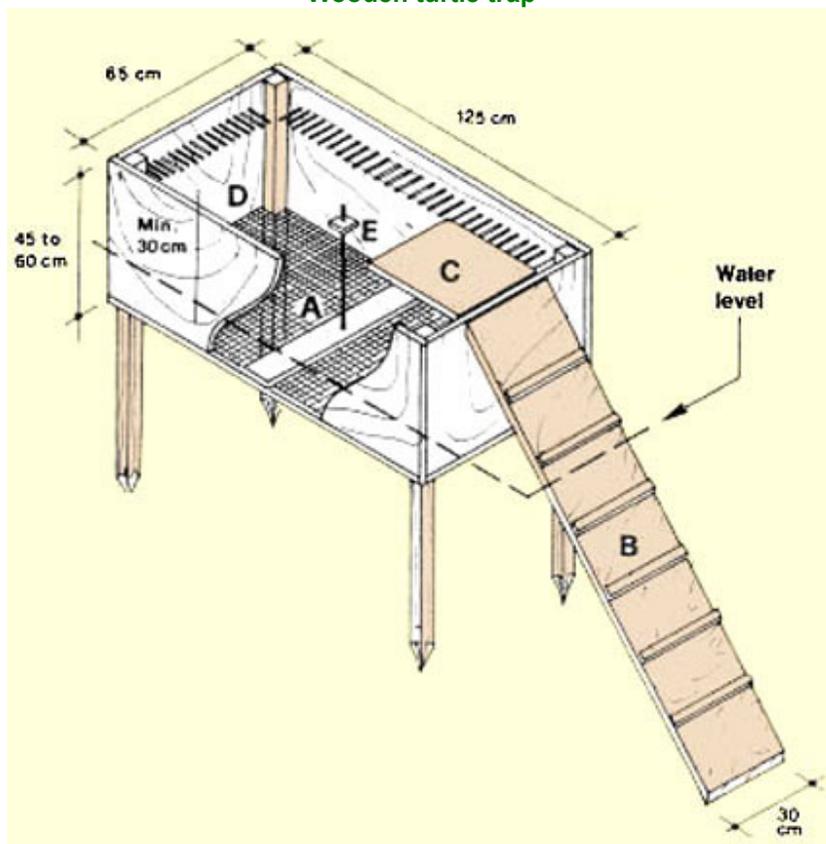
- (a) Assemble a **square wooden frame** made of four boards. Add **four legs**. The frame should be high enough so that at least 30 cm of it will be above water level in the shallow part of the pond.
- (b) Add a bottom made of wire mesh or chicken wire.
- (c) Anchor the trap well in shallow water.
- (d) Place a slanting board on the outside of this frame, leading from the pond bottom to its top edge. This will serve as a ramp for turtles.
- (e) Fix another board at the end of the slanting board to tip inside the frame when weight is put on it. If you use spring hinges, the tip board will return to the upright position after a turtle has fallen into the trap.
- (f) All around the upper edge of the frame, drive in a row of nails fairly close together and bend them slightly down.
5. **Bait the trap at its centre** with fish or meat. Any turtle climbing up one of the slanting boards and crawling on to the tip board should fall into the trap.

Trapping water snakes

6. A simple cylindrical trap, 25 cm in diameter and 70 cm long, can be made with fine metal netting. The two end openings are closed with funnels, one of which can be easily removed.

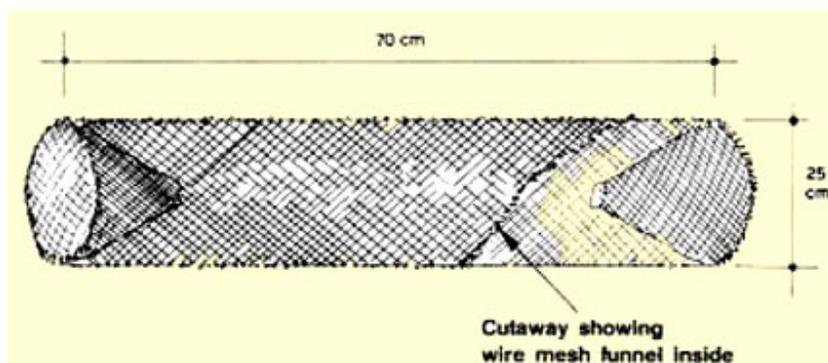
7. Install several traps **close to the area where the young fish are fed**. Half of the trap should be kept under the water surface. Bait the traps with dead fish or frogs and check them every day.

Wooden turtle trap



- A Wire mesh or chicken wire
- B Turtle ramp
- C Tip board
- D Row of nails
- E Bait post

Wire mesh snake trap



Controlling frogs

8. Frogs are equally harmful in breeding and nursery ponds, where some species such as *Xenopus* actively feed on young fish; in addition, tadpoles compete for food.

9. Frog control is not easy and seldom completely successful. **To reduce the population** as much as possible, try the following regularly.

(a) **Catch tadpoles**, either with a scoop net or a lift net. Use the lift net over a feeding trough where the tadpoles accumulate, or bait the net itself with some food to attract tadpoles. A lift net can be attached to a movable post, which can be taken from place to place around a pond or from pond to pond.

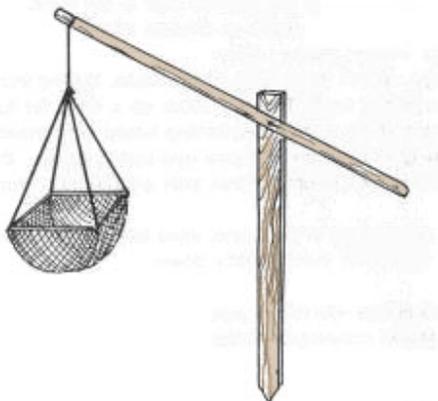
(b) **Trap adult frogs**, especially *Xenopus*, in baited wire traps set along the pond banks. This is similar to the wire trap shown for snakes above.

(c) **Fence those ponds** that need particular protection using a material over which frogs cannot climb, such as plastic or corrugated metal sheets. Such a protection should be at least 50 cm high.

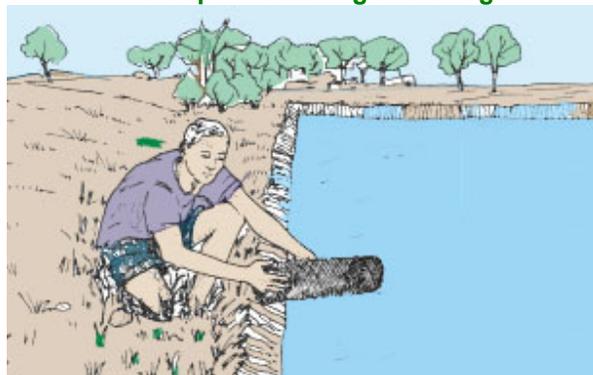
Scoop net for catching tadpoles



Lift net for catching tadpoles



Wire trap for catching adult frogs



Protecting against birds

10. Several kinds of bird are fond of fish, for example kingfishers, herons, fish eagles, pelicans and cormorants. In shallow ponds and wherever fish are concentrated, the damage and losses incurred can be considerable.

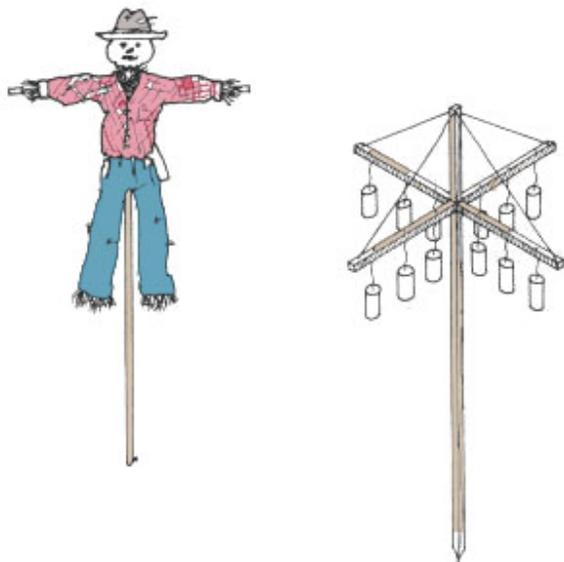
11. There are several ways to protect **particularly vulnerable areas** of the fish farm, such as broodstock, breeding, nursery and storage ponds. Those most commonly used are:

- **scaring devices** installed next to or inside the ponds, such as scarecrows, bamboo raffles, empty-can rattles, pieces of mirror on string, or flags;

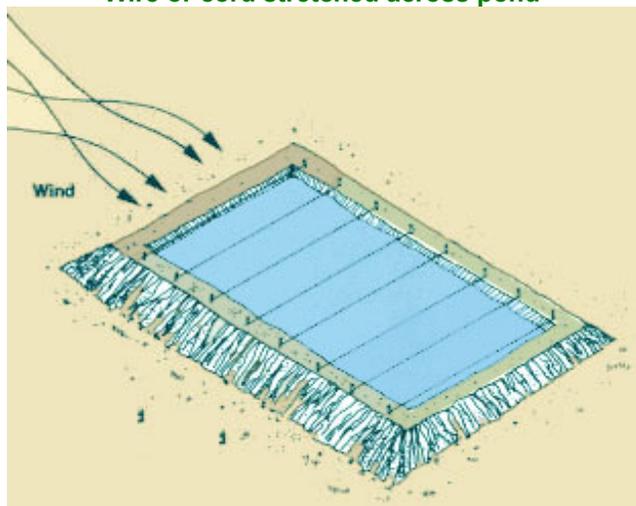
- **thin wires** or strings stretched across the ponds and perpendicular to prevalent wind to keep the flying birds from landing on, sweeping over or diving into the ponds. On small ponds, stretch wires or strings 50 to 70 cm apart, on larger ponds, up to 8 to 15 m apart; attach streamers to the wires;
- **fencing the shallower parts** of the ponds or stretching thin wires about 50 cm above water level and 50 cm offshore to keep out wading birds;
- **covering the ponds** with netting material.

12. One of the best deterrents is **human activity** near the ponds. If you live on your fish farm you will have far fewer problems than if your ponds are completely isolated.

Straw scarecrow or empty-can rattles set in the water



Wire or cord stretched across pond



Controlling harmful mammals

13. Aquatic mammals can be harmful in two ways:

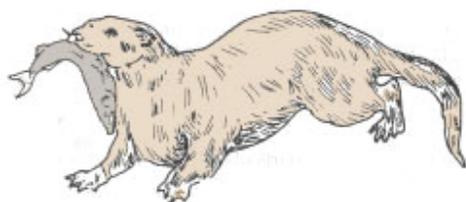
- some, like **otters**, can be active predators;
- others, like **muskrats**, can seriously damage pond dikes by digging long burrows above water level.

14. Apart from fencing, which might be expensive, the most effective control is obtained by:

- **trapping**, using specially designed traps; and
- **poisoning**, using poisoned baits.

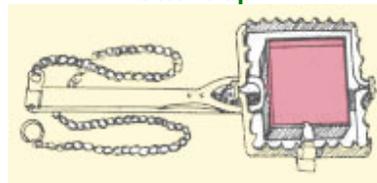
15. Action should be taken as soon as it has been discovered that an animal has become active on the farm itself or in the neighbourhood.

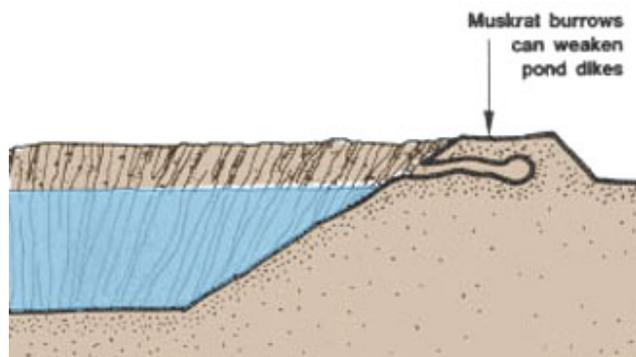
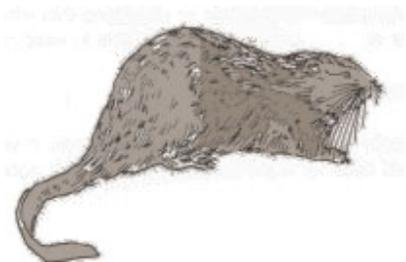
Otter with fish



Muskrat

Otter trap





Preventing theft

16. Theft of fish caused by people is unfortunately rather common on fish farms, particularly if the ponds are isolated and far away from housing.

17. As you learned earlier in Section 4.5, a good **security fence** is expensive. Its use should be limited to the protection of the most valuable fish stocks, such as broodstocks and food fish held ready for marketing.

18. To protect a fattening pond from **poaching with nets** such as **seine** or **cast nets** (see Sections 8.2 and 8.3), you can use one of the following simple ways.

(a) Throw **bamboo, stripped of leaves, with plenty of lateral branches** into the pond, particularly along its banks.

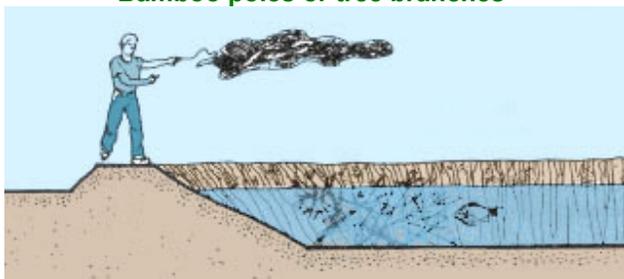
(b) Take a young tree and cut off all its branches, leaving 10 to 15 cm close to the tree trunk. Cut off the tip of the tree down to where the stem is about 15 cm thick. Cut this end into a point and drive the **tree upside-down** about 50 cm deep into the pond bottom. Repeat for several trees, placing some at 1.5 to 2 m from the banks and others in the rest of the pond area.

(c) **Make some hooks** about 60 cm long from iron rods and set them into old metal containers filled with concrete. Sink these devices into your pond at various locations.

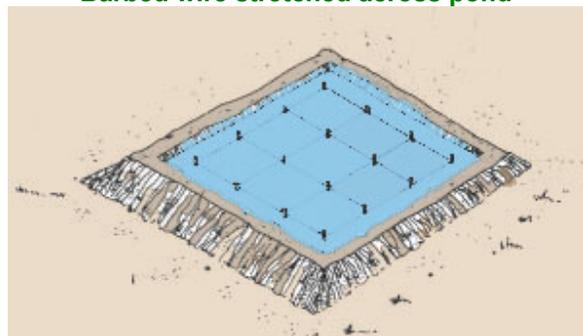
(d) Install a series of **wooden stakes** in the pond bottom. Join them with **barbed wire** or simply secure a few layers of barbed wire around the head of each stake.

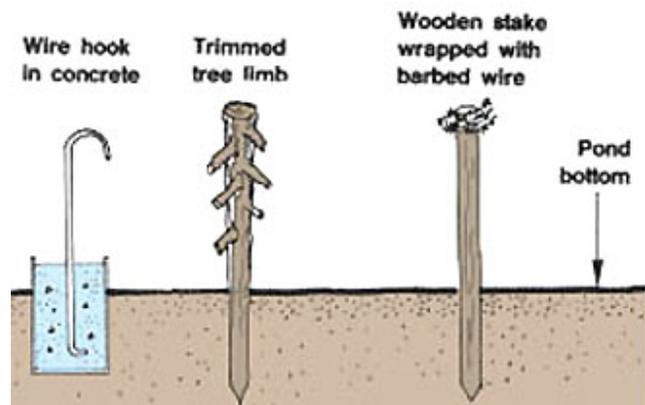
19. It is usually difficult **to steal fish by draining a pond**, unless it is unguarded for long periods of time. Avoid the risk, and avoid loss of water caused by someone tampering with **the outlet structure**. Make access to monks and pipes difficult, by removing valve handles and, if necessary, putting locks on monk and sluice boards.

Bamboo poles or tree branches



Barbed wire stretched across pond





4.9 Aquatic vegetation control in fish ponds

Introduction

1. Aquatic vegetation may exist in various forms and is usually classified as floating, submersed or emersed plants. A small growth may not be harmful but, if it becomes excessive, it may result in adverse effects on fish pond management. **Vegetation control** then becomes necessary for several reasons:

- Vegetation absorbs too many **nutrients** from water and bottom mud.
- It reduces **sunlight penetration** into the water, reducing **photosynthesis** (see [Section 2.0](#)).
- It provides refuge for the **enemies and competitors** of fish.
- It makes **the pond bottom too rich** in cellulose fibres, slowing down the decomposition of mud.
- It may greatly hamper **the harvesting** of farmed fish.

2. Vegetation should be controlled regularly as part of **routine pond management**. It is cheaper to weed out vegetation before it becomes excessive. Natural food production and sanitary conditions will be improved as a result.

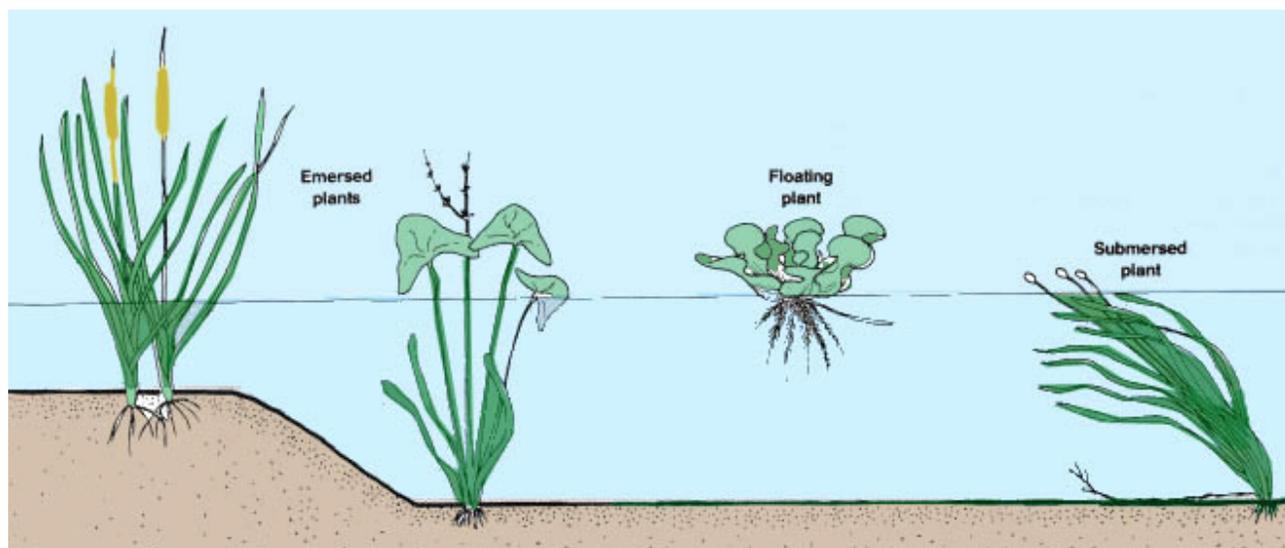
Remember: a fringe of emersed plants can be useful for protecting dikes exposed to the wind (see [Section 4.3](#)).

3. There are **three** ways to control aquatic vegetation:

- **biological methods**, using specific animals;
- **mechanical methods**, by hand or with the help of equipment;
- **chemical methods**, based on the application of specific chemicals.

4. As far as possible, you should choose biological or mechanical methods. **Chemical methods should be restricted** to situations where the other methods cannot be applied, for example because of high cost of labour or large farm size.

Various kinds of aquatic vegetation



Controlling aquatic vegetation biologically

5. Some herbivorous fish can be effectively used to control many kinds of plants, for example:

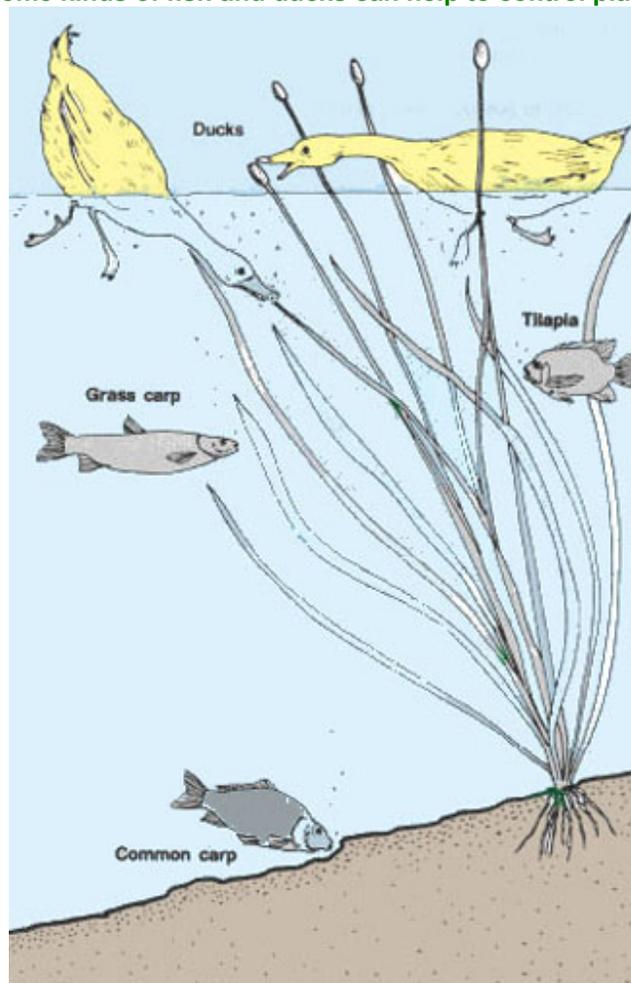
- Chinese grass carp (*Ctenopharyngodon idella*): use 100 to 200 g fish at the average stocking rate of 1.5 to 2 kg per 100 m² of water surface;
- *Puntius gonionotus*: usually stocked as fingerlings, 10 to 20 g at 2 to 5 kg/100 m²;
- *Tilapia rendalli* and *Tilapia zillii*: stocked as fingerlings of 10 to 20 g at 2 to 5 kg/100 m², or as larger fish (at least 50 g) at 1 to 2 kg/100 m².

6. Provided they are not too hard, most submersed, floating and even emerged plants are eaten by these fish. The bigger the fish, the larger and harder the plants they can usually control.

7. Some fish, such as the **common carp**, can indirectly control vegetation growth by digging the bottom mud for food and increasing the water turbidity. It has been observed that at least ten fish of 250 g or more each are necessary per 100 m² of water surface. A similar result may be obtained through **water fertilization**, which will increase plankton turbidity (see Section 6.0).

8. **Ducks** can also help to control submersed vegetation in the shallower parts of ponds while searching for food (see Section 7.3). They also feed on some floating plants such as duckweed, *Lemna* sp.

Some kinds of fish and ducks can help to control plants



Controlling aquatic vegetation mechanically

9. **Hand clearing** of aquatic vegetation is probably the most common method used. It can be most effective in smaller ponds, especially if carried out in drained ponds just before they are refilled.

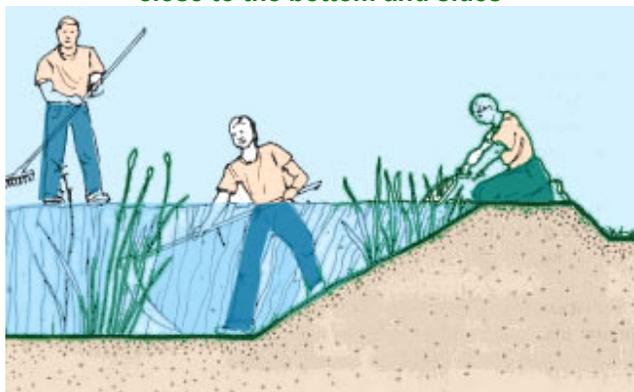
10. It is best to **pull out rooted plants** entirely. With some strong emerged species such as reeds and papyrus, this is not always possible.

11. If the roots of the plant are too strong to pull, cut them as close to the ground as possible when the pond is dry or after the water level has been lowered. The pond should be refilled as soon as possible thereafter

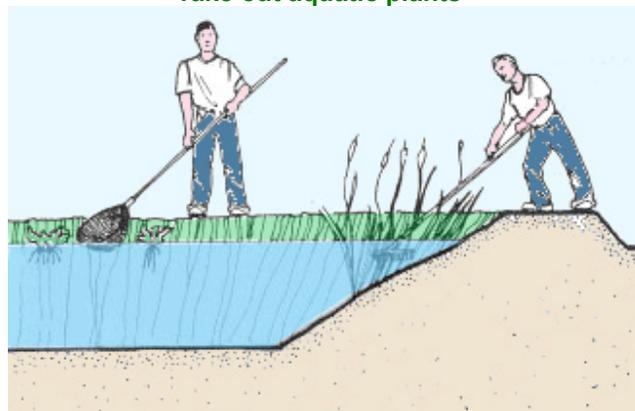
12. In small ponds, **filamentous algae** and **non-rooted floating plants**, such as duckweed, can be pulled out using a perforated scoop fixed at the end of a long pole. **Loosely rooted vegetation** can be removed with hand rakes or a hook attached to a heavy rope.

13. The detached vegetation should always be **removed from the pond** to prevent further sprouting and to avoid any accumulation of decomposing organic matter which might cause dissolved oxygen deficiency (see [Section 2.5](#)). Such plant material can be most usefully [Section 2.5](#). Such plant material can be most usefully **recycled into organic fertilizer through composting** (see [Section 6.4](#)). When this plant material is dry enough, it is sometimes preferable **to heap and burn it** in the drained pond. The ashes can then be spread over the pond bottom.

In drained ponds, cut strong-rooted vegetation close to the bottom and sides



In undrained ponds, scoop out or rake out aquatic plants



Controlling aquatic vegetation chemically

14. Several commercial chemicals are known to control algae (**algicides**) or higher plants (**herbicides**), in particular emerged and floating species. The control of submersed species is much more complicated, especially in full and stocked ponds.

15. **The control of algae and algal blooms** is best done with **copper sulphate** (CuSO_4), a very effective and cheap algicide which can be safely used in stocked ponds if the total alkalinity of the water is sufficiently high. For best results, remember the following points:

(a) Determine **the total alkalinity** of the water (see [Section 5.0](#)). If it is higher than 50 mg CaCO_3/l you can treat the pond in the presence of fish. If not, you have to harvest the fish first.

(b) Determine which **type of algae** are to be controlled:

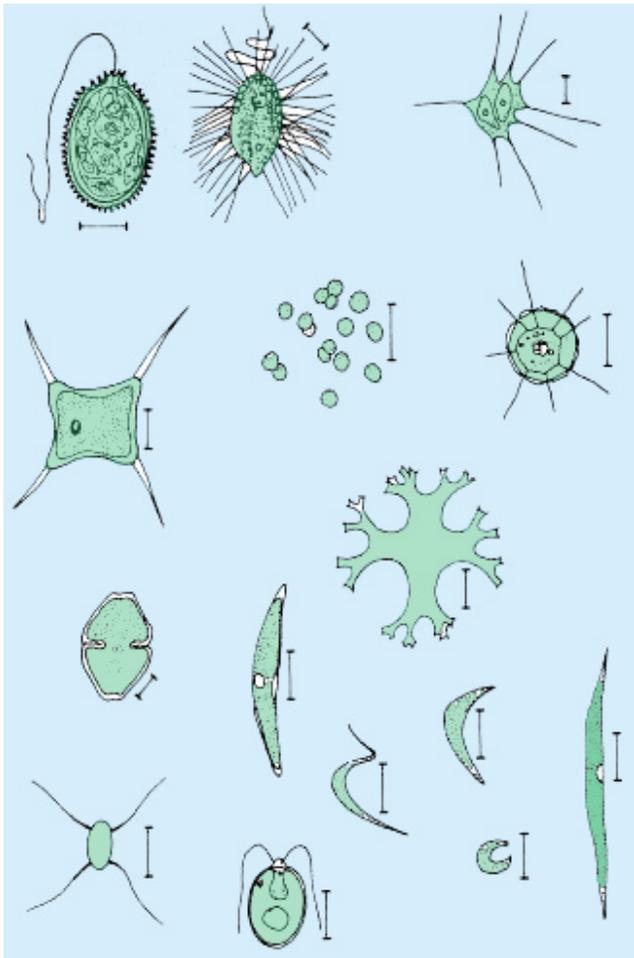
- for a microscopic **unicellular species** or **a larger colonial species**, use an average dose of 0.1 to 0.3 g of copper sulphate per m^3 of water;
- for a **filamentous or multicellular species** such as *Spirogyra*, *Anabaena*, *Oscillatoria*, *Chara* or *Nitella*, you will require higher doses of copper sulphates. Proceed according to [the chart below](#).

Note: the bar scales adjacent to all examples of cellular, colonial and filamentous algae shown below are equal to **ten micrometres**, with the exception of the plant-like filamentous algae where the bar scales are equal to **one millimetre**.

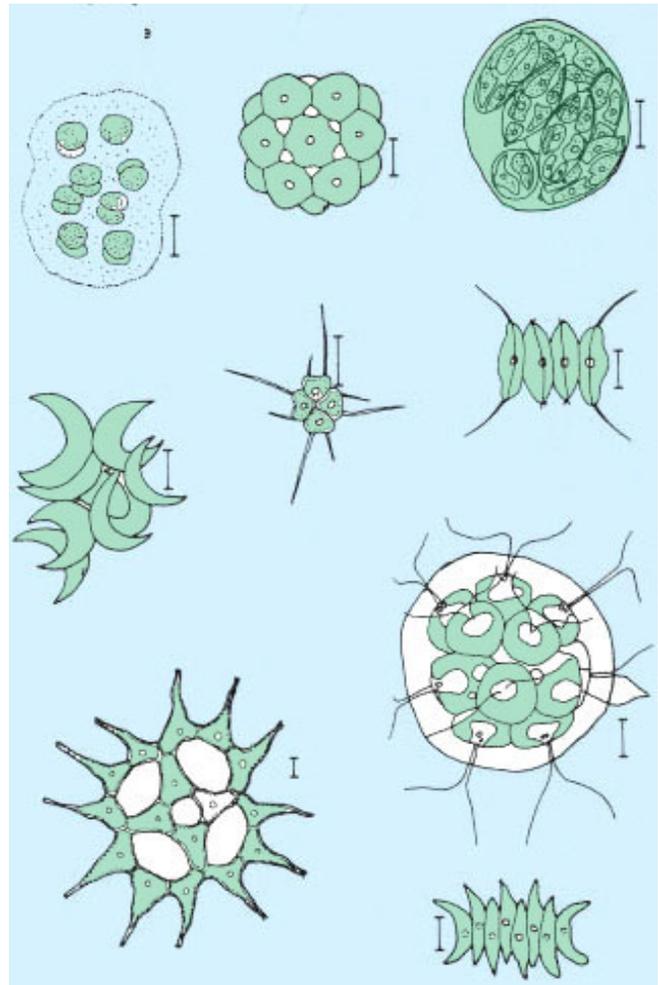
Remember: 1 micrometre (micron) = $1\mu\text{m}$ = 0.001 mm or one thousandth of a millimetre.

Examples of unicellular algae

Examples of colonial algae

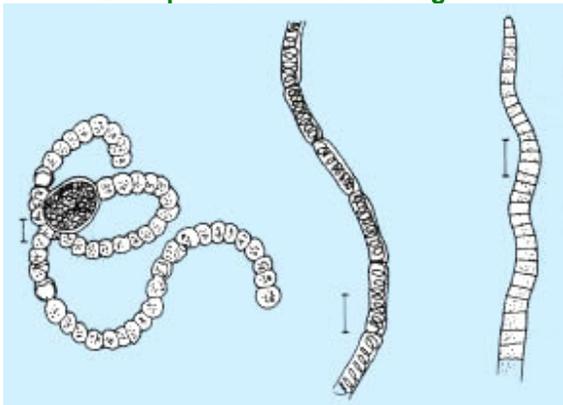


Note: bar scales = 10 µm



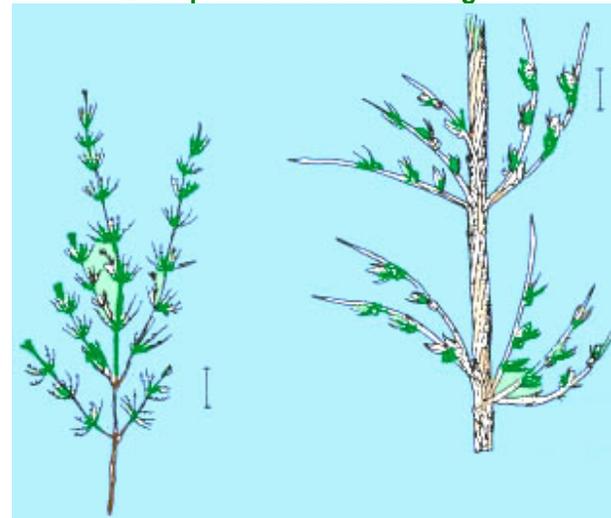
Note: bar scales = 10 µm

Examples of filamentous algae



Note: bar scales = 10 µm

Examples of multicellular algae



Note: bar scales = 1 mm

Control of filamentous algae with copper sulphate

Water total alkalinity (mg CaCO ₃ /l)	Treatment
Lower than 50	Do not treat in the presence of fish During their absence, use an average dose of 0.5 g/m ³
50-100	Treat with caution in the presence of fish using an average dose of 0.5 g/m ³

100-200	Treat at the average dose of 0.5-1 g/m ³
200-400	Treat at the average dose of 1-2 g/m ³
Higher than 400	Do not use copper sulphate for control

Note: 1 g/m³ = 1 mg/l

(c) **If fish are stocked**, it is safer **to treat only one-third or one-half of the pond surface** at any one time, particularly if the total alkalinity of the water is low or if you are using concentrations higher than 1 g/m³.

(d) It is most important **to determine carefully the volume of water to be treated (see Water, 4)**.

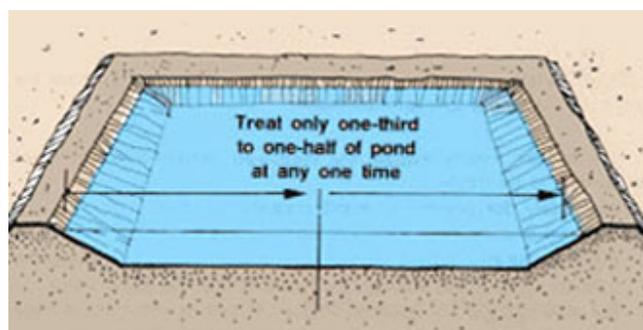
(e) Whenever possible, choose **a dry, calm day** for the treatment.

(f) It may be necessary **to repeat the treatment** after a few weeks.

(g) After the treatment and the killing of the algae, carefully **watch for any sign of dissolved oxygen deficiency** and take appropriate action (see Section 2.5).

(h) Copper sulphate is a poison. **Handle and store it with care.**

16. If possible, test the dose of copper sulphate you plan to use on some of your fish in two to three plastic or glass containers filled with pond water, before treating the stocked pond. Observe the behaviour of the fish over 24 to 36 hours (**see also Section 15.3**).



17. Copper sulphate exists in two forms, powder or crystal. **To treat the pond**, use one of the following methods.

(a) **For powder**, evenly distribute the required amount over the water surface to be treated.

(b) Alternately, **for powder or small crystals**, completely dissolve the required amount in 10 to 20 l of lukewarm water and evenly apply this concentrated solution to the water area to be treated. Keep the solution well mixed. Ensure good mixing with the pond water.

(c) **For crystals**, put the required amount in one or more **small bags** made of mesh material, such as netting. Attach these bags to a **floating support**. Distribute the chemical in the pond area to be treated as evenly as possible by moving the float back and forth over this area. You may use:

- in small ponds, one inner-tube;
- in medium-sized ponds, two inner-tubes connected by a wooden support;
- in larger ponds, a boat with the bags attached over the sides.

18. **The use of herbicides to control aquatic higher plants** is a much more delicate matter. The success of the herbicide depends on the choice of the most suitable chemical mainly in relation to the kind of vegetation, the time of the year, the fish species present, the treatment method to be used and the care with which it is applied. In fish farms, herbicide treatment should only **be carried out by competent and skilled personnel**.

Distributing copper sulphate crystals

