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Sustainable Agricultural Livelihood Restoration, Rehabilitation and Resilience in Kenya

Training Manual

2.2.5 SUB-MODULE 5: IRRIGATION AND DRAINAGE

Introduction

In the dry lands of sub-Saharan Africa, water defficiency is the most important environmental factor limiting yields in agriculture. When irrigated, these areas can have a high yield potential because of the high solar radiation, favourable day and night temperature and low atmospheric humidity, conditions that decrease the incidence of pests and diseases compared to areas in temperate zones. The key to maximising crop yields per unit of supplied water in dry lands is ensuring that as much as possible of the available moisture is used through plant transpiration and as little as possible is lost through soil evaporation, deep percolation and transpiration from weeds.

There has been growing concern on the performance of conventional irrigation systems in sub-Saharan Africa. The poor performance of irrigation projects seems to have contributed to stagnation in new irrigation development. Irrigation potential in the region is considerable but largely unexploited.

The anticipated long-term yield increases for irrigated land which earlier depended on unpredictable and unreliable rainfall have not always been achieved. This has contributed to irrigation losing its appeal as an investment strategy. Good performance in irrigation systems is not only a matter of high output but also of efficient use of available resources. For example, the inefficient use of irrigation water in arid areas is not only wasteful but often leads to salinization of the soil profile. Irrigation systems that are to be effective and efficient must ensure that drainage, maintenance of soil fertility and salinity-control measures are employed.

Major Methods of Irrigation

Irrigation water is applied to land by three general methods: surface irrigation, sprinkler irrigation and localised irrigation systems. The choice of irrigation method is site specific and depends on topography, the amount of water available, the quality of the water and soils, as well as economic and social considerations.

Surface Irrigation

The surface method of irrigation involves applying water over the soil surface. The water is conveyed over the soil surface and infiltrates into the soil at a rate determined by the infiltration capacity of the soil. Surface irrigation methods include:

Basin Irrigation

Basin irrigation where water is applied to a flat area surrounded by dikes. The water ponded in the basin area continues to percolate into the soil sometime after the stream has been turned off. Basin irrigation stream sizes are usually 15.240 litres per second depending on soil texture, field size, required depth of irrigation and bund height.

Advantages

- Check basins are useful when leaching is required to remove salts from the soil profile.
- Rainfall can be conserved, and soil erosion is reduced by retaining large part of rain
- High water application and distribution efficiency.

Limitations

- The ridges interfere with the movement of implements.
- More area occupied by ridges and field channels.
- Impedes surface drainage
- Precise land grading and shaping are required
- Labour requirement is higher.
- Not suitable for crops which are sensitive to wet soil conditions around the stem.

Border Irrigation

In Border irrigation, water is allowed to flow down a gentle slope (< 0.1%) between bunds. It advances slowly down the strip and is stopped when sufficient water has infiltrated at the top of the border strip. Border stream sizes are usually 2.15 l/s/m depending on soil type, slope, width and length of border strip and depth of irrigation.

Advantages

- Border ridges can be constructed with simple farm implements like bullock drawn “A” frame ridger or bund former.
- Labour requirement in irrigation is reduced as compared to conventional check basin method.
- Uniform distribution of water and high-water application efficiencies are possible.
- Large irrigation streams can be efficiently used.
- Adequate surface drainage is provided if outlets are available.

Furrow irrigation

Furrow irrigation where water is allowed to flow down slope in small channels (furrows) between crop rows. The water is gradually absorbed into the bottom and sides of the furrow to wet the soil. Furrow irrigation stream sizes are usually 0.2.3.0 l/s.

Advantages

- Water in furrows contacts only one half to one fifth of the land surface.
- Labour requirement for land preparation and irrigation is reduced.
- Compared to check basins there is less wastage of land in field ditches.

There are 2 types of furrow irrigation based on the alignment of furrows

- Straight furrows
- Contour furrows

There are 2 types of furrow irrigation based on size and spacing

- Deep furrows
- Corrugations

Based on Irrigation:

- All furrow irrigation: Water is applied evenly in all the furrows and are called furrow system or uniform furrow system.
- Alternate furrow irrigation: It is not an irrigation layout but a technique for water saving. Water is applied in alternate furrows for e.g. during first irrigation if the even numbers of furrows are irrigated, during next irrigation, the odd number of furrows will be irrigated.
- Skip furrow irrigation: They are normally adopted during water scarcity and to accommodate intercrops. A set of furrows are completely skipped out from irrigation permanently. The skipped furrow will be utilised for raising intercrop. The system ensures water saving of 30-35%. By this method, the available water is economically used without much field reduction.
- Surge irrigation: Water is applied into the furrows intermittently in a series of relatively short ON and OFF times of irrigation cycle. Intermittent application of water reduces the infiltration rate over surges thereby the waterfront advances quickly. Hence, reduced net irrigation water requirement. This also results in more uniform soil moisture distribution and storage in the crop root zone compared to continuous flow. The irrigation efficiency is between 85 and 90%.

Surface irrigation, however, may not be appropriate for porous soils (final infiltration rates > 7 cm/h) such as sandy soils, or soils with final infiltration rates that are too low (< 0.3 cm/h). Although surface irrigation can be efficient (70% or more), in a typical farmer's situation less than half of the applied water reaches the plant because of poor irrigation practices. Higher efficiencies can be obtained where land characteristics are suitable for surface irrigation with proper design and better water management.

Sprinkler Irrigation

In overhead sprinkler irrigation, water is distributed in pipes under pressure and sprayed into the air so that the water breaks up into small water droplets that fall to the ground like natural rainfall. Sprinkler irrigation methods include conventional sprinklers, rain guns, centre pivot and linear move systems. Compared to surface irrigation, sprinkling generally requires less land levelling, can be adapted to sandy and fragile soils and requires less labour. However, higher pumping energy is required to lift the water and create enough pressure to operate the sprinklers. Care must be taken to sprinkle the water at rates lower than the soil's final infiltration rate. This is especially important on heavy soils and sloping land where proper management of the soil is essential to ensure that the soil's infiltration rate is not reduced below the rate at which sprinklers apply the water.

A typical application efficiency is 75%, that is, some three-quarters of the applied water reaches the roots of the plant, while one-quarter is lost through deep percolation, runoff and evaporation losses.

There are 2 types of sprinkler systems

- 1. Rotating head (or) revolving sprinkler system
- 2. Perforated pipe system

Based on the portability

- ***Portable system***: It has portable mainlines and laterals and a portable pumping unit
- ***Semi portable system:*** This is similar to a fully portable system except that the location of the water source and pumping plant are fixed.
- ***Semi-permanent system:*** This system has portable lateral lines, permanent main lines and sub - mains and a stationary water source and pumping plant. The main lines and sub-mains are usually buried, with risers for nozzles located at suitable intervals.
- ***Solid set system:*** This system has enough laterals to eliminate their movement. The laterals are placed in the field early in the crop season and remain for the season.
- ***Permanent system:*** It consists of permanently laid mains, sub-mains and laterals and a stationary water source and pumping plant. Mains, sub-mains and laterals are usually buried below plough depth. Sprinklers are permanently located on each riser.

Advantages

- Water saving to an extent of 35-40% compared to surface irrigation methods.
- Saving in fertilisers - even distribution and avoids wastage.
- Suitable for undulating topography (sloppy lands)
- Reduces erosion
- Suitable for coarse textured soils (sandy soils)
- Frost control - protects crops against frost and high temperature
- Drainage problems eliminated
- Saving in land
- Fertilisers and other chemicals can be applied through irrigation water

Disadvantages

- High initial cost
- Efficiency is affected by wind
- Higher evaporation losses in spraying water

- Not suitable for tall crops like sugarcane
- Not suitable for heavy clay soils
- Poor quality water cannot be used (Sensitivity of crop to saline water and clogging of nozzles).

Localised Irrigation Systems

Localised irrigation systems apply water directly where the plant is growing thus minimising water loss through evaporation from the soil. Such localised irrigation systems include drip irrigation, porous clay pots, porous pipes, and perforated plastic sleeves.

Drip Irrigation

With drip or trickle irrigation the water is applied into the soil through a small-sized opening directly on the soil surface or buried in the soil. By applying water at a very slow rate, drip irrigation can deliver water to the roots of individual plants as often as desired and at a relatively low cost. Because drip irrigation makes it possible to place water precisely where and when needed with a high degree of uniformity and efficiency (90% or more) the method is useful under many field and water situations.

Losses to runoff, deep percolation and evaporation are minimal; this means that most of the irrigation water is taken up by the plant. Drip irrigation is often the favoured method of irrigation, for example on steep and undulating slopes, for porous soils, for shallow soils, fields having widely varying soils, where water is scarce, where water is expensive, and where water is of poor quality.

Components

- A drip irrigation system consists of a pump or overhead tank, main line and sub-mains.
- The main line delivers water to the sub-mains and the sub-mains into the laterals.
- The emitters which are attached to the laterals distribute water for irrigation.
- The mains, sub-mains and laterals are usually made of black PVC (polyvinyl chloride) tubing. The emitters are also made of PVC material
- The other components include regulators, filters, valves, water metre, fertiliser application components, etc.

Advantages

- Water saving - losses due to deep percolation, surface runoff and transmission are avoided. Evaporation losses occurring in sprinkler irrigation do not occur in drip irrigation.
- Uniform water distribution
- Application rates can be adjusted by using different sizes of drippers
- Suitable for wide spaced row crops, particularly coconut and other horticultural tree crops
- Soil erosion is reduced
- Better weed control
- Land saving

- Less labour cost

Disadvantages

- High initial cost
- Drippers are susceptible to blockage
- Interferes with farm operations and movement of implements and machineries
- Frequent maintenance
- Trees grown may develop shallow confined root zones resulting in poor anchorage.

Drip irrigation demonstration trials at KALRO-Kabete

Porous Clay Pots

This is a method of irrigation in which water is stored in clay pots buried in the ground, is slowly released to the plants. This method is good for fruit trees. Such use of soil-embedded porous jars is one of the oldest continuous irrigation methods that probably originated in the Far East and North Africa. The method consists of:

Clay Pots that are placed in Shallow Pits Dug for this Purpose.

Soil is then packed around the neck of the pots so that the necks protrude a few centimetres above the ground surface. Water is poured into the pots either by hand or by means of a flexible hose connected to a water source. The pots are made of locally available clay with optimum properties of strength (to resist crushing), permeability (to exude water into the soil at an approximately steady rate), and size (to hold enough water for at least one day’s supply). The potential of clay-pot irrigation has not been fully exploited by farmers in the eastern and southern Africa region, even though the technology is suitable for small- scale farmers.

Porous Clay Pipes

This method is most suited to closely spaced crops such as vegetables. Water is spread along a continuous horizontal band in the soil. The locally made clay pipes are approximately 24 cm in length and 7.5 cm in internal diameter, with wall thickness of 2 cm. The pipes are placed at the bottom of a shallow trench (about 25 cm deep) representing the centre line of a 1-m wide bed.

Perforated Plastic Sleeves

Plastic sheeting has been used to make a sleeve-like casing. The advantage of this is the low cost. However, the method has several distinct disadvantages that restrict the range of its applicability. Since the soft plastic material used for making the sleeve does not retain its shape, the sleeve must be filled with sand before being placed in the soil. The sand filling reduces the capacity of the sleeve by some 50.60%. Moreover, the sand itself tends to retain a significant fraction of the moisture and thus restrict outflow.

Since the plastic casing is essentially impervious, it must be perforated. The difficulty of standardising the diameter and density of the perforations introduces another variable onto the system. The best configuration must be established by trial and error.

This method has been used with success in Senegal. An interesting variation in Sri Lanka consists of a 50-cm long PVC pipe of standard ½-inch diameter. The pipe ends in an emitter, a block made from a 1:10 cement/sand mixture. The design was found to be effective in enhancing the survival and growth rate of young fruit trees.

Different Irrigation Methods used in Horticultural Crops

Different horticultural crops require different amounts of water during their growth cycle. Some horticultural crops like sweet capsicum, tomatoes, watermelon and onions can be efficiently irrigated through drip irrigation systems. The drip system will allow for water and fertiliser to be used efficiently at the root zone of the plants for the crop to benefit effectively. It allows the crop to benefit from low water use, reduced weed pressure, higher quality produce with low diseases and pest pressure.

POSSIBLE IRRIGATION METHODS FOR DIFFERENT CROPS

Crop type	Possible irrigation methods	Advantages	Disadvantages

Vegetable crops (Edible plant stems like celery asparagus, cole crops like broccoli and cauliflowers, Solanaceae crops, Bulb crops, salad greens and root crops among others	Drip irrigation	Reduces the water use, increase crop yield and quality	Expensive to installation and maintenance, its labor-intensive and may not be economical in lower value crops
All field crops	Sprinkler irrigation	Suitable for all field conditions, Allows for uniform distribution of water	High initial cost, requires high and continuous power supply
Water logging-sensitive staple food and fibre crops such as Maize, soybeans and cotton	Furrow/flood irrigation	The runoff water can be recycled to improve efficiency	Is the least efficient irrigation method due to water loss through runoff, evaporation, and infiltration