Introduction to Irrigation

Lesson Aim

To describe the nature and scope of the irrigation industry.

INTRODUCTION

Irrigation is the technique of supplying a plant’s needs for water. It is an integral part of successful crop production ranking as highly in terms of importance with fertilising and the control of weeds, pests and diseases. Its interrelationship with these other techniques can determine the outcome of the irrigation, whether beneficial or detrimental, depending on the skill with which it was undertaken. For example, irrigation may provide adequate water for successful crop production or it may provide too much. In the latter case, this could cause overloading of drainage systems or cause water tables to rise to the point whereby salts etc. are brought within reach of the plants’ root zones. Water may also make nutrients readily available or it may leach nutrients if applied excessively.

Water is essential to plant growth and is often the major limitation to productivity. Irrigation is now playing a more important role in horticulture than ever before. However, depending on the climate, the value of the plant, the value of the land and its suitability for irrigation, the cost, reliability and quality of the water supply, irrigation may or may not be possible or feasible.

Irrigation is most widely undertaken in arid and semi-arid climates where soils may be quite fertile, but natural rainfall is insufficient for plant requirements. It is also undertaken successfully in areas with other climate characteristics where it can be used to overcome water shortages in dry times, thus extending growing seasons and hence the types of crops that can be grown, or simply increasing the range of crops. It may also act as a safeguard against times of irregular or unreliable rainfall. Irrigation requirements may range from the complete supply of a plant's needs over the entire growing season down to the occasional small supplementary needs of plants in severe dry seasons. The use of irrigation to produce improved yields where plants can be grown with just natural rainfall is termed as *supplemental irrigation*.

It may supplement the existing rainfall and improve growth rates by extending the growth period of the plant, or by ensuring there is adequate moisture during critical periods when the plant is growing most rapidly. The value of irrigation can vary greatly from year to year depending on the distribution of rainfall during the growth season. Irrigation at appropriate times may also improve the quality of turf or the general health of garden plants.

OBJECTIVE OF IRRIGATION

The main objective of irrigation schemes or systems is to produce a particular desired pattern of plant growth. Maximum vegetative growth does not necessarily correspond to maximum yield of the part of the plant desired e.g. fruit, nuts, or roots. In addition, achieving maximum yield may require inefficient use of available resources, whether it is land, water, equipment, or labour. 'Optimum yield' is usually the desired objective.

This has been defined as the yield at which the benefit/cost ratio is at maximum, although even this may be hard to achieve if any of the resources required for the irrigation system e.g. land, water, or equipment is limited. Therefore, it is important to clearly define the purpose or desired outcome of an irrigation system

IRRIGATION: THE WIDER VIEW

Irrigation can be used to produce outcomes in terms of crop production. Irrigation schemes may also have other outcomes. Large-scale schemes may have an impact on human settlement patterns, causing local migrations of labour to or from irrigated areas with subsequent changes in the availability and cost of housing and services.

Land prices may also be severely affected as land use patterns change. Impoundment of rivers and streams into dams and lakes can result in major environmental changes (such as changes to river characteristics and to flora and fauna populations) in areas both adjacent and far removed from those features. Small scale, even down to individual garden size systems, can still cause far-reaching changes. For example, the base flow component (year-round flow) of many urban streams derives almost entirely from home irrigation of gardens. If this was to stop these streams would cease flowing for much of the year. In addition, much of the excess water from irrigation systems that flow to streams, rivers and lakes is high in chemicals leached out of gardens or other crop areas. These chemicals, particularly nitrogen and phosphorous from fertilisers and pesticides, can cause major changes in vegetation and animal populations in and adjacent to water bodies.

SOURCES OF WATER

Water for irrigation is generally obtained from one or more of the following sources:

- On-site storage such as dams or tanks where runoff is collected and stored for later use
- Bore water or underground wells
- Irrigation channels where water is distributed from storage facilities often large distances away
- From streams, lakes or rivers
- From mains or town water systems (usually carried by pipes and/or aqueducts or channels).

FEASIBILITY OF IRRIGATION

Before undertaking or designing a large-scale irrigation project, a feasibility study should be undertaken to show whether it is desirable to commit resources such as capital, labour, time, land, etc. to such a project. Specialist irrigation consultants are used for large projects, as many complex and far-reaching factors such as topographic features, national and international agricultural and financial markets, transport and communications networks, state and federal policies need to be considered.

The economics of small irrigation systems, including systems for nurseries, farms and even home gardens, also need to be evaluated. Factors to consider include the availability of materials, the expertise and cost required to install and operate the system, and the outcomes and profitability of the system.

HOW TO IMPROVE THE QUALITY OF WATER FROM ANY SOURCE

The main sources of water for use on the farm are; rain, river, stream, bore, well or underground spring, and dam or irrigation channel. When we want to use water for a specific purpose we must consider its quality: a supply that is of a high quality for one purpose may be of low quality for another.

Likely Quality Problems in Different Kinds of Water

Table 1 below shows the likely quality of water from different sources, and possible problems that can be caused by impurities. Physical impurities are particles in the water; chemical impurities are substances dissolved in the water. Biological impurities are algae and some micro-organisms; bacteriological impurities are shown separately because of their importance.

The quality of water may be found by testing a sample. This can be carried out by the following companies:

- Companies that sell equipment for the treatment of water
- Local organisation such as dairy factories and water treatment trusts
- The department of Agriculture
- Department of Mines
- Department of Health
- Rivers and Water Supply Commission.

Before collecting water for testing you should contact the testing organisation for advice on how the sample should be gathered.

Table 1. Comparison of Water Sources

	Kind of Water			
	Rain, Creek	**River or Spring**	**Bore or Channel**	**Dam and Irrigation**
Likely Physical Impurities	Hardly Any	Sediment, Turbidity & Colour	Hardly Any	Sediment, Turbidity & Colour

Likely Chemical Impurities	Hardly Any	Many or Few Depending on: Alkalinity, Corrosion, Salinity	Salt Causing Hardness	Generally Few
Likely Biological Impurities	Algae	Many or Few Depending on Source	Hardly Any	Good but Depending on Source may Contain Iron Bacteria
Likely Bacteriological Impurities	Good if Stored Properly	Good or Poor Depending on Source	Good but may Contain Iron Depending on Source	Medium or Poor depending on Supply

PROBLEMS OF WATER QUALITY AND THEIR REMEDIES

1) PHYSICAL IMPURITIES

Sediment

This consists of insoluble particles greater than 1000 millimicrons in size. Generally they are clay particles

Problems:

These particles will tend to settle out, silting up pipes, water heaters and tanks.

Treatment:

The particles can be filtered out by using a sand filter.

Turbidity

This is caused by suspended particles less than 1000 millimicrons in size. They stay suspended in water indefinitely because they have a large surface area compared to their mass, and they are negatively charged, which prevents them grouping together and settling out.

Problems:

These include staining of equipment and unpleasant appearance.

Coagulants:

The fine particles must be made to group together so they can no longer remain in suspension. This can be done by using a chemical coagulant. Aluminium Sulphate $Al2(SO_4)^3$ and slaked lime

$Ca(OH)^2$ are used. The coagulant neutralises the negative charges on the particles causing them to group together and form a jelly-like floc which entangles and collects other particles.

Colour

This is often referred to as leaf stain. It is usually caused by organic materials such as tannins and lignins released from leaves and other vegetation.

Problems:

The only problem is usually the unpleasant appearance of the water.

Treatment:

In some cases colour will be removed by treatment for turbidity. Colour can also be removed by suitable cationic coagulants supplied by commercial companies.

Treatment for turbidity:

Sediment, turbidity and sometimes colour can be removed by alum like treatment in damns and tanks. Tank treatment is preferable.

2) CHEMICAL IMPURITIES

Hardness

This is caused mainly by calcium and magnesium salts, which are dissolved in the water as it filters through soil. The nature of the soil will largely determine the hardness. Hardness is classified in terms of the amount of calcium carbonate in the water.

Hardness is measured either in terms of parts per million (ppm), milligrams per litre (mg per l), grains per gallon (gpg) or degrees of hardness. Chemists and engineers prefer to use mg per l; the water treatment trade prefers to use gpg.

Conversions are:

1 mg per L = 1 ppm

1 mg per L = 0.07 gpg

1 gpg = 1 degree of hardness

Table 2. Hardness of Different Soil Types

CLASSIFICATION	mg per litre of $CaCO^3$	gpg
Soft	0 - 50	0 - 3.5
Moderately Soft	50 - 100	3.5 - 7.0
Slightly Hard	100 - 150	7.0 - 10.5

Hard	150 - 300	10.5 - 21
Very Hard	More than 300	More than 21

Hardness can be temporary or permanent.

Temporary hardness:

This is caused mainly by calcium and magnesium bicarbonates. These substances are decomposed by heat (bicarbonate ions are converted to carbonate ions on heating) and precipitated as insoluble carbonates. The carbonates build up as scale on heating elements and kettles.

Permanent hardness:

This is caused by the presence of calcium and magnesium chlorides, nitrates or sulphates in water.

Problems caused by hardness:

- It prevents lathering of soap, making washing and cleaning difficult
- It accelerates the formation of milk stone on dairy equipment
- It shortens the life of pipes and water heaters. Scale accumulates on heating elements and causes poor transfer of heat, overheating and burning out of the elements.

Treatments and remedy:

- Use of synthetic detergents specially formulated for use in hard water. These can be used in water containing up to 500 mg per L hardness.
- Reduction of formation of scale by controlling temperature in heaters. Hardly any scale is formed below temperatures of 71°C (160°F)
- Hard water can be treated with lime $Ca(OH)^2$ and soda ash Na^2CO_3 in tanks.
- Hard water can be treated with commercially available water softeners. Analysis of the water will allow you to determine the problems present and what chemicals will deal with them.

Alkalinity

This is caused mainly by bicarbonate, carbonate and hydroxide ions in the water. Alkalinity is usually associated with hardness.

Problems:

- Often, alkaline water will be highly corrosive. The higher the proportion of hydroxide ions present the more corrosive it will be. These problems are dealt with under 'corrosion' below
- Water spotting and dullness of surfaces of equipment
- High alkalinities can interfere with the action of detergents and sanitisers
- The disinfecting action of chloride compounds is decreased at pH levels often associated with alkalinity.

Treatment and remedies:

- Use of de-alkaliser: softener is very expensive and its use is not warranted
- Mix alkaline water with water of low alkalinity if available
- Use an alternative supply if available.

Corrosion

The acidity and alkalinity of water are measured by a scale called the pH scale. On this scale, water of pH 7 is neither alkaline nor acid. Water of pH less than 7 is acid, water of pH higher than 7 is alkaline. The higher the pH the higher the alkaline level, and the lower the pH the more acidic the water will be. Acid water has a bitter taste, and alkaline water is like a weak solution of washing soda. Highly acidic and highly alkaline water are both corrosive.

Problems:

- Corrosion and pitting of pipes; blockage of galvanised pipes; red stain in water from galvanised pipes
- Green staining of clothes and fittings caused by products of corrosion of copper pipes and water heaters.

Treatments:

- Neutralise acid water by adding the appropriate amount of alkali
- Neutralise alkaline water by adding the appropriate amount of acid
- A number of commercial water treatment companies market neutraliser filters.

Iron

Reddish brown discolouration of water is generally caused by corrosion, but may be caused by dissolved iron in the water supply or by the action of iron bacteria. Iron bacteria are often found in bore waters that are acidic.

Problems:

- Water turns cloudy followed by the formation of insoluble reddish brown sediment on exposure to the air. This happens when soluble ferrous iron in water is oxidised to form a precipitate of Ferric Oxide
- Iron deposits build up in a pipes and tanks and the equipment is stained
- The taste of the water may be spoiled
- Slimy, mucous substances may form and clog pipes. These are caused by the action of a group of bacteria that need iron to live. They get the iron from iron bearing water, or by corroding pipes.

Treatments:

- Iron bacteria can be killed by chlorinating the water supply, or by mixing 30 grams of calcium hypochlorite into a smooth paste and diluting it into 200 litres with water. This diluted solution can be injected into the bore. It can also be used to flush out pipelines, tanks and troughs.
- The dissolved iron can be removed by precipitating it. This is done by speeding up the oxidation process so that the dissolved iron will precipitate. The first requirement is to raise the pH to 7 (neutral).
- If the iron is present in the water to the extent of 0.2 - 3.0 mg per L it can be prevented from discolouring and staining the water by feeding a polyphosphate into the water, This reacts with iron to form a soluble complex.
- If iron is present to the extent of 0.2 -25 mg per L it can be removed by chlorination to oxidise the iron, followed by filtration through a sand bed. The iron may also be oxidised by building a simple aerator.
- Some water softeners can remove up to 3 mg per L of Iron.
- Commercial companies market an oxidising filter for iron treatment.

Salinity

This is caused by soluble salts. It may be a problem in waters from bores.

Problems:

- If sodium in saline water replaces exchangeable cations on the soil clay particles the soil will have poor physical condition and take water very slowly.
- Scorching and wilting of plants.

Remedy:

Nothing can be done about excessive salt in a water supply without great cost. The salinity may be bought down to useable limits by mixing the saline water with non saline water, if available. Salt tolerant plants may be used.

Tastes and Odours

Many tastes and odours that commonly spoil the palatability of water are caused by mineral or organic substances dissolved in it. They indicate pollution of the water supply. The pollution may come from algae, fungi, bacteria, animal waste, decaying organic materials, metallic compounds such as iron and manganese, chlorides, hydrogen sulphide, sulphates, industrial waste and sewage.

Treatments and remedies:

- Locate and remove the source of the taste and odour
- If caused by algae, treat as described in section on algae
- Chlorination may be necessary, depending on what is causing the problem, to kill bacteria and make the water safe to use
- Commercial water treatment companies market activated carbonless filters which will remove taste and odours
- Aeration treatment may remove tastes and odours caused by iron.

3) BIOLOGICAL IMPURITIES

Algae

These are primitive forms of plant life that are common and normal in surface water.

Problems:

- Plentiful growth of algae can indicate pollution of the water supply. Nutrients for the growth of algae comer from animal waste, decaying organic matter, phosphates, industrial waste and sewage
- Tastes and odours
- Blockage of pipes and fittings
- Removal of oxygen from water
- Corrosion of metal pipes and tanks.

Treatments and Remedy:

- If algae grow in tanks and the tops of bores, clean them out and cover. Algae cannot grow in the absence of sunlight.

- Copper Sulphate can be used. Small amounts of copper are toxic to algae. The copper sulphate should be applied at a rate of 400gms to one megalitre of water.(1,000,000 litres)
- A number of algaecides are available from chemical firms.

Micro-organisms

These are primitive forms of animal life that may be present in water supplies. They are much bigger than bacteria but can generally be treated in the same way as bacteria by chlorination.

These are important in the case of water used for domestic purposes. Many bacteria are harmless, but for water to be safe for domestic use it must be free of pathogenic bacteria.

Remedy and treatments:

- Roofs from which rainwater is collected should be clean, so should gutters and tanks. Tanks should be covered to prevent contamination by dust, insects and bird droppings.
- Water can be chlorinated by a small feed pump to inject controlled amounts of chlorine solutions into the supply. Chlorinated water must be held up to one hour to kill bacteria. Water to be chlorinated must be clear and it's pH below 7.6.
- Water for domestic use should be chlorinated to give 0.5 to 0.8 mg of residual free chlorine per litre at the point of use.
- Super-chlorination does away with the need for long holding times. In this method 3 - 5 mg per litre of residual free chlorine is added by a chemical feed pump and then removed by an activated carbon filter.

SET READING

Refer to, and read any reference material you have access to that relates to the aim of this lesson. This may include any of the following:

- Websites
- Books in your own possession, or which you find in a library
- Periodicals you have access to (i.e. magazines, journals or newspapers)

Spend no more than 2 hours doing this.

SET TASK

Set Task 1

Contact the body responsible for water distribution in your local area. This may be a state government body, or perhaps a local statutory authority. Find out all that you can about the different sources of water (including groundwater) in your locality. Find out also what you can on the quality of water from these sources. If possible collect any leaflets or brochures they provide.

Set Task 2

Compare the water quality from at least three sources you identified in your first Set Task. Example: compare bore water with the quality of town water and rain water, etc.

How do they rate in terms of suitability for irrigating a garden?

Set Task 3

Contact someone who has recently installed an irrigation system for a garden, park, or other landscaped area. Look closely at the system and consider what would be involved in the installation. Find out the reasons for installing it and detail, as much as possible, the costs involved in installing the system and operating the system. Make notes on the wastage of water from the system. Are there ways to improve the system?

If you are unable to do this, conduct an internet or library search into a particular type of horticultural irrigation system of your choice. Look closely at the system and consider what would be involved in the installation. Find out the advantages of installing the particular system and summarise, if you are able to, the costs involved in installing and operating the system. Make notes on any wastage of water from the system. Can you see ways to improve the system?