Module 3: FIELD WATER MANAGEMENT

a: Basin Irrigation
b: Furrow Irrigation
c: Overhead Irrigation
1: Evapotranspiration
2: Canal losses
3: Percolation
MODULE 3

FIELD WATER MANAGEMENT

Introduction

An adequate water supply is important for plant growth. When rainfall is not sufficient, the plants must receive additional water from irrigation. The farmer can use various methods to supply irrigation water to the plants. To choose an irrigation method, the farmer must know the advantages and disadvantages of various methods. He or she must know which method suits the local conditions best.

The two main areas of this module, field irrigation practices and crop water management are the topics of the two sub-modules.

References

In the preparation of the exercises in the module use is made of the following publications:

- Irrigation water management training manual No. 1, Introduction to Irrigation 1985, FAO
- Irrigation water management training manual No. 3, Irrigation water needs 1986, FAO
- Irrigation water management training manual No. 4, Irrigation Scheduling, 1989, FAO
- Irrigation water management training manual No. 5, Irrigation methods, 1988, FAO

Additional technical information can be obtained from the above mentioned publications.
Sub-module 3.1: Field Irrigation practices

An introduction and review of different irrigation method(s) takes place in exercise 3A (phase: planning). The basin, furrow, overhead and localized irrigation methods are being reviewed in exercise 3B (phase: planning), 3C (phase: planning) and 3E (phase: planning). In exercise 3D (phase: construction) farmers will observe and discuss Land preparation and levelling to prepare the land for surface irrigation.

Sub-module 3.2: Crop water management / practices

The crop water requirements are discussed in the field by the farmers in exercise 3F (phase: planning) and irrigation scheduling in exercise 3G (phase: operation).
SUB-MODULE 3.1
FIELD IRRIGATION PRACTICES

EXERCISE 3A: INTRODUCTION OF DIFFERENT FIELD IRRIGATION METHODS

Introduction

Various methods can be used to supply irrigation water to the plants. Each method has its advantages and disadvantages. Farmers should take these into account when choosing the method that is best suited to their own local circumstances.

Surface irrigation is by far the most widespread irrigation method. It is normally used when conditions are favourable: mild and regular slopes, soil type with medium to low infiltration rate, and a sufficient supply of surface or groundwater. In the case of steep or irregular slopes, soils with a very high infiltration rate or scarcity of water, sprinkler and drip irrigation may be more appropriate. When introducing sprinkler and drip irrigation it must be ensured that the equipment can be maintained.

Objectives

- To review presently use and other field irrigation methods and assess shortcomings.
- To introduce possible alternative field irrigation methods.

Expected outputs

- List of constraints of presently used and other field irrigation methods.
- Selection of suitable field irrigation methods for the farmers in the area.

Preparations required

- Field survey to evaluate different field irrigation methods practised and to select an area for field visit.
- Prepare demonstration on infiltration rates and water retention capacity.

Materials required

- 3-4 empty (milk powder) tins with drainage holes in the bottom, buckets, bottles with water, (stop-) watch.
- Large sheets of paper and marker.

Time required

- Three hours

Timing

- No timing restrictions
Procedure (Steps)

Plenary Introduction (10 min)

1. Explain the specific objectives and expected output.

Field visit / activity (one hour and 50 min)

2. Visit with the farmers agricultural fields where different irrigation methods are being practised. Ask the farmers to observe the type and slope of the soil, if there is excessive run off (see drains), unequal growth as result of unequal water distribution, unequal infiltration rates, etc. and discuss the time required to apply the water.

3. Demonstrate the differences in infiltration rate and water retention capacity between the different soil types collected during the observations. (a) Fill empty milk powder tins, with holes in the bottom, each half with of the collected soil samples. (b) Poor carefully an equal amount of water on top of the different soil samples. (c) Measure the time till water starts to drip out of the holes in the bottom of the tins and (d) collect the percolated water in buckets. (e) List down the time needed and the amount of water collect for each of the different soil samples.

4. Discuss the differences in infiltration rates and retention capacities observed for the different collected soil samples in relation to irrigation method(s) used.

Brainstorming (20 min)

5. Ask the farmers to mention all the irrigation methods they have observed in the field and others they know off. List them down on a large sheet of paper and, if needed, add the once missing.

6. Ask the farmers to recall the observations made in the field on soil type and slope, water distribution for each irrigation method and time needed. List the observation made in a column behind the irrigation methods listed.

Plenary discussion (40 min)

7. Discuss the methods listed and observations made. When needed, explain some of the irrigation methods listed. Conclude on what the soil type and slope restrictions are of each method observed.

8. Discuss shortly other restrictions (climate, water availability, water quality, type of crop, level of technology, labour inputs and costs) of each irrigation listed. At these to the column behind the irrigation methods listed.
9. Ask the farmers what the most appropriated irrigation methods are which can be used in their situation. Ask the farmers to indicate why.

10. Summarise the discussions and observations made.


Guidelines for (technical) preparations/ questions for discussions

Various methods to supply irrigation water to the plants

Surface irrigation:
Application of water by gravity flow to the surface of field.

Basin irrigation:
Basins are flat areas of land, surrounded by low bunds. In general, the basin method is suitable for crops that are unaffected by standing in water for long periods (12-24 hours). Large application gifts (50-120 mm) are normally given and crops will be irrigated over long interval period (10-20 days).

Furrow irrigation:
Furrows are small channels, which carry water down the land slope between the crop rows. The crop is usually grown on top or half way down the ridges between the furrows. This method is suitable for row crops that cannot stand in water for long periods. The method allows applying light irrigation (30-50 mm) and can be laid out in sloping fields along the contour. Considerable water savings can be obtained if layout is well done.

Border irrigation:
Borders are long, sloping strips of land separated by bunds. They are sometimes called border strips. Require accurate land levelling and good control of flow to be efficient.

Overhead and localised irrigation:

Sprinkler irrigation:
Sprinkler irrigation is similar to natural rainfall. Water is pumped through a pipe system and then sprayed onto the crops through rotating sprinkler heads. For a more localised water supply the use of mini/micro sprinklers can be considered.
**Drip irrigation:**
With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers that are located close to the plants. Only the immediate root zone of each plant is wetted. Drip irrigation is sometimes called trickle irrigation.

**Watering plants with a watering can or bucket:**
Bringing water from the source to each plant with a bucket or a watering can. This can be very time-consuming method and involves very heavy work. However, it can be used successfully to irrigate very small plots of land, such as vegetables gardens, that are close to the water source.

**Improving field irrigation methods**

The suitability of the various irrigation methods depends mainly on the following factors: previous experience with irrigation, natural conditions, type of crop, type of technology, required labour inputs and costs and benefits.

a. **Previous experience with irrigation**
   Introducing a previously unknown method may lead to unexpected complications. Often it will be easier to improve the traditional irrigation method than to introduce a totally new method.

b. **Natural conditions**
   - **Soil type:** Sandy soils have low water storage and a high infiltration rate. They need frequent but small irrigation applications and sprinkler or drip irrigation are therefore more suitable.
   - **Slope:** Sprinkler or drip irrigation are preferred above surface irrigation on steeper or unevenly sloping lands as they require no land levelling.
   - **Climate:** Strong wind can disturb spraying of water from sprinkler. For only supplementary irrigation, sprinkler or drip irrigation may be more suitable because of their flexibility and adaptability.
   - **Water availability:** Water application efficiency is generally higher with sprinkler and drip irrigation and is preferred when water is in short supply.
   - **Water quality:** Surface irrigation is preferred if the irrigation water contains much sediment. If the water contains dissolved slats, drip irrigation is particularly suitable, as less water is applied. Sprinkler systems are more efficient than surface irrigation in leaching out salts.

c. **Type of technology**
   In general drip and sprinkler irrigation are technically more complicated methods. The purchase of equipment requires high capital investment per hectare and the maintenance of equipment a high level of ‘know-how’. Also, a regular supply of fuel and spare parts must be maintained. Basin irrigation is considered as the simplest of the surface irrigation methods.

d. **Required labour inputs**
   Surface irrigation often requires a much higher labour input – for construction, operation and maintenance – than sprinkler or drip. Basin irrigation uses the least labour and the least skill.
e. Costs and benefits

On the cost side not only the construction and installation, but also the operation and maintenance should be taken into account and compared with the expected benefits (yields).

Example table characteristics of irrigation methods

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Watering can</th>
<th>basin</th>
<th>furrow</th>
<th>border</th>
<th>sprinkler</th>
<th>drip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type</td>
<td>all</td>
<td>No sand</td>
<td>No cause sand</td>
<td>No coarse sand</td>
<td>all</td>
<td>All</td>
</tr>
<tr>
<td>Slope</td>
<td>all</td>
<td>&lt; 0.1%</td>
<td>0.05-0.5%</td>
<td>0.05-5%</td>
<td>all</td>
<td>All</td>
</tr>
<tr>
<td>Climate</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>not windy</td>
<td>All</td>
</tr>
<tr>
<td>water use efficiency</td>
<td>high</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Water quality</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Low in sediments</td>
<td>Low in sediments</td>
</tr>
<tr>
<td>Type of crop</td>
<td>Home garden</td>
<td>Grains, trees</td>
<td>Row crops</td>
<td>All except paddy</td>
<td>High value</td>
<td>Trees, row crops</td>
</tr>
<tr>
<td>technology</td>
<td>low</td>
<td>low</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
<td>High</td>
</tr>
<tr>
<td>costs</td>
<td>low</td>
<td>low</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
<td>High</td>
</tr>
<tr>
<td>Labour inputs</td>
<td>high</td>
<td>Low-med.</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>low</td>
</tr>
</tbody>
</table>

For more technical information, see also:

- Irrigation water management training manual No. 1, Introduction to Irrigation 1985, FAO, Chapter 2.2: Entry of water into the soil, and chapter 5.3: Field application systems.
- Irrigation water management training manual No. 5, Irrigation methods, 1988, FAO, Chapter 7: Choosing an irrigation method.
- FAO Filmstrip Sprinkler Irrigation

Questions for discussions

- Which irrigation method is most used in the area?
- Is the selection of irrigation method dominated by the selection of crop? Or
- The selection of crop dominated by the selection of irrigation method?
- Could another irrigation method maybe be more economical?
- If money is a problem would you consider sprinkler or drip irrigation?
- Which irrigation method uses water most efficiently?
## EXERCISE 3B: BASIN IRRIGATION

### Introduction

Paddy rice is always grown in basins and probably therefore a very widely spread irrigation method. But also many other crops can also be grown in basins. In general it can be stated that to operate the system, basin irrigation requires the least labour and the least skill of the three different surface irrigation methods.

### Objectives

- To evaluate performance present basin irrigation.
- To assess the suitability of basin irrigation, basin construction, operation and maintenance.
- To identify shortcomings and potential improvements.

### Expected outputs

- Plan of the optimal basin sizes and levelling and construction methods.
- Operation plan for basin irrigation.

### Preparations required

- Select an area for a field visit with basin irrigation in operation.

### Materials required

- Digging materials to check wetting front.
- Large sheets of paper and markers.

### Time required

- Three hours

### Timing

- When some basins contain water
**Procedure (Steps)**

**Plenary Introduction** (15 min)

1. Review of the previous training session (Exc. 1, Part C)
2. Explain the specific objectives and expected output.

**Field visit** (2 hours)

3. Visit with the farmers a nearby-situated area with basin irrigation in operation (with standing water). Ask the farmers to observe and discuss how the basins have been constructed, the techniques used to level the land and to construct the bunds.
4. Ask the farmers what the important factors and indicators are on the size and shape of the basin, in the levelling of the land and construction of the bunds.
5. Summarise these factors and indicators and ask the farmers to inspect the irrigation basins if the levelling and constructions have been carried well. Discuss and conclude on what should be done to improve levelling and construction of the basins.
6. Introduce and discuss the two methods of supplying irrigation water to basins; direct and cascade methods. Ask which method is being used in the area.
7. Ask the farmers what important is in obtaining an ideal wetting pattern and ask them to inspect the wetting patterns in the basins.

**Plenary discussion** (50 min)

8. Summarise the discussions and observations made during the field visit.
9. Ask the farmers about the scheduling of water supply and different water levels farmers try to obtain during the different stages of the crop. Discuss the importance of the water level in the basin in relation to the crop development, weed growth and pest management.
10. Discuss if there is a need to improve the scheduling of water supply and, If so, how this should be done?
11. Summarise the observations and discussions. Prepare a construction and operation plan for basin irrigation.
Guidelines for (technical) preparations / questions for discussions

Suitable crops

Crops that are suited to basin irrigation include:
- Pastures, e.g. alfalfa, clover;
- Trees, e.g. citrus, banana;
- Crops which are broadcast, such as cereals;
- To some extent row crops such as tobacco.

Not suitable are crops that cannot stand in wet or waterlogged conditions for periods longer than 24 hours (root and tuber crops).

Limitation of basin width and size

Slope
The main limitation on the width of a basin is the land slope. If the land slope is steep, the basin should be narrow, otherwise too much earth movement will be needed to obtain level basins.

Soil texture and Stream size
The size of basins depends also on the infiltration rate of the soil and the speed of which water is flowing over the surface (stream size).

Table: Approximate values for the maximum basin or terrace width (m)

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Maximum width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>average</td>
</tr>
<tr>
<td>0.2</td>
<td>45</td>
</tr>
<tr>
<td>0.5</td>
<td>28</td>
</tr>
<tr>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>13</td>
</tr>
<tr>
<td>2.0</td>
<td>10</td>
</tr>
<tr>
<td>4.0</td>
<td>5</td>
</tr>
</tbody>
</table>

Table: Suggested maximum basin area (m²) for various soil types and available stream sizes

<table>
<thead>
<tr>
<th>Stream size (l/sec)</th>
<th>Sand</th>
<th>Sandy Loam</th>
<th>Clay Loam</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>35</td>
<td>100</td>
<td>200</td>
<td>350</td>
</tr>
<tr>
<td>10</td>
<td>65</td>
<td>200</td>
<td>400</td>
<td>650</td>
</tr>
<tr>
<td>15</td>
<td>100</td>
<td>300</td>
<td>600</td>
<td>1000</td>
</tr>
<tr>
<td>30</td>
<td>200</td>
<td>600</td>
<td>1200</td>
<td>2000</td>
</tr>
<tr>
<td>60</td>
<td>400</td>
<td>1200</td>
<td>2400</td>
<td>4000</td>
</tr>
<tr>
<td>90</td>
<td>600</td>
<td>1800</td>
<td>3600</td>
<td>6000</td>
</tr>
</tbody>
</table>

Irrigation depth
If the required irrigation depth is small, the basin should be small to obtain good water distribution.

Mechanisation
In mechanised farming the basin dimensions are chosen to be some multiple of the width of the machines.
Summary how basin sizes should be

Basins should be small if the:
1. Slope of the land is steep
2. Soil is sandy
3. Stream size to the basin is small
4. Required depth of the irrigation is small
5. Field preparation is done by hand or animal traction.

Basin can be large if the:
1. Slope of the land is gentle or flat
2. Soil is clay
3. Stream size to the basin is large
4. Required depth of the irrigation application is large
5. Field preparation is mechanised.

Basin construction

Step 1 Setting out of the basin(s)
Step 2 Forming the bunds
Step 3 Smoothing (levelling) the land

Irrigating Basins

The direct method: Each field receives water directly from the field channel.
The cascade method: On sloping land, where terraces are used, the irrigation water is supplied to the highest terrace, and then allowed to flow to a lower terrace and so on.

Wetting pattern

It is important to obtain a uniformly wetted root zone (ideal wetting pattern).

- The surface of the basin must be level.
- The basin should have a uniform soil type
- Prevent a compacted sub-soil, which slows down infiltration resulting in waterlogging (not for growing rice)
- Apply sufficient irrigation water (required irrigation depth), not too much or too little). Irrigation time depends on; a) the stream size (l/sec), b) the required irrigation depth (mm) and c) the size of the field to be irrigated (ha). Irrigation time (hours) = (2.78 x b x c)/a.
- Irrigation water must be applied quickly to minimise the percolation losses near the field channel. The stream size should be large enough for the water to cover the entire field in a quarter of the time needed to fill the root zone with sufficient water (“rule of thumb” called quarter time rule).
For more technical information, see also:
- Irrigation water management training manual No. 5, Irrigation methods, 1988, FAO, Chapter 2: Basin irrigation and Chapter 4: Border Irrigation

Questions for discussions

- Why do you only grow rice in your basins?
- Would there be a market for the other identified potential crops that can be grown with basin irrigation?
- What would be the advantages of diversifying the types of crops you are growing in your basins?
- Do you sometimes change the size of your basin(s)? Why?
- Do you experience problems in obtaining a uniform wetting of the root zone in your basin? If so, what have you done to prevent these problems?
- What would you do if not enough water is available to irrigate the entire basin (under-irrigate or irrigate only a part of the basin)?
- How do you determine the time you irrigate your field?
EXERCISE 3C: FURROW IRRIGATION

Introduction

Furrow irrigation is suitable for many crops, especially row crops. Furrow irrigation can be used with crops that could be damaged if water covers their stem or crown (basin irrigation). Furrows are small, parallel channels, made to carry water in order to irrigate the crop. The crop is usually grown on the ridges between the furrows.

Objectives

- To evaluate performance present furrow irrigation.
- To assess the suitability of furrow irrigation, furrow construction, operation and maintenance.
- To identify shortcomings and potential improvements.

Expected outputs

- Plan of the optimal furrow layout.
- Operation plan for furrow irrigation.

Preparations required

- Select an area for a field visit where furrow irrigation is being practised.

Materials required

- Digging materials to check wetting front.
- Large sheets of paper and markers.

Time required

- Three hours

Timing

- When furrow irrigation is being practised.
Procedure (Steps)

Plenary Introduction (15 min)

1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Field visit (2 hours)

3. Visit with the farmers a nearby-situated area with furrow irrigation in operation. Ask the farmers to observe and discuss how the furrows have been constructed, length and positioned with respect to the slope of the land.
4. Ask the farmers what the important factors and indicators are on the length, shape and slope of the furrows and how they have been constructed.
5. Summarise these factors and indicators and ask the farmers to inspect the irrigation furrows if the layout has been carried out well. Discuss and conclude on what should be done to improve layout of the furrows.
6. Introduce and discuss the use of siphons, spiles and gated pipes for supplying irrigation water to furrows and the number of furrows that can be irrigated at the same time.
7. Ask the farmers what important is in obtaining an ideal wetting pattern and ask them to inspect the wetting patterns in the furrows.

Plenary discussion (50 min)

8. Summarise the discussions and observations made during the field visit.
9. Discuss what the influence is of soil texture on obtaining an ideal wetting pattern during irrigating the furrows. Ask the farmers what the consequences are of that on furrow spacing.
10. If not yet mentioned, introduce and explain how the factors “slope”, “soil type”, “stream size”, “irrigation depth” and “cultivation practice” and “field length” influences the maximum furrow length.
11. Summarise the observations and discussions. Prepare a layout and operation plan for basin irrigation.
Guidelines for (technical) preparations / questions for discussions

Suitable crops for furrow irrigation

- Row crops such as maize, sunflower, sugarcane, soybean;
- Crops that could be damaged by inundation, such as tomatoes, vegetables, potatoes, beans;
- Fruit trees such as citrus, grape;
- Broadcast crops (corrugation method) such as wheat.

Furrow layout

Length

Slope Although furrows can be longer when the land slope is steeper, the maximum recommended furrow slope is 0.5% to avoid soil erosion. A minimum grade of 0.05% is recommended so that effective drainage can occur. Further the slope should be uniform.

Soil type Furrows should be shorter in sandier soils, so that water will reach the downstream end without excessive percolation losses.

Stream size Normally stream sizes up to 0.5 l/sec will provide an adequate irrigation. It is advised not to use stream sizes larger than 3.0 l/sec to prevent erosion.

Irrigation depth Applying larger irrigation depths usually means that furrows can be longer as there is more time available for water to flow down the furrows and infiltrate.

Cultivation practice Shorter furrows require more attendance but can be irrigated more efficiently. Longer furrows are easier for mechanised farming.

Table: Practical values of maximum furrow lengths (m) depending on slope, soil type, stream size and net irrigation depth.

<table>
<thead>
<tr>
<th>Furrow slope (%)</th>
<th>Maximum stream size (l/s) per furrow</th>
<th>Clay (Net irrigation depth (mm))</th>
<th>Loam</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>0.0</td>
<td>3.0</td>
<td>100</td>
<td>150</td>
<td>60</td>
</tr>
<tr>
<td>0.1</td>
<td>3.0</td>
<td>120</td>
<td>170</td>
<td>90</td>
</tr>
<tr>
<td>0.2</td>
<td>2.5</td>
<td>130</td>
<td>180</td>
<td>110</td>
</tr>
<tr>
<td>0.3</td>
<td>2.0</td>
<td>150</td>
<td>200</td>
<td>130</td>
</tr>
<tr>
<td>0.5</td>
<td>1.2</td>
<td>150</td>
<td>200</td>
<td>130</td>
</tr>
</tbody>
</table>

Shape

Soil type On sandy soils, narrow deep V-shaped furrows are desirable to reduce the soil area through which water percolates. In clay soils a wide, shallow furrow to obtain a large wetted area to encourage infiltration.
Stream size The larger the stream size the larger the furrow must be to contain the flow.

Spacing

Soil type Coarse sand: 30 cm; fine sand: 60 cm; clay soils 75-150 cm.

Cultivation practices in mechanised farming a compromise is required between spacing requirements of the machinery, ideal spacing for crops and to provide adequate lateral wetting off the soil.

Construction of furrows

Straight furrows

Step 1: A straight line is set out in the field along the proposed line of furrows. This can be done by setting up ranging poles or marking a line on the ground with chalk powder.

Step 2: The ridger is moved along the line. The resulting furrow should be straight.

Step 3: About every 5 m. a new straight line should be set out.

Contour furrows on sloping or undulating land

Step 1: A guide furrow must first be set out along the upper edge of the field close to the farm channel using a levelling device (A frame) to locate the contour line. Further guide furrows are set out every 5 m. on undulating ground and 10 m. on uniform sloping land.

Step 1: Working from each guide furrow, furrows are made to halfway along the next guide furrow.

Wetting patterns

In an ideal situation adjacent wetting patterns overlap each other, and there is an upward movement of water (capillary rise) that wets the entire ridge.

The wetting patterns are different in sandy and clay soils. In sandy soils water infiltrates quickly to deeper layers and there is little horizontal (lateral) movement of water. In clay soils the water infiltrates slowly to deeper layers and there is a substantial lateral movement of water in the soil as well as capillary rise. Therefore to obtain an overlapping wetting pattern the spacing in clay soils can be larger then in sandy soils.
For more technical information, see also:
- **Irrigation water management training manual No. 5, Irrigation methods, 1988, FAO, Chapter 3: Furrow irrigation**

Questions for discussions

- Do you consider furrow irrigation more difficult and labour demanding comparing with other irrigation methods?
- How do you decide between using basin or furrow irrigation?
- Do you sometimes change the length of your furrows? Why?
- Do you experience problems in obtaining a uniform wetting of the root zone in your field with furrow irrigation?
- If so, what have you done to prevent these problems?
- What would you do if not enough water is available to irrigate the entire field (under-irrigate or irrigate only a selection of furrows?)
- How do you determine the time you irrigate your field/furrow(s)?
Plot length and fieldslope adapted to field conditions. Waterflow and application time adjusted to soil condition (infiltration rate) and field lay-out.

A too high flow-rate will result in erosion, excessive run-off or under-irrigation.

A too low flow-rate will result in over-irrigation at the top and under-irrigation at the bottom of the field.

A too steep slope gives a rapid water-flow over the field, resulting in under-irrigation and excessive run-off.

A too flat slope gives a slow water movement over the field, resulting in over-irrigation in the first part and under-irrigation at the lower part of the field.
A too long plot gives a strongly reduced flow near the lower end, resulting in under-irrigation.

In too short a plot, the water will reach the lower end too soon, resulting in either too short an infiltration time, thus under-irrigation, or excessive run-off.

Poor field leveling will give an uneven water movement over the field, resulting in over-irrigation in the depressions and possible waterlogging.

Poor drainage at the plot end can result in standing water and waterlogged soils in that section.

Different soil types in one plot will give different infiltration rates.
Exercise 3D: LAND PREPARATION

Introduction

One of the factors that affect plant growth is land preparation. Properly prepared fields promote root development and better weed pest and disease management. Particularly in irrigated farming a proper levelling of the land is very important to obtain an equal distribution of water in the field.

Objectives

- To improve land preparation, field layout and land levelling to obtain a more equal distribution of water in the field.

Expected outputs

- Plan for improved field layout, levelling and land preparation practices

Preparations required

- Select a nearby-situated newly planted area for the field visit.

Materials required

- Large sheets of paper and markers.

Time required

- Two and half hours

Timing

- Few weeks after planting/sowing
Procedure (Steps)

Plenary Introduction (15 min)
1. Review of the previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Brainstorming (30 min)
3. Ask the farmers to mention all the things that can be noted on a field and crop in relation to (bad) land preparation, field layout and land levelling. Write it down on a large sheet of paper.
4. Discuss the listed “indicators”. Come to an agreement on the important indicators to assess land preparation, field layout and land levelling.

Field visit / small group activity (1 hour and 50 min)
5. Visit with the farmers a newly planted area. Ask the farmers in small groups to study and discuss the performed land preparation, field layout and land levelling in a newly planted field.
6. Ask each group to prepare a presentation on a large piece of paper, listing the different land preparation, field layout and land levelling activities carried out and the quality of how they have been carried out. Ask the groups to make use of the listed indicators.
7. Ask the groups to present their observations and discussions.
8. Discuss the presentations. Ask how the land preparation, field layout and land levelling influence the effectiveness of irrigation. Summarise the main points discussed and prepare a plan for improved field layout, levelling and land preparation practices.
Guidelines for (technical preparations) / questions for discussions

List of questions (indicators) to assess land preparation

Is the presence of weeds a problem? Is seed germination even? Is the crop healthy? Is it well established? Is the field prepared in beds? Are there localised irrigation and/or drainage problems in the field? When was the land preparation carried out?

Questions for discussions

- What is good land preparation?
- What is the importance of thorough land preparation?
- What are the characteristics of a well-prepared field?
- When is the best time to do first ploughing and succeeding harrowing?
- What is the importance of straight furrowing?
- What are the advantages and disadvantage of frequent or intense land preparation?
- How can land preparation help in weed pest and/or disease management?
EXERCISE 3E: OVERHEAD AND LOCALISED IRRIGATION

Introduction

Sprinkler irrigation (overhead) and drip irrigation (localised) are two systems that distribute water through a system of pipes usually by pumping. In the case of sprinkler irrigation the water is sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. With drip (or trickle) irrigation water drips onto the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants or root zone so that only part of the soil in which the roots grow is wetted.

Objectives

- To evaluate performance of present sprinkler or drip irrigation.
- To assess the suitability of sprinkler or drip irrigation, layout, operation and maintenance.
- To identify shortcomings and potential improvements.

Expected outputs

- Plan of the optimal sprinkler or drip layout.
- Operation plan for sprinkler or drip irrigation.

Preparations required

- Select an area for a field visit where sprinkler or drip irrigation is being practised.

Materials required

- Digging materials to check wetting front.
- Large sheets of paper and markers.

Time required

- Three hours

Timing

- When sprinkler or drip irrigation is being practised
Procedure (Steps)

Plenary Introduction (15 min)

1. Review of previous training session (Exc. 1, Part C).
2. Explain the specific objectives and expected output.

Field visit (2 hours)

3. Visit with the farmers a nearby-situated area with sprinkler or drip irrigation in operation. Ask the farmers to observe and discuss the layout and positioning of the sprinklers or drippers.
4. Ask the farmers what the important factors and indicators are on the distance between the sprinklers or drippers in obtaining an ideal wetting pattern. Discuss what the influence is of soil texture on obtaining an ideal wetting pattern.
5. Summarise these factors and indicators and ask the farmers to inspect the layout and distribution of sprinklers or drippers and the wetting pattern. Discuss and conclude on what should be done to improve layout.
6. Observe and discuss the type of pump, pipes, filters, etc. used and the suitability (quality) of the water for sprinkler or drip irrigation.

Plenary discussion (50 min)

7. Summarise the discussions and observations made during the field visit.
8. Discuss the water pressure needed in the system and its consequences on the maximum length of the pipe system.
9. Summarise the observations and discussions. Prepare a layout and operation plan for sprinkler or drip irrigation.
10. Summary and Closure (Exc. 2, Part C)
**Guidelines for (technical) preparations / questions for discussions**

**Suitable crops for sprinkler and drip irrigation**
- Sprinkler irrigation: Most crops are suitable with the exception of delicate crops as lettuce because the large drops may damage the crop.
- Drip irrigation: Most suitable for high value row crops.

**Slope**

Both irrigation methods are adaptable to any farmable slope.

**Soil type**

Both irrigation methods are suitable for most soils. The application discharge rates of the sprinklers or drippers is always chosen to be less than the basic infiltration rate of the soil to avoid surface ponding and runoff. Sprinklers are not suitable for soils that easily form a crust. On sandy soils higher emitter discharge rates will be needed to ensure adequate lateral wetting of the soil.

**Irrigation water**

A good clean supply of water, free of suspended sediments, is required to avoid problems of sprinkler nozzle or dripper (emitters) blockage and, in the case of sprinkler irrigation, spoiling the crop by coating it with sediment. If the water is not free of sediments, filtration of the water is needed. Blockage may also occur if the water contains algae, fertiliser deposits and dissolved chemicals which precipitate such as calcium and iron.

**Sprinkler system layout**

A typical sprinkler irrigation system consists out of:
- A **pump unit**, usually a centrifugal pump that takes water from the source and provides adequate pressure for delivery into the pipe system.
- **Mainline and sub mainlines**, pipes that deliver water from the pump to the laterals. They can be permanent and laid on the ground or buried, and can be moved from field to field.
- **Laterals**, which deliver water from the (sub-) mainlines to the sprinklers. They are often portable but can be permanent.
- **Sprinklers**, most common are the rotary sprinklers spaced 9-24 m. apart along the lateral.

A common problem with sprinkler irrigation is the large labour force needed to move the pipes and sprinkler around the field. To overcome this problem (expensive) mobile systems have been developed.
**Operation sprinkler system**

The main objective of a sprinkler system is to apply water as uniform as possible to fill the root zone of the crop with water.

- **Wetting patterns**: The wetting pattern from a single rotary sprinkler is not very uniform. The heaviest wetting is close to the sprinkler. For good uniformity several sprinklers must be operated close together so that their patterns overlap. For good uniformity the overlap should be at least 65% of the wetted diameter. Spray from sprinklers is easily blown about by even a gentle breeze and this can seriously reduce uniformity further. Another influencing factor is a too low or too high pressure.

- **Application rate**: The application rate depends on the size of sprinkler nozzles, the operating pressure and the distance between sprinklers.

- **Sprinkler drop size**: larger sprinklers produce large drops, which can damage delicate crops and soils. In such a case it better to select smaller sprinklers operating at or above the normal recommended operating pressure.

**Drip system layout**

A typical drip irrigation system consists out of:

- **Pump unit**, see sprinkler irrigation
- **Control head**, this consists of valves to control the discharge and pressure in the entire system. It may also have filters and a fertiliser or nutrient tank.
- **Mainlines, submains and laterals**, see sprinkler system
- **Emitters or drippers**, are devices used to control the discharge from the laterals to the plants.

**Operation drip system**

A drip system is usually permanent and therefore can easily be automated. Water can be applied frequently (every day if required).

- **Wetting patterns**: Drip irrigation only wets part of the soil root zone. The wetting pattern that develops from dripping water onto the soil depend on discharge and soil types With a higher discharge the wetting pattern will be broader but less deep. The same happens in a heavier soil (clay).

- The water savings that can be made using drip irrigation are the reductions in deep percolation, in surface runoff and in evaporation from the soil. These savings depend as much on the user of the equipment as on the equipment itself.
For more technical information, see also:
- FAO Filmstrip Sprinkler Irrigation

Questions for discussions

- Is there sufficient knowledge on how to operate the sprinkler/drip irrigation system and to deal with common problems?
- Are there enough skilled technicians available to carry out repairs?
- Is the quality of the water a problem?
- How do you deal with bad quality water?
- Are there problems with obtaining an equal water distribution with sprinkler irrigation when there are strong winds?
- How do you deal with these situations?
- Does it pay back the costly investments and high operation costs?
- Is there a marked for high value crops?
- Is there a risk of stealing of equipment in the field?
- What is the power source for the pump?
- How reliable is the availability of the source?
SUB-MODULE 3.2
CROP WATER MANAGEMENT / PRACTICES

EXERCISE 3F: CROP WATER REQUIREMENTS

Introduction

Without water crops cannot grow. Too much water is not good for many crops either. Excess water must be removed through drainage. If there is too little water from rain, water must be supplied from other sources. The amount of irrigation water which is needed depends not only on the amount of water already available from rainfall, but also on the total amount of water needed by the various crops. The crop water need mainly depends on the climate, the crop type and growth stage of the crop.

Objectives

- To determine the water needs of the crops cultivated.

Expected outputs

- List of factors influencing crop water needs.
- List of water needs of the crops cultivated for each month of the cropping season.

Preparations required

- Collect or calculate the crop water uses of the main crops cultivated by the farmers for each month of the cropping season. Present the crop water uses in a table on a large sheet of paper.

Materials required

- Irrigation equipment, buckets and measuring tape.
- Large sheets of paper and marker.

Time required

- Two hours

Timing

- During the cropping season.
**Procedure (Steps)**

**Plenary Introduction** (15 min)

1. Review of previous training session (Exc. 1, Part C)
2. Explain the specific objectives and expected output.

**Plenary discussion** (50 min)

3. Ask the farmers which major climatic factors influences crop water needs, and how? List them down on a large sheet of paper.
4. Ask the farmers if they think that, under the same climatic conditions, all crops have the same water need or if there are differences. Ask the farmers examples of crops, which do need less and once that need more water.
5. Discuss with the farmers the influence of the growth stage of the crop on crop water needs. Discuss the different stages and the corresponding water needs (initial (50% of maximum), crop development (50-100%), mid-season (100%) and late season (100% for fresh harvested and 25% for dry harvested crops).
6. Introduce the Et crops (mm/day) for the main crops cultivated by the farmers for each month of the cropping season (calculated by the facilitator or obtained from research stations). Translate mm/day into bucket water (20L.)/m²/day. Discuss the different values of Etcrop using all the influencing factors discussed before.

**Field visit** (1 hour)

7. Go into the field with the farmers and ask the farmers to irrigate a small area of their crop (1-10 m².) as they are used to do. Estimate the area irrigated, total amount of water used and the expected number of days before the crop needs to be irrigated again in case it will not rain.
8. Assist the farmers in the calculation of the irrigation water use (mm/day). Discuss how the calculated irrigated water use and how it relates to the crop water need during that time.

---

1 In case of basin irrigation, the estimated drop (mm) in water level in one day without any rain can be used as well.
Guidelines for (technical) preparations / questions for discussions

Relation between climate, crop, ET, local conditions and irrigation requirement:
**Effect of major climatic factors on crop water needs**

<table>
<thead>
<tr>
<th>Climatic factor</th>
<th>Crop water need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunshine</td>
<td>High: Sunny (no clouds)</td>
</tr>
<tr>
<td>Temperature</td>
<td>High: Hot</td>
</tr>
<tr>
<td>Humidity</td>
<td>High: cool</td>
</tr>
<tr>
<td>Wind speed</td>
<td>High: windy</td>
</tr>
</tbody>
</table>

**Average daily water need (Eₜₒ) of standard grass during irrigation season**

<table>
<thead>
<tr>
<th>Climatic zone</th>
<th>Mean daily temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (&lt; 15°C)</td>
</tr>
<tr>
<td>Desert/arid</td>
<td>4-6*</td>
</tr>
<tr>
<td>Semi arid</td>
<td>4-5</td>
</tr>
<tr>
<td>Sub-humid</td>
<td>3-4</td>
</tr>
<tr>
<td>humid</td>
<td>1-2</td>
</tr>
</tbody>
</table>

4-6 litres of water per m²/day

**Crop water needs (Eₜ crop) in peak period of various field crops as compared to standard grass**

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30%</td>
<td>-10%</td>
<td>Same as standard grass</td>
<td>+10%</td>
<td>+20%</td>
</tr>
<tr>
<td>Citrus</td>
<td>Olives</td>
<td>grapes</td>
<td>Cucumber</td>
<td>Radishes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carrots</td>
<td>Cabbage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lettuce</td>
<td>Onion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Melon</td>
<td>Peppers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tea</td>
<td>Peas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coffee</td>
<td>Potatoes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fruit trees.</td>
<td>Safflower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sunflower</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Four growth stages of a crop**

1. **The initial stage**: This is the period from sowing or transplanting until the crop covers about 10% of the ground.
2. **The crop development stage**: This period starts at the end of the initial stage and lasts until the full ground cover has been reached (ground cover 70-80%).
3. **The mid-season stage**: This period starts at the end of the crop development stage and lasts until maturity; it includes flowering and grain-setting.
4. **The late season stage**: This period starts at the end of the mid season stage and lasts until the last day of the harvest; it includes ripening.

The relation between the reference grass crop and the crop actually grown is given by the crop factor, \( K_c \), as shown in the following formula. Each crop has for each crop stage its own crop factor (\( K_c \))

\[
E_{to} \times K_c = ET
\]

### Values of the crop factor (\( K_c \)) for various crops and crop stages

<table>
<thead>
<tr>
<th>Crop</th>
<th>Initial stage</th>
<th>Crop development stage</th>
<th>Mid-season stage</th>
<th>Late season stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>days</td>
<td>( K_c )</td>
<td>days</td>
<td>( K_c )</td>
</tr>
<tr>
<td>Barley/wheat</td>
<td>15</td>
<td>0.35</td>
<td>25-30</td>
<td>0.75</td>
</tr>
<tr>
<td>Bean, green</td>
<td>15-20</td>
<td>0.35</td>
<td>25-30</td>
<td>0.70</td>
</tr>
<tr>
<td>Bean, dry</td>
<td>15-20</td>
<td>0.35</td>
<td>25-30</td>
<td>0.70</td>
</tr>
<tr>
<td>Cabbage</td>
<td>20-25</td>
<td>0.45</td>
<td>25-30</td>
<td>0.75</td>
</tr>
<tr>
<td>Cotton</td>
<td>30</td>
<td>0.45</td>
<td>50</td>
<td>0.75</td>
</tr>
<tr>
<td>Cucumber</td>
<td>20-25</td>
<td>0.45</td>
<td>30-35</td>
<td>0.70</td>
</tr>
<tr>
<td>Eggplant</td>
<td>30</td>
<td>0.45</td>
<td>40</td>
<td>0.75</td>
</tr>
<tr>
<td>Grain, small</td>
<td>20-25</td>
<td>0.35</td>
<td>30-35</td>
<td>0.75</td>
</tr>
<tr>
<td>Lentil/Pulses</td>
<td>20-25</td>
<td>0.45</td>
<td>30-35</td>
<td>0.75</td>
</tr>
<tr>
<td>Lettuce</td>
<td>20-35</td>
<td>0.45</td>
<td>30-50</td>
<td>0.60</td>
</tr>
<tr>
<td>Maize, sweet</td>
<td>20</td>
<td>0.40</td>
<td>25-30</td>
<td>0.80</td>
</tr>
<tr>
<td>Maize, grain</td>
<td>20-30</td>
<td>0.40</td>
<td>35-50</td>
<td>0.80</td>
</tr>
<tr>
<td>Melon</td>
<td>25-30</td>
<td>0.45</td>
<td>35-45</td>
<td>0.75</td>
</tr>
<tr>
<td>Millet</td>
<td>15-20</td>
<td>0.35</td>
<td>25-30</td>
<td>0.70</td>
</tr>
<tr>
<td>Onion, green</td>
<td>25</td>
<td>0.50</td>
<td>30-40</td>
<td>0.70</td>
</tr>
<tr>
<td>Onion, dry</td>
<td>15-20</td>
<td>0.50</td>
<td>25-35</td>
<td>0.75</td>
</tr>
<tr>
<td>Peanut</td>
<td>25-30</td>
<td>0.45</td>
<td>35-40</td>
<td>0.75</td>
</tr>
<tr>
<td>Pea, fresh</td>
<td>15-20</td>
<td>0.45</td>
<td>25-30</td>
<td>0.80</td>
</tr>
<tr>
<td>Pepper, fresh</td>
<td>25-30</td>
<td>0.35</td>
<td>35-40</td>
<td>0.70</td>
</tr>
<tr>
<td>Potato</td>
<td>25-30</td>
<td>0.45</td>
<td>30-35</td>
<td>0.75</td>
</tr>
<tr>
<td>Sorghum</td>
<td>20</td>
<td>0.35</td>
<td>30-35</td>
<td>0.75</td>
</tr>
<tr>
<td>Soybean</td>
<td>20</td>
<td>0.35</td>
<td>30</td>
<td>0.75</td>
</tr>
<tr>
<td>Sunflower</td>
<td>20-25</td>
<td>0.35</td>
<td>35</td>
<td>0.75</td>
</tr>
<tr>
<td>Tomato</td>
<td>30-35</td>
<td>0.45</td>
<td>40-45</td>
<td>0.75</td>
</tr>
</tbody>
</table>
**Example:** Calculation of crop water need for sweet maize in a Semi-arid climate with a medium daily temperature. Average daily water need of standard grass is 5-6 mm.

<table>
<thead>
<tr>
<th>Sweet maize</th>
<th>Initial stage</th>
<th>Crop development stage</th>
<th>Mid season stage</th>
<th>Late season stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kc²</td>
<td>0.40</td>
<td>0.80</td>
<td>1.15</td>
<td>1.00</td>
</tr>
<tr>
<td>Crop water need (mm/day)</td>
<td>2-2.4</td>
<td>4-4.8</td>
<td>5.75-6.9</td>
<td>5-6</td>
</tr>
</tbody>
</table>

For more technical information, see also:
- [Irrigation water management training manual No. 3, Irrigation water needs, 1986, FAO, Part I: Principles of irrigation water needs.](#)

**Questions for discussions**
- What will be the influence of a windbreak on the crop water need?
- Is all rain, effective rain for crop growth? And irrigation water?
- How does the length of the crop growth period influence the crop water need?

---

² Kc values are influenced also by the humidity and wind speed.
EXERCISE 3G: IRRIGATION SCHEDULING – FREQUENCY AND AMOUNTS

Introduction

When there is already a form of irrigation in place still it is important that the farmer knows how much he/she has to irrigate and how often. In most cases the water sources are scares and the farmer should make use of the water in an optimum way. Over irrigation is a waist of water, time and energy, but under irrigation will reduce yield. For farmers it is often difficult to find the right balance.

Objectives

- To assist farmers in defining a proper irrigation frequency and irrigation amounts.

Expected outputs

- Farmers know how they can determine the irrigate amounts.
- The frequency of a piece of land that has to be irrigated.

Preparations required

- Investigate if there is a clear difference in crop performance among the fields as result of differences in irrigation intensities.

Materials required

- Irrigation equipment available on the field.

Time required

- Three hours.

Timing

- During irrigation season.
Procedure (Steps)

Plenary Introduction  (15 min)

1. Review of previous training session (Exc. 1, Part C).

2. Explain the specific objectives and expected output.

Field visit/field practice  (two hours and 20 min)

3. Visit with the farmers one of their irrigation fields where the crop is not performing well, most likely as result of too much or too little irrigation.

4. Ask the farmer to show how he or she normally irrigates the field on a small part of the field.

5. After the demonstration of the farmer ask the other farmers if the piece of land has been sufficiently irrigated and what the indicators are they use to determine if the land has been irrigated sufficiently.

6. Discuss the indicators mentioned by the farmers, the plant observation method (change in colour, curling of the leaves, leave orientation and leave temperature) and the change in soil moisture content.

7. Ask the farmers to dig a hole at the just irrigated land close to where the crop is planted to observe the wetting front and crop rooting depth. Determine if sufficient water was irrigated. Discuss the influence of the rooting depth and soil type on the total amount that can be irrigated during one application.

8. If there are indications that the water has been unequally distributed in the field, dig also holes at different locations within the field for observation. Discuss how the layout of the field can be changed to support an equal water distribution.

9. If more could be irrigated or too much was irrigated, ask the farmer to irrigate another piece of the field with an adjusted amount of water. Dig again a hole to let the farmers check the wetting front.

Plenary discussion  (30 min)

10. Summarise the discussions and observations made in the field. Discuss the influence of the rooting depth on the total amount of water per irrigation application and, consequently, the intervals between the applications.

11. Discuss the irrigation water need as the crop water need (see exercise 3F) minus the effective rainfall and consequently, the influence of climate.
12. Summarise the factors influencing the irrigation scheduling (amount or net irrigation depth and application intervals). Introduce the estimated irrigation schedules for the crops grown by the farmers from the table and compare the estimated intervals and amounts with the farmer’s practice.


Guidelines for (technical) preparations / questions for discussions

Plant observation method

Plant observation method is based on observing changes in the plant characteristics, such as changes in colour of the plant, curling of the leaves. When a plant comes under water stress the appearance change from vigorous growth to slow or even no growth. Some crops change their leaf orientation when little water is available. Another indicator is the leaf temperature, which increases during the hot part of the day when there is a shortage of water.

The disadvantage of the plant observation method is that by the time the symptoms are evident, the irrigation water has already been withheld too long for most crops and yield losses are already inevitable. Unfortunately it is often the only method farmers can use together with checking the moisture content of the soil. To reduce the negative effect of this method the farmer should select the sandiest spot in his or her field for the observations, where the plants will first show stress characteristics.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Shallow rooting crops</th>
<th>Medium rooting crops</th>
<th>Deep rooting crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow and/or sandy soil</td>
<td>15</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Loamy soil</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Clayey soil</td>
<td>30</td>
<td>50</td>
<td>70</td>
</tr>
</tbody>
</table>
### Estimated irrigation schedules for the major crops during peak water use periods (mid-season stage)

<table>
<thead>
<tr>
<th>Climate</th>
<th>Shallow and/or sandy soil</th>
<th>Loamy soil</th>
<th>Clayey soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interval (days)</td>
<td>Net irr. Depth (mm)</td>
<td>Interval (days)</td>
</tr>
<tr>
<td>Alfalfa</td>
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*) cabbage, cauliflower, etc.
For more technical information, see also:

- **Irrigation water management training manual No. 4, Irrigation Scheduling, 1989, FAO**

Questions for discussions

- What time do you spend on irrigating your field each day?
- Can you irrigate your entire field in that time or only a portion?
- How do you estimate if you have irrigated a piece of land long enough?
- Do you know how much water you irrigate per plant or m²?
- How deep do you think the irrigation water should infiltrate the soil?
- What will happen with the water that infiltrates below the rooting zone?
- What will happen if the irrigation water will only infiltrates a part (top) of the rooting zone?
- Will it take the same amount of water to saturate the entire rooting zone with water on a sandy soil compared to a heavy clay soil?
- What needs to be done to irrigate the entire rooting zone?
- How often do you irrigate the same plants?
- What is the relationship between the irrigation amount and irrigation frequency?
- Does the frequency of irrigation differ with the development of the crop?