Soil and Water Conservation

Farmer-to-Farmer Participatory Training Course

Objectives

- Recognize the importance of preventing soil erosion and preserving water resources
- Learn strategies of how to preserve soil and efficiently manage water
- Appreciate the need for short and long term conservation measures in farm planning

Soil and Water Conservation

Soil Erosion

How does soil erosion affect crop productivity?

Most organic matter is located in the topsoil along with approximately 50 percent of plant-available phosphorus (P) and potassium (K). Losing topsoil to erosion, therefore, contributes to a loss of valuable nutrients and will cause yields to decline over time. Applying more fertilizer can replace these lost nutrients, but the organic matter, which a lack of can cause water stress on crops, is more difficult to replace. To maintain your yields keep your soil in place. To increase your yields keep your soil in place and build up your soil organic matter levels.

What are the two natural factors that cause soil erosion?

Water erosion: In north Central China, water erosion is generally worse in the summer when summer storm events occur. Intense rains that have not been captured within the landscape can create torrents of water which erode surficial soils. This can result in the forming of deep gullies.

Wind erosion: This type of erosion is often worse in the winter and early spring when the soils are dry and barren and wind speeds are high.

What factors contribute to water erosion?

- ***Length of slope:*** the longer the slope, the more chance the water has to build up and disperse soil particles.

- ***Steepness of slope****:* the steeper the slope, the more energy the water has to wash out soil from the ground surface.

- ***Lack of surface cover****:* surface residue intercepts rain droplets and slows down water moving across the field (surface residues act on water in a similar way that windbreaks slow down the wind).

- ***Soil Type****:* Certain soils are more prone to erosion. For example, silty soils are particularly vulnerable to water erosion especially when water pools on the surface. Loess soil is particularly susceptible.

- ***Soil Infiltration****:* The rate of water that permeates through the soil can greatly affect the occurrence of water erosion. If water cannot infiltrate into the soil very easily, water will pool on the surface and is more likely to wash away surficial soil. Factors that affect infiltration include:

- ***Soil type:*** Explain
- ***Organic Matter:*** Explain
- ***Tilling:*** Destroys soil structure and passageway

What factors contribute to wind erosion?

- ***Wind Speed:*** the more velocity the wind has, the more potential it has for displacing and picking up soil particles

- ***Length of field****:* the larger the field, the more potential for high wind speeds and the less potential for soil to be trapped in the landscape

- ***Erosive nature of the soil****:* when fine soils dry out and are excessively tilled they are highly prone to erosion

Soil Conservation

What farming practices can reduce wind and water erosion?

1. Water Erosion Prevention Practices

Contour farming: contour farming reduces the steepness of the slope and the length of the slope by creating even terraces. It also encourages farmers to till perpendicular (across) the slope. This will increase water infiltration.

Direction of tillage: tilling across the slope to help trap water in the field and reduce the volume and velocity of water running down the field

Reducing tillage: minimizing the amount of tillage on the field

Check Dams: check dams help trap the sediment suspended in runoff waters, slow down the velocity of runoff water and increase water infiltration in the landscape.

ACTIVITY: Field Trip

Show farmers how to make and use an A-frame, and how to lay out contour lines across a field.

2. ***Wind Erosion Prevention Practices***

Windbreak: Windbreaks help reduce the wind-speed of the air that passes through the field. The best windbreak has 50% porosity and is planted across the direction of the predominant wind (50% porosity means when you look at the windbreaks from the side 50% of the space is covered by stems, leaves and branches and 50% is open for air flow). Solid windbreaks are not as effective as they deflect wind and it can lead to increased crop damage in the field. The reduction in wind speed affects crop growth downwind from the windbreak to a distance of up to 15 times the height of the windbreak. Crop yields are typically increased by about 15% because the soil is warmer in the spring and less damage occurs to the crop during establishment and during growth and maturation. Trees and shrubs used in windbreaks should include many species that can be beneficial in other ways such as increasing fruit production, provides shade for livestock, and prevents soil erosion by stabilizing the slope.

3. ***Practices to cover the soil which prevent both Wind and Water erosion***

Soil Cover: Vegetative cover can help reduce soil erosion as it reduces the impact of rainfall hitting the soil, increases water infiltration and slows down the speed at which runoff flows through the field.

Proper soil management: Soils that are excessively tilled have poor structure and tend to be easily eroded by surface water. Reducing tillage, keeping good soil structure and retaining soil organic matter helps hold the soil in place.

Crop residues cover*:* Having a minimum 30% surface crop residue cover is considered beneficial for minimizing soil erosion. Mulching crop residues helps slow down surface runoff velocities, improve water infiltration, increase soil organic matter levels, and improve the water holding capacity. This may be most important for crops with limited residues such as lentils. If residues are being used for fuel, it is best to leave them in the field for as long as possible to prolong their erosion control benefits.

Increasing surface cover through cropping: Increased use of perennial crops, cover crops, green manure, and solid seeded crops (particularly winter crops) will help reduce potential for erosion because the soil is protected with at least a 30% cover for a longer part of the year. Growing only a short season annual crop once each year makes the soil more vulnerable to erosion.

Planting pattern*:* Row crop planting is bad for soil erosion because water can easily move between rows through much of the growing season. Row crops also tend to lead to poor soil structure. Solid seeding of crops like soybeans is better than row planting to reduce erosion.

Permanently cover sloping lands: Revegetating steeply sloped areas with perennial grasses, shrubs and trees may be the only practical solution for stopping erosion on steeply sloped areas. They can be planted with grasses for forage utilization or

multipurpose agroforestry species such as sea buckthorn and caragena. Ideally some of the area should be converted back into native species.

Prevent grazing on sloping lands: Excessive grazing of sloping lands is a primary reason for the gullied landscape found in much of North Central China. Keeping livestock in confined areas eliminates the problem. However, this must be balanced with animal welfare and sustainable fodder production and transport.

Crop Selection: Growing crops that have deep root zones will help stabilize the soil.

Vegetative barriers*:* Planting narrow strips of grasses on field contours can be very effective at helping trap crop residues and sediments from moving off fields. Sea buckthorn can also act as vegetative barrier to prevent erosion when planted in a gully.

ACTIVITY: Group Discussion

Discuss which crops are good and/or bad for soil erosion and why.

Crops good for soil erosion:

- ***Perennial grasses****:* These have a high soil cover and a fine and extensive root system which help prevent soil from being displaced by runoff water
- ***Alfalfa****:* These are like perennial grasses but with less surface rooting
- ***Shrubby trees:*** These trees have limited surface rooting but intercept water well and encourage other species to grow around them (i.e. sea buckthorn)
- ***Annual soil seeded grasses****:* These grasses consist of a solid canopy which intercepts rainfall well and a large root system which holds the soil particles (i.e. millet)
- ***Annual solid seeded legumes****:* These legumes interception of rainfall well but have limited surface rooting (i.e. peas)

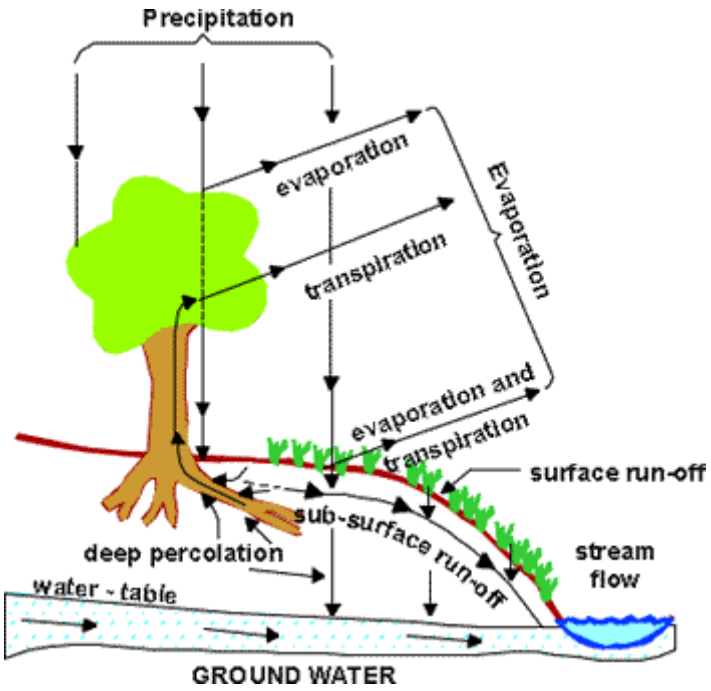
Crops bad for soil erosion:

- ***Row crops:*** These crops do not intercept rainfall well due to their poor crop canopy cover. Soil is also left bare in the furrows and is more susceptible to soil erosion (i.e. potatoes and corn)

Water Loss

How is water lost to the atmosphere?

Evaporation and transpiration are two natural processes that result in water loss to the atmosphere**.** Evaporation is water loss from a soil surface and transpiration is water loss from a plant surface. Collectively, these two forms are known as **evapotranspiration**.



Evapotranspiration is mainly affected by the physical characteristics of water and soil, as well as the type, density and rate of plant growth in the field. Other factors include net solar radiation, wind speed, availability of soil moisture, rooting depth, reflective land-surface characteristics, and season of year. Assuming that water is available, evapotranspiration is dependent primarily on the solar energy utilized to vaporize the water.

Water Conservation

What can you do to reduce evapotranspiration from your fields?

1. Plant Windbreaks

A windbreak reduces wind velocities which decreases the rate of evapotranspiration in the area directly downstream of the barrier. As explained before, windbreaks should consist of 50% porosity so that the wind is slowed as it passes through the windbreak and not deflected over the windbreak. Windbreaks must be planted across the direction of the predominant wind. A diversity of adapted species can provide best results as they reduce the risk of pest and disease problems, provides shade for livestock, and prevents soil erosion by stabilizing the slope. Drought tolerant species would not need as much irrigation, minimizing competition for water among the surrounding crops.

2. Keep crop residues on the field

Crop residues reduce the wind-speed at the soil surface which reduces evapotranspiration; conserve moisture because it shades the soil reducing soil temperatures and solar radiation; and acts as a windbreak at the soil surface. The best residues are those that do not decompose or break down rapidly. Crop residues should be left standing in the field as long as possible after harvest or only partially removed for fuel/fodder use. During harvest time, stubbles should be cut at a high point in the plant so that much of the plant residue is retained in the field.

3. Choosing Water Conserving Species

Conserve water use in the landscape by not growing too much high water utilizing crops like poplar trees. In Beijing, too many poplars have been planted and it is negatively affecting the regional water table. Crops that transpire the least amount of water are generally low biomass producing annual legumes like peas, lentils and chickpeas. Alfalfa, because of its high evapotranspiration rates, is the main field crop farmer in Central China grow that dries out the soil more extensively than all other field crops. This can be detrimentally impact the amount of groundwater available for future crops.

ACTIVITY: Group Discussion

Select a farmer from the group to draw a seasonal rainfall chart for the area. Discuss the following questions:

- **How much precipitation do you get each year in mm? And in which months does it fall most?**

  Dingxi and Zhunger county, 380 mm. Include info about monthly rainfalls.

- **How much water do crops use?**

  See below.

Below are results from studies that show annual water use (in mm) for various crops from the dryland areas of the United States and Canada.

Table 1. Seasonal water use (evapotranspiration) of crops in Western Nebraska, USA.

Crop	Water Use (mm)
Corn	580-660
Soybeans	508-559
Dry beans	381-406
Sorghum	457-508
Winter Wheat	406-457
Alfalfa	787-838

www.ianr.unl.edu/pubs/irrigation/g992.htm

Table 2. Average water use for various crops in the Central Great Plains, U.S.A.

Crop	Water Use (mm)	Yield (kg/ha)	Yield (kg/ha/mm)
Corn	406	4115	10.1 kg
Sunflowers	357	1269	3.6 kg
Millet	243	2286	9.4 kg
Winter Wheat	371	2991	8.1 kg
Peas	182	1267	7.0 kg

www.akron.ars.usda.gov/annualreport/croprottillwater.htm

Table 3. Average water use and yield for various crops in Saskatchewan, Canada

Crop	Water Use (mm)	Yield (kg/ha)	Yield (kg/ha/mm)
Spring wheat	327	3102	9.5 kg
Peas	286	2632	9.2 kg
Chickpea	309	1915	6.2 kg
Lentil	303	1456	4.8 kg
Mustard	289	1422	4.4 kg

http://res2.agr.ca/swiftcurrent/lre-tre/millrpulse8_e.htm

ACTIVITY: Group Discussion.

Which crops best preserve soil moisture? Rank the crops you grow from most to least drought tolerant.

These tables indicate: alfalfa, corn, and sunflowers as heavy water users; warm season crops (i.e. corn, millet) as efficient in terms of yield; and of the grain legumes, peas as the lowest water users and producers of a good yield per water consumed.

Best for preserving soil moisture: peas and lentils
Medium for preserving soil moisture: wheat
Low for preserving soil moisture: corn and sunflowers
Very low for preserving soil moisture: alfalfa

In dryland areas, high moisture using crops deplete soil moisture, which affects growth and productivity of the succeeding crop in most years.

What characteristics of plants make them more or less drought tolerant and why?

- ***Perennials:*** they are not as vulnerable to poor establishment due to dry spring germinating conditions. Their deep roots also allow them to have greater access to water (i.e. caragana and seabuckthorn)

- ***Extensive root system:*** the larger and deeper the root system the more effective the plants are in accessing water held in the soil (i.e. millet)

- ***Small and narrow leaves:*** Crops with a high stem to leaf ratio and narrow leaves (like millet) tend to resist drought more effectively than wide leaved crops. In a drought, corn often rolls its wide leaves to help conserve water. Cactus is the most extreme, it holds much moisture in its stem and has needles as leaves.

Deepen Your Understanding

Plants use water at different levels of efficiency. Warm season grass crops like millet, corn and sorghum have a different photosynthetic cycle (internal cycle of plants that turns sunlight into carbohydrates) than cool season species like wheat oats, and peas. Under normal growing conditions C4 *(warm season) crops tend to use only about 50% of the water of cool season crops. This is mainly due to the fact that they have a different internal design inside their leaves than C3 or cool season plants. This is an ecological adaptation that allows them to grow well under hot and dry conditions. When the weather gets hot and dry C4 plants can continue to grow, while C3 plants continue to use moisture but no net growth occurs. You can think of C4 plants as the camels of the plant world, they can keep moving along during normal hot and dry conditions while other animal forms of transport still need water but are no longer capable of moving at a normal pace until a change in the weather occurs.

ACTIVITY: Group Discussion.

Complete the following table. List all of the drought tolerant types of vegetation in their area. Mark which crops can be used for food, fodder, medicine, cash generation, and/or improve soil fertility.

Plant Species	Food	Fodder	Medicine	Cash Generation	Improve Soil Fertility
Carragena		X			X
Corn	X	X	X		

4. ***Adopt Suitable Crop Rotations***

Discuss.

5. ***On-farm Management Practices***

There are several on-farm practices which can help conserve water in the soil. These include:

Increasing organic matter levels: Increased soil organic matter levels increases water infiltration and the water holding capacity. This can be done through many ways such as reducing tillage, improving cropping rotations, and adding soil amendments.

Soaking seeds: Improve and speed up germination by soaking seeds before seeding. This is especially valuable for large seeded grain legume seeds like peas. Different seeds need different soaking times, usually not more than 24 hours for most seeds. Seeds should not be soaked until they sprout; sprouting needs to occur in the soil. This practice reduces the need for water irrigation

Aid Crop Emergence: Seeds need to be packed after seeding to ensure good seed to soil contact. This is especially true for small seeded forage crops like alfalfa. In row seeded crops, packing is usually done only over the row. Moisture loss can be further prevented from the packed row by placing loose soil over the row. This can be accomplished by dragging "snake chains"(a 40 cm long chain with an 8 cm circle at the end too lightly. This practice helps reduce evapotranspiration in the field.

Proper Irrigation Water Management: Overuse of irrigation water can cause the "mining" (extraction of resources) of groundwater. Overuse of water is not sustainable and needs to be avoided.

6. ***Adopt Suitable Irrigation Methods***

What is irrigation?

A water-wise landscape requires a minimal amount of supplemental water from irrigation. When irrigation is used, water should be applied efficiently and effectively to make every drop count. Wasted water can cost money and may lead to the salinization of the soil, as well as surface or groundwater contamination.

There are four methods of applying water to fields:

1. **Hand Watering:** An effective and efficient way of applying water to selected plants that show signs of stress during dry periods. The direct application of water to the base of the plant uses less water and can be more efficient than sprinkler and flood irrigation.
2. **Drip Irrigation:** Also called trickle or micro-irrigation, this method applies water slowly and directly to the roots of plants through small flexible pipes and flow control devices called emitters. It uses 30 to 50 percent less water than sprinkler irrigation.
3. **Sprinkler Irrigation:** This method distributes water onto the field through the use of a piping and/or hose system. Sprinkler heads, located at regular intervals within the piping system, spray water onto the crops. Sprinkler irrigation is more efficient than flood irrigation because it distributes the water more evenly and reduces losses to seepage.
4. **Flood Irrigation:** In this system, the field is flooded with water. Flood irrigation has the poorest efficiency rate for water usage.

What is a bucket drip irrigation system?

A bucket drip irrigation is a low cost irrigation system that relies on gravity fed water from a bucket rather than a water pump to feed the water to a drip irrigation system. It is ideally suited to small farmers growing vegetables for their own households or for small market gardens. The buckets are mounted on posts 3' (1m) high, enabling enough water pressure for water distribution under the gravity flow irrigation. A kit costs about 800 RMB and consists of fittings and sufficient irrigation tape to irrigate two 50' (16m) rows of vegetables by filling the bucket 1-2X's daily. These kits are already in use in more than 70 countries.

http://www.hydrosource.com/w3clp008.htm

When is the best time of day to irrigate in order to conserve water?

Hand watering and drip irrigation systems can be operated at any time of day. Minimal evaporative water losses are associated with this system because the foliage generally stays dry.

The best time to irrigate using the sprinkler or flood irrigation method is after 9 p.m. and before 9 a.m. During this time there is generally less wind, lower temperatures, and less sunlight, which results in less water loss to evaporation. Irrigating after 9 p.m. is not seen as a problem as the dew formed during the night does not harbour disease problems.