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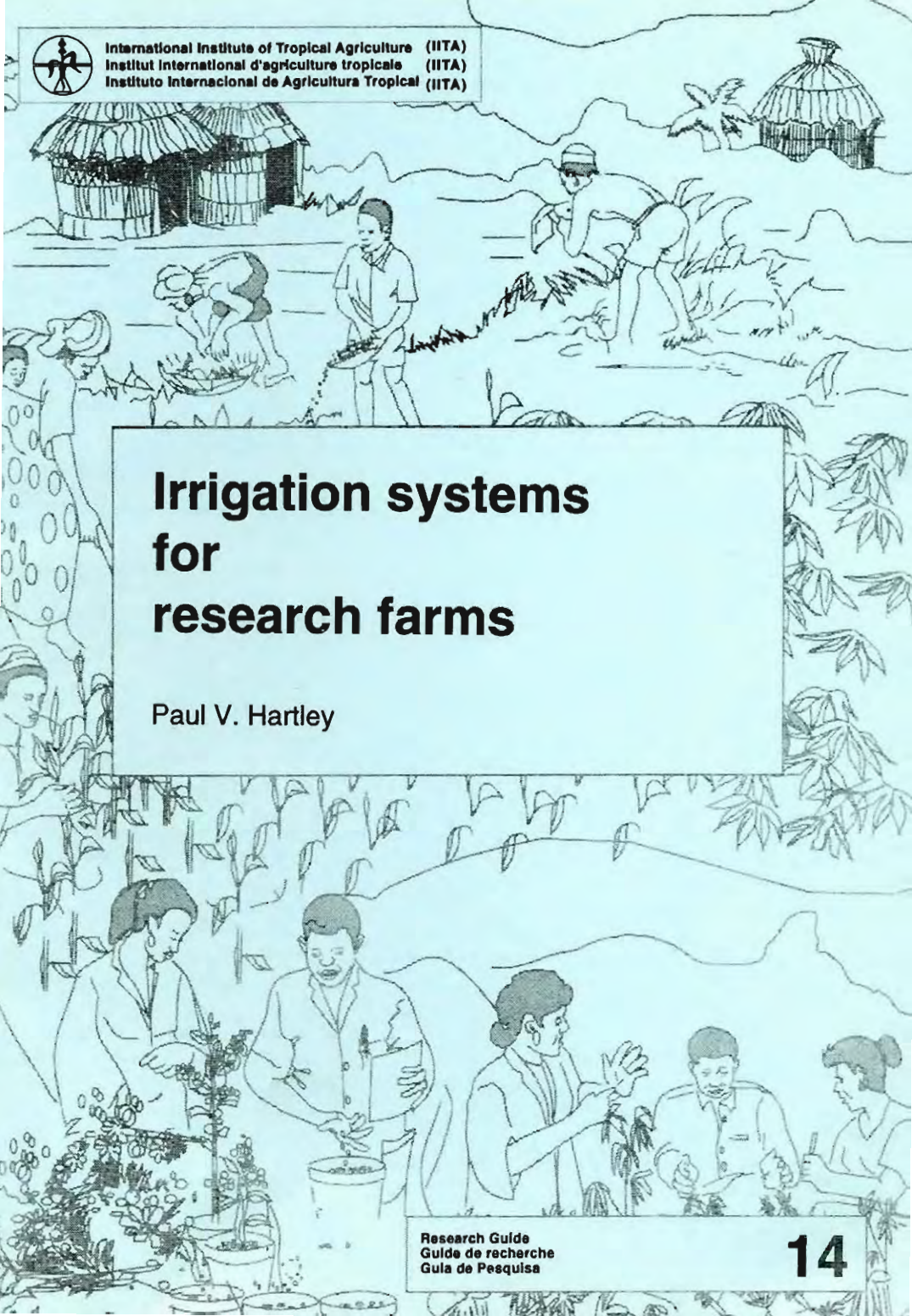

Irrigation systems for research farms

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IITA Research Guides

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Irrigation systems for research farms

Objectives. This guide is intended to enable you to:

- list factors affecting irrigation;
- describe factors that influence types of irrigation;
- discuss factors of water conveyance;
- describe irrigation systems;
- explain pump and pipe irrigation.

Study materials

- Tables with rainfall and evaporation data.
- Illustrations or models of pumps.
- Illustrations of irrigation systems.
- Irrigation equipment.

Practicals

- Calculate water requirements and flow rates.
- Dismantle and review irrigation pumps.
- Observe drainage problems in the field.
- Irrigate a field with different irrigation systems.

Questions

1 What are the effects of bad drainage?

2 What is the single most important input into any successful irrigation system?

3 On what factors does irrigation requirement depend?

4 What are the effects of over-irrigation?

5 What are the moisture characteristics of coarse soils and fine soils?

6 On what factors does the type of irrigation depend?

7 What are usual methods of powering pumps?

8 How can you measure the flow rate of water?

9 What lining materials are available for conveyance of water?

10 Discuss flood and furrow irrigation.

11 What is the principle of ground water irrigation?

12 Name several systems of sprinkler irrigation.

13 What is the principle of the multi-sprinkler static irrigation?

14 What possibilities exist to make the multi-sprinkler mobile?

15 What is a single sprinkler static?

16 Describe single sprinkler mobile.

Irrigation systems for research farms

Abstract. Irrigation is as old as civilization. Irrigation supplements the water available from rainfall and ground water. The real value of irrigation is not so much in preventing a total crop loss as in getting maximum yield. If irrigation is for profit, the increase in crop value due to irrigation must be equal to, or more than the cost of the irrigation system. Only good management practices bring good results.

1 Factors affecting irrigation

Irrigation is a specialized subject. If a large irrigation scheme is planned for an area, it is advisable to request the services of a specialist for advise and design on system layout.

Quality irrigation is only possible with the correct water pressures and flow rates. Quality drainage is only possible when the drainage system is clear and clean without weeds. Bad drainage leads to water logging and consequent build up of salts in the soil.

The single most important input into any successful irrigation system is **enough water.** Irrigation requirements depend on several other factors:

- amount, duration and frequency of rainfall;
- evaporation rate;
- soil/water retention capability;
- soil situation: slopes, depressions and drainage;
- costs and return.

Advantages of proper irrigation are increased yields from higher plant densities and healthier plants.

Over-irrigation, however, is damaging. Effects of over-irrigation is water logging caused by poor drainage and resulting in:

- poor establishment,
- poor growth,
- salinity.

Remember:

coarse soils	high intake rate but low retention;
fine soils	low intake rate but high retention.

2 Water sources and supply

Types of irrigation depend on :

- water sources,
- water removal,
- transportation of water.

Water sources. Irrigation water can come from several sources. The sources must be approved. Irrigation requires more water several times than domestic use. Consideration must also be given to other users if they depend on the same source further "down stream", as in the example of a river.

Water sources are:

- rivers,
- lakes,
- ponds,
- reservoirs,
- boreholes (not domestic ones!).

Water removal. Because of the enormous variation of demand for water, the methods of water removal are more than the types of sources. Every installation or scheme is different and specifically designed and purpose built.

Water can be removed by gravity or pumping. Pumps can be:

- axial,
- centrifugal
  - single stage,
  - multi stage,
- turbine
  - single stage,
  - multi stage,
- bucket and valves,
- piston and valves.

Usual methods of powering pumps are by:

- electricity,
- engine power (diesel, petrol, steam),
- wind power,
- animal power,
- human power.

Vast areas of irrigation in the world are operated by old manual systems.

Transportation of water. In general, the largest volumes of water are transported in open waterways by gravity. Sometimes, large volumes of water have to traverse a valley either above ground by way of an aqueduct, open or closed, or below ground by way of an inverted syphon, often of very large dimensions. However, smaller volumes are moved by pipe of one form or another from the source to the point of supply, depending on the irrigation system used.

Usual methods of water transport are:

• Rivers	channels, canals, field laterals, ditches (usually waste water).
• Pipes below ground	mains, laterals, hydrants.
• Pipes above ground	mains, laterals, lines.
• Holding ponds and reservoirs	filled slowly by canal, pipe or pump, emptied quickly for irrigation by gravity or by pump.

3 Water conveyance

Water loss. In the dryer areas of the world, irrigation is often the only means of cultivating a crop. Yet, these dryer areas because of their soils, pose the greatest problem. Much water is lost during transportation from one area to another.

Overcoming water losses is expensive. In areas where retention methods are not affordable, larger canals and waterways may be constructed to convey more water expecting a high proportion to seep away.

If the water is pumped at a cost however, losses are unaffordable and the canal must be lined with an impervious membrane. Concrete lining is usually preferred.

On a smaller scale, water losses can occur with pipes, both above and below ground level. Leakage from pipes is more critical where pressure is required. Many irrigation systems require "pressure" in the system. To produce pressure, a large or a high-pressure pump is required. Every point or section where a leak could occur must be checked.

Flow rate. Flow rates in irrigation systems are vital. Without flow rates, it is impossible to know how much water has been applied to the field or irrigation plot. Time alone is not sufficient to know how much irrigation water has been applied, although time is also important.

In open channels, water can be measured by passing it through a "vee" notch or a flume with known dimensions. In the "pipe", water is passed through a flow meter which records the quantity per minute (flow rate) and the total volume.

Conveyance medium. In the past, on both large and small-scale canals, concrete lining was used. Concrete is expensive, therefore other lining materials were discovered.

Membranes formed from asphalt, plastics and synthetic rubber are widely used in an exposed form to line canals. Membranes are buried for durability and increased life span.

Water conveyance in pipes has also changed. Originally, pipes of 1 m diameter or less were steel while larger pipes were concrete. Steel has many advantages, especially where control valves, off takes, changes of pipe direction, and long spans of supported pipe occur. However, for use over a distance, steel pipes are expensive and slow to install.

Cast iron pipes are cheaper. Asbestos and plastics are cheaper and easier to install. However, both asbestos and plastic pipes are generally not suitable for aboveground applications.

4 Irrigation systems

Irrigation systems include:

- gravity irrigation,
- ground water irrigation,
- pump and pipe irrigation.

Gravity irrigation. Gravity irrigation includes flood irrigation and furrow irrigation.

Flood irrigation. If water supply is unlimited, the water can be used to flood crops. However, the land must be level, otherwise water logging occurs.

Furrow irrigation. Furrow irrigation is generally more economical and better suited to uneven land which has a fall away from the water source. The system involves ridging the land and passing the irrigation water down the furrows.

The water can be supplied onto the land either through gated pipe – irrigation pipe fitted with small sliding gates which when lifted allows the water to pass out, or by syphon tubes. Syphon tubes are either curved, rigid aluminium or plastic pipes, or flexible tubes which syphon out water from a higher level (canal or field feeder) to a lower level (field furrow).

Ground water irrigation. With surface irrigation, water losses occur through seepage and evaporation. Ground water irrigation can overcome this problem.

Above ground, water is carried in small bore plastic pipes and discharged out through "emitters". The flow rate is determined by the size of the hole in the unit (drip irrigation).

A similar system can be used with below ground application of water (trickle irrigation), whereby water discharges directly into the ground and the root zone of the plant.

Both systems are usually used in orchards for the production of fruit trees, or in vineyards and soft fruit farms. As the systems are semipermanent and constantly discharge water to the plant root zone, they are unsuitable for field crops. The systems are also very expensive.

Pump and pipe irrigation. Irrigation by pump and pipe implies that irrigation water is taken from a source by a pump, pressurized by the pump, and discharged down a pipeline to the field where it is distributed by one large sprinkler (usually a mobile rain gun). A network of smaller units (usually a permanent fixed set of knocker or turbine sprinklers) is also used.

Pump and pipe irrigation is described in the following section.

5 Pump and pipe irrigation

A pumping unit may require a permanent pump house with the pumps installed within, or the unit may be just a mobile pump set up beside the water source. The pump discharges into a main pipeline system, which could be above or below ground.

From the main pipeline, irrigation water is distributed into the field by lateral lines to which the sprinkler lines are attached to form a total grid coverage of the field or plot. Many systems are available to supply sprinklers:

- multi-sprinkler static,
- multi-sprinkler mobile,
- single-sprinkler static,
- single-sprinkler mobile.

Multi-sprinkler static. Pipes remain permanently in the field, and sprinklers are set up to cover the whole plot. Sometimes, the sprinklers are moved from pipe to pipe once or twice a day. In this case, smaller pumps and smaller bore pipes can be used. Also, less water has to be supplied for a row of sprinklers as opposed to a whole field at the same time. Both systems - "solid set" or "porta grid" give the most uniform irrigation coverage.

Sprinklers used on these systems are the "knocker" type whereby a "spoon" deflector is placed in line with the discharge jet. The jet causes the spoon to react against a spring. When the spoon rebounds, it knocks the sprinkler body, thereby causing the body to rotate.

Recently, turbine sprinklers have been developed which give a more constant, even, and continuous discharge of irrigation water.

Multi-sprinkler mobile. One method of irrigating a large area is to move the lateral or sprinkler pipeline mechanically and usually automatically by:

- side wheel roll,
- side wheel move,
- center pivot,
- side move lateral.

Side wheel roll. The sprinkler pipe is "rolled" by being set up in wheel centers. The wheels then rotate. A fairly complicated system of droppers ensure that the sprinklers are vertical at all times.

Side wheel move. The side wheel move is similar to the side wheel roll, but instead of rotating, the pipe remains fixed with the sprinklers vertical. The whole pipe is moved by wheels mounted on a chassis.

Center pivot. The sprinkler pipe is joined to the pivot at one end from where water is passed into the line. The whole pipe is carried on supporting frames which are powered by electric motors, hydraulically by water or mechanically around the pivot in continual circles.

Side move lateral. The disadvantage with the center pivot is that the lateral pipe and sprinklers move in circles. However, not all fields are circular or can accommodate pivots easily. A sophisticated form of side move was developed by moving a center pivot type lateral in a linear fashion across the field or plot. These systems can be complicated, taking their water from channels, set across the field or automatically coupling onto field hydrants as in the latest machines. Built in computers control the center pivot and lateral or linear move.

Single-sprinkler static. The single sprinkler is a rain gun. The rain gun is used as supplementary irrigation capable of "throwing" water approximately 50 m. In the static form, it spreads farmyard effluent onto the field, and would only be moved when the area was saturated. However, the rain gun is commonly found in a mobile configuration.

Single-sprinkler mobile. Two basic methods of moving a rain gun across a field are:

- making the rain gun self propelled where it winches itself on a cable and drags its hose behind if it does not reel it in;
- pulling the rain gun by the feed hose as the hose is reeled in onto a drum at the side of the field.

It is simpler to station the hose reel at the side of the field and pull the rain gun which is mounted on a trolley or skid towards it. The reel is generally quite heavy. The hose reel has various built in shut down devices in case of fault or failure. The hose reel is either turbine or piston driven, powered by the water or by a small diesel engine for large units.

Other types of mobile multi-sprinkler systems exist for example, the rotating boom, but the designs are old and obsolete.

6 Bibliography

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7 Suggestions for trainers

If you use this Research Guide in training ...

Generally:

- Distribute handouts (including this Research Guide) to trainees one or several days before your presentation, or distribute them at the end of the presentation.

- Do not distribute handouts at the beginning of a presentation, otherwise trainees will read instead of listen to you.

- Ask trainees not to take notes, but to pay full attention to the training activity. Assure them that your handouts (and this Research Guide) contain all relevant information.

- Keep your training activities practical. Reduce theory to the minimum that is necessary to understand the practical exercises.

- Use the questions on page 4 (or a selection of questions) for examinations (quizzes, periodical tests, etc.). Allow consultation of handouts and books during examinations.

- Promote interaction of trainees. Allow questions, but do not deviate from the subject.

- Respect the time allotted.

Specifically:

- Discuss with trainees about experiences and problems of irrigation (10 minutes).

- Present and discuss the content of this Research Guide, considering the study materials listed on page 3 (45 minutes).

  As far as possible, have (transportable) irrigation equipment available.

- Conduct the practicals suggested on page 3 in groups (3-4 trainees per group; 2 hours). Make sure that each trainee has the opportunity to practice. Have resource persons available for each group and practical.

  Organize your practicals/demonstrations well. Keep trainees busy. Prevent trainees from scattering around the field.

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