CHAPTER 3

3.0 Drainage systems

3.1 COMPONENTS OF A DRAINAGE SYSTEM

As shown in Figure 1, a drainage system has three components:

The field drainage system is a network that gathers the excess water from the land by means of field drains, possibly supplemented by measures to promote the flow of water to these drains.

The field drainage system is the most important component for the farmers. More details on field drainage systems are given in the following section.

The main drainage system is a water-conveyance system that receives water from the field drainage systems; surface runoff and groundwater flow, and transports it to the outlet point.

The main drainage system consists of some collector drains and a main drainage canal. A collector drain collects water from the field drains and carries it to the main drain for disposal.

Collector drains can be either open drains or pipe drains.

The main drain is the principal drain of an area. It receives water from collector drains, diversion drains, or interceptor drains (= drains intercepting surface flow or groundwater flow from outside the area), and conveys this water to an outlet for disposal outside the area. The main drain is often a canalized stream (i.e. an improved natural stream), which runs through the lowest parts of the agricultural area.

The outlet is the terminal point of the entire drainage system, from where the drainage water is discharged into a river, a lake, or a sea.

An outlet can be one of two kinds: a gravity outlet or a pumping station. A gravity outlet is a drainage structure in an area which has outside water levels that rise and fall. There, the drainage water can flow out when the outside water levels are low. In delta areas, drainage by gravity is only possible for a few hours a day when tides are low. In the upstream regions of a river, drainage by gravity might not be possible for several weeks, during periods when river levels are high.

A pumping station is needed in areas where the water levels in the drainage system are lower than the water level of the river, lake or sea.

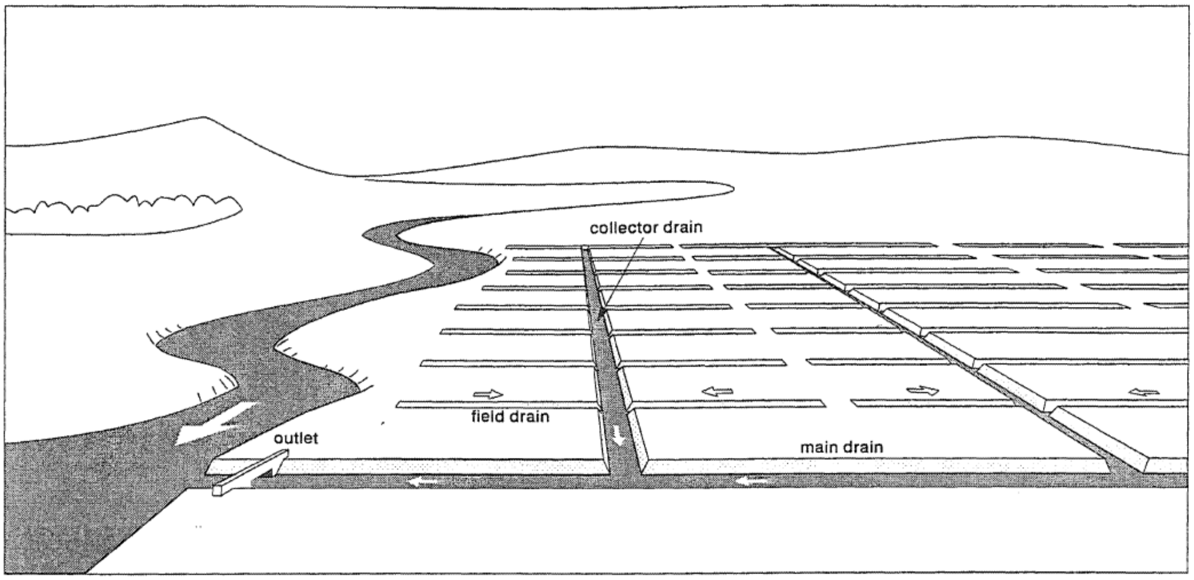

Fig 3.1 Schematic layout of drainage systems

3.2 FIELD DRAINAGE SYSTEMS

A field drainage system can be a surface drainage system (to remove excess water from the surface of the land) or a subsurface drainage system (to control the water table in the soil). In surface drainage, field drains are shallow graded channels, usually with relatively flat side slopes.

In subsurface drainage, field drains can be either open drains or pipe drains. Open drains and pipe drains have the same function. The difference between them is the way they are constructed: an open drain is an excavated ditch with an exposed water table; a pipe drain is a buried pipe.

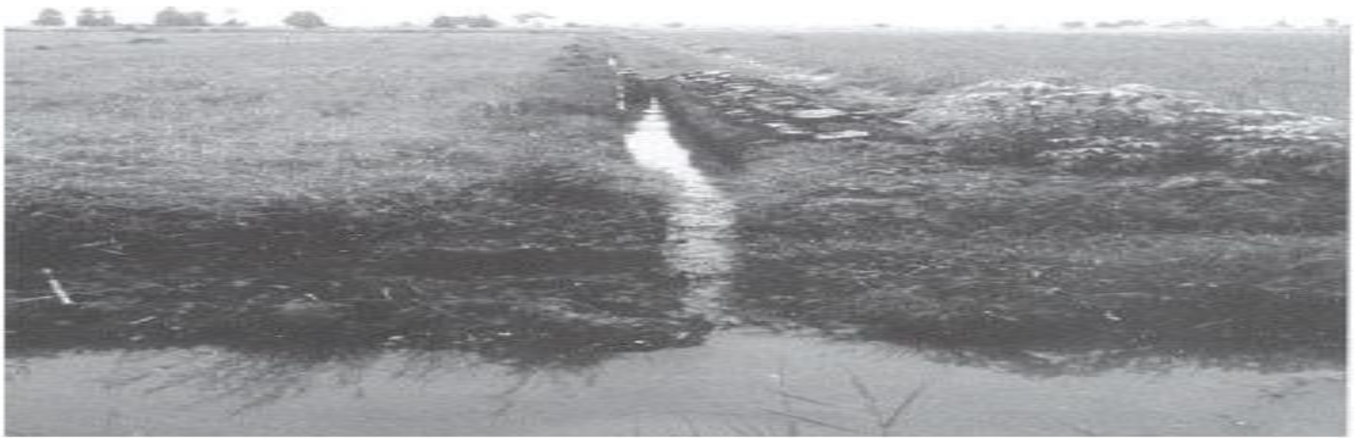

Fig 3.2 a field drains for surface drainage

3.2.1 SURFACE DRAINAGE SYSTEMS

A surface drainage system always has two components:

- The construction of Open field drains to collect the ponding water and divert it to the collector drain.
- The shaping of the surface by Land forming to enhance the flow of water towards the field drains

A **surface drainage system is** a system of drainage measures, such as open drains and land forming, to prevent ponding by diverting excess surface water to a collector drain

Land forming is changing the surface of the land to meet the requirements of surface drainage or irrigation. There are three land-forming systems: bedding, land grading and land planning.

Bedding is a surface drainage method achieved by ploughing land to form a series of low beds, separated by parallel field drains. . With this system, the land surface is formed into beds. This work can be done by manual labour, animal traction, or farm tractors. The beds are separated by parallel shallow, open field drains, oriented in the direction of the greatest land slope (figure 3.2). The water drains from the beds into the field drains, which discharge into a collector drain constructed at the lower end of the field and at right angles to the field drains. The bedding system is normally used for grassland. In modern farming, bedding is not considered an acceptable drainage practice for row crops, because rows near the field drains will not drain satisfactorily. To overcome the disadvantages of the bedding system, the two other methods of land forming have been developed: land grading and land planning.

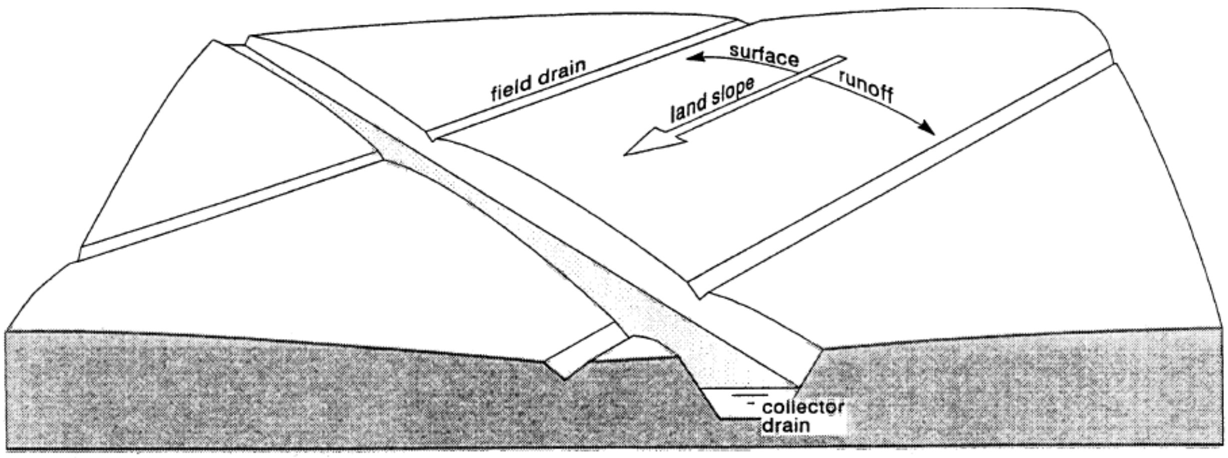

Figure 3.3 bedding system

Land grading: Land grading for surface drainage consists of forming the land surface by cutting, filling and smoothing it to predetermined grades, so that each row or surface slopes to a field drain (Figure 3.4). It is a one-time operation. Land grading for surface drainage differs from land leveling for irrigation in that, for drainage, the grades need not be uniform. They can be varied as much as is needed to provide drainage with the least amount of earthmoving.

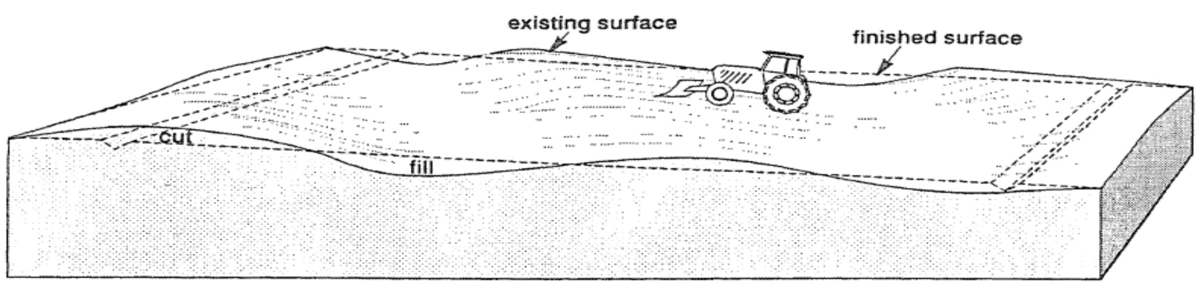

Figure 3.4 land grading for surface drainage in the forming of the land surface to predetermined grades

Land planning: Land planning is the process of smoothing the land surface to eliminate minor depressions and irregularities, but without changing the general topography (Figure 3.5). It is often done after land grading, because irregular micro-topography in a flat landscape, in combination with heavy soils, can cause severe crop losses.

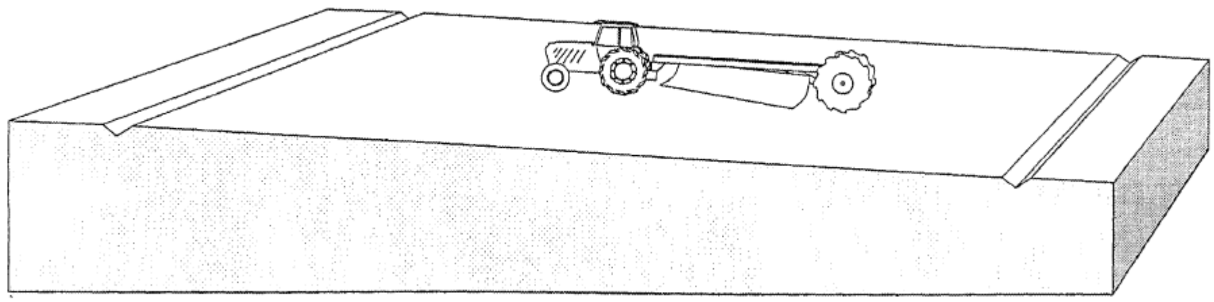

Figure 3.5 land grading

In the field, surface drainage systems can have two different layouts**: the random field drainage system, and the parallel field drainage system.**

RANDOM FIELD DRAINAGE SYSTEM

The random field drainage system is applied where there are a number of large but shallow depressions in a field, but where a complete land-forming operation is not considered necessary. The random field drainage system connects the depressions by means of a field drain and evacuates the water into a collector drain (Figure 16). The system is often applied on land which does not require intensive farming operations (e.g. pasture land) or where mechanization is done with small equipment.

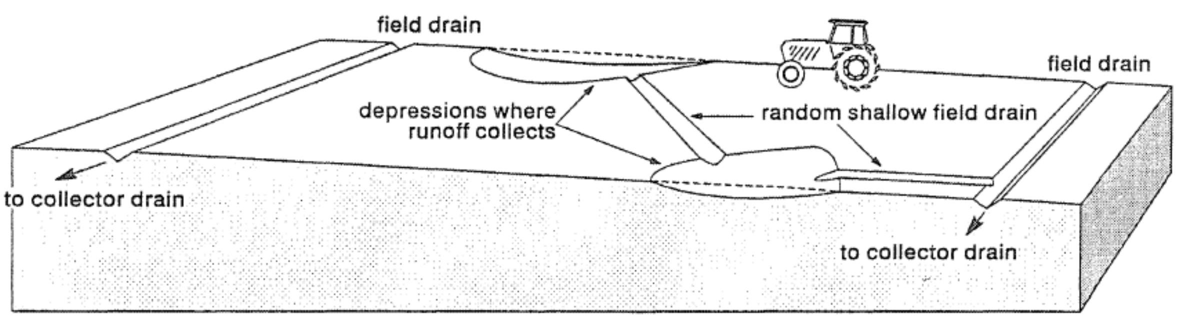

Figure 3.6 Random field drainage systems

Parallel field drainage system

The parallel field drainage system (Figure 3.7), in combination with proper land forming, is the most effective method of surface drainage. The parallel field drains collect the surface runoff and discharge it into the collector drain. The spacing between the field drains depends on the size of fields that can be prepared and harvested economically, on the tolerance of crops to ponding, and on the amount and costs of land forming. The system is suitable in flat areas with an irregular micro-topography and where farming operations require fields with regular shapes.

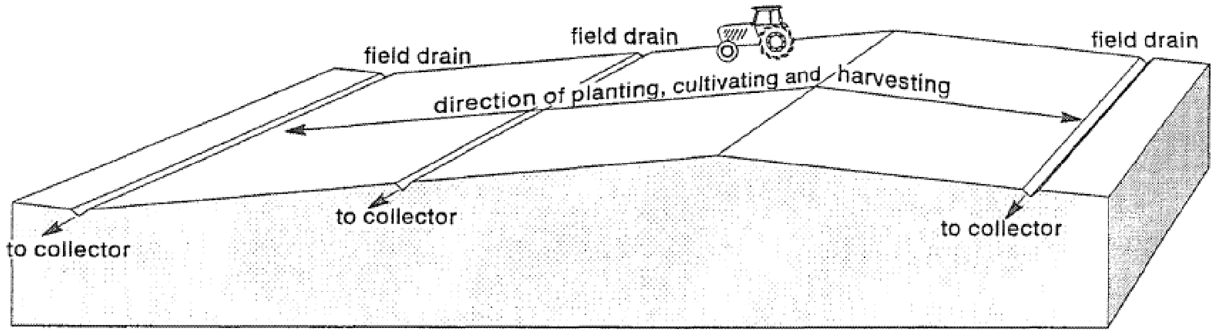

Figure 3.7 the parallel field drainage system

3.2.2 SUBSURFACE DRAINAGE SYSTEMS

A **subsurface drainage system** is a man-made system that induces excess water and dissolved salts to flow through the soil to pipes or open drains, from where it can be evacuated.

If it is decided to install a subsurface drainage system, a choice has to be made between open drains or pipe drains. Open drains have the advantage that they can receive overland flow and can thus also serve as surface drainage. The disadvantages are the loss of land, the interference with the irrigation system, the splitting up of the land into small farm blocks, which hampers farming operations, and that they are a maintenance burden.

The choice between open drains or pipe drains has to be made at two levels: for field drains and for collector drains. If the field drains are to be pipes, there are still two options for the collectors:

- ✓ open drains, so that there is a singular pipe drainage system;
- ✓ Pipe drains, so that there is a composite pipe drainage system.

In a singular pipe drainage system, each field pipe drain discharges into an open collector drain (Figure 3.8).

A **singular drainage system** is a drainage system in which the field drains are buried pipes and all field drains discharge into open collector drains.

In a composite system, the field pipe drains discharge into a pipe collector (Figure 19), which in turn discharges into an open main drain. The collector system itself may be composite, with sub-collectors and a main collector.

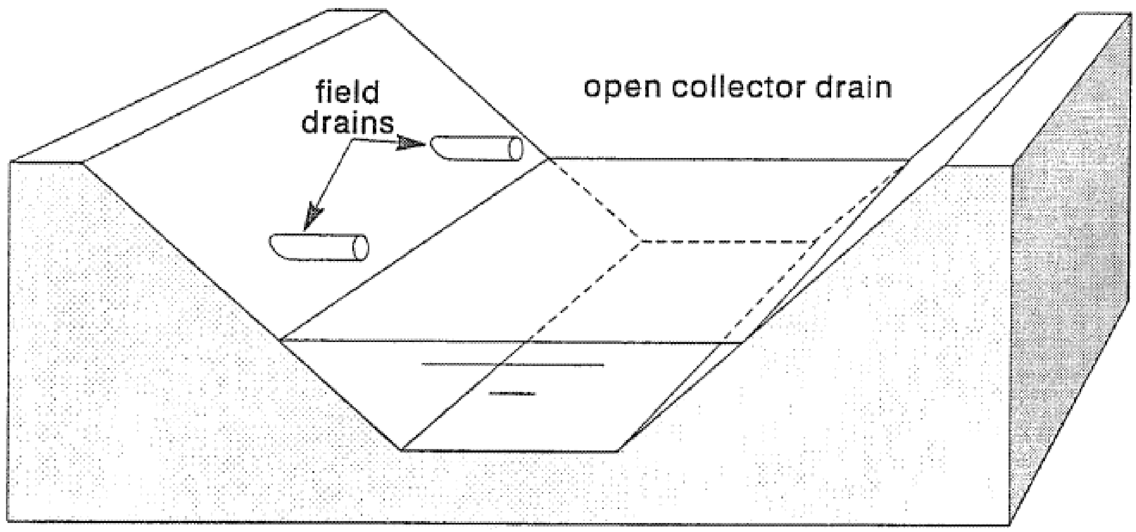

Figure 3.8 in a singular pipe drainage system each pipe drain discharge in to open collector drain

A **composite drainage system** is a drainage system in which all field drains and all collector drains are buried pipes

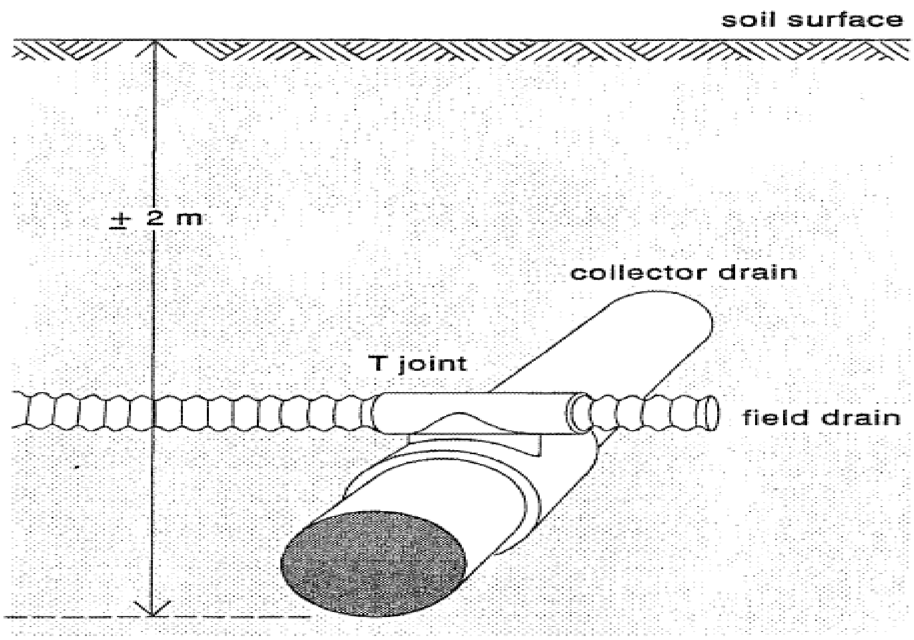

Figure 3.9 in a composite system in the collector drain is also buried pipe

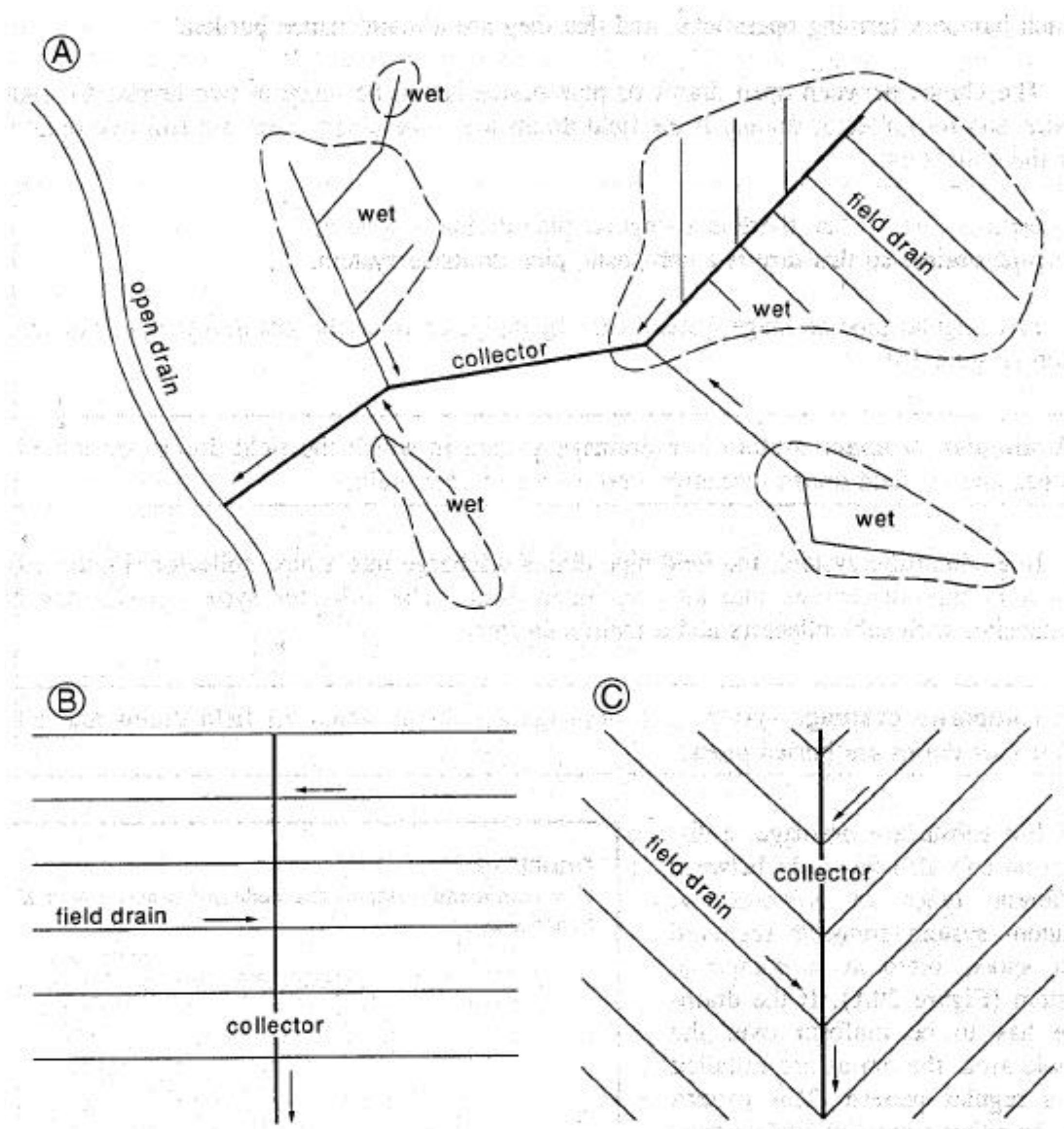

Figure 3.10 Three layouts for a subsurface drainage system: (A) random system; (B) parallel grid system; (C) herringbone system

3.2.3 Tube well drainage system

Tube well drainage systems are, similar to subsurface system, used to control the water table.

However, better use is made of the more permeable deeper soil layers.

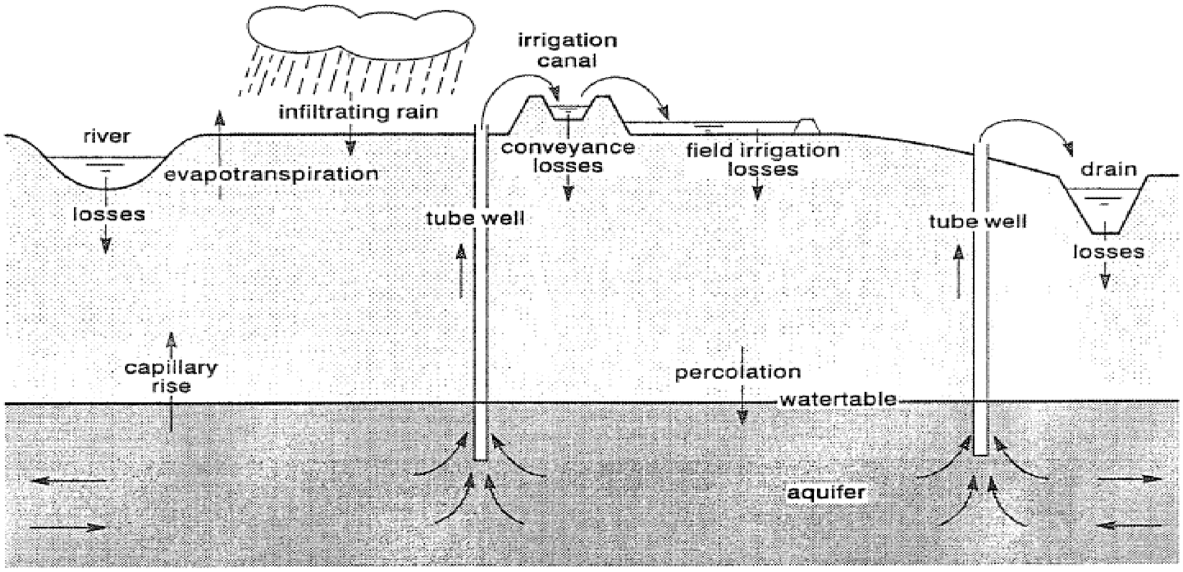

Figure 3.11 tube well drainage is a technique of controlling the water table by removing the excess water from the (more permeable) underground

3.2.4 Combined Drainage Systems

Sometimes combined surface and subsurface drainage systems are used. Whether this is needed depends on a combination of factors like the intensity and duration of the rainfall, surface storage, the infiltration rate, the hydraulic conductivity (which is a measure for the water-transmitting capacity of soils and will be discussed in Section 4.6), and the groundwater conditions. Some examples of combined systems are:

- In irrigated areas in arid and semi-arid regions, where the cropping pattern includes rice in rotation with 'dry-foot' crops (maize, cotton, etc), as in the Nile-Delta in Egypt. Subsurface drainage is needed for salinity control of the dry-foot crops, whereas surface drainage is needed to evacuate the standing water from the rice fields, e.g. before fertilizer applications or to dry the crop before harvest.
- Areas with occasional high-intensity rainfall (say more than 50 mm/day) that causes water ponding at the soil surface, even when a subsurface drainage system is present.

In both cases, the standing water could be removed by the subsurface drainage system, but this would either take too long or require drain spacings which are economically unjustifiable. In such circumstances, it is generally more efficient to remove the ponded water by surface drainage.