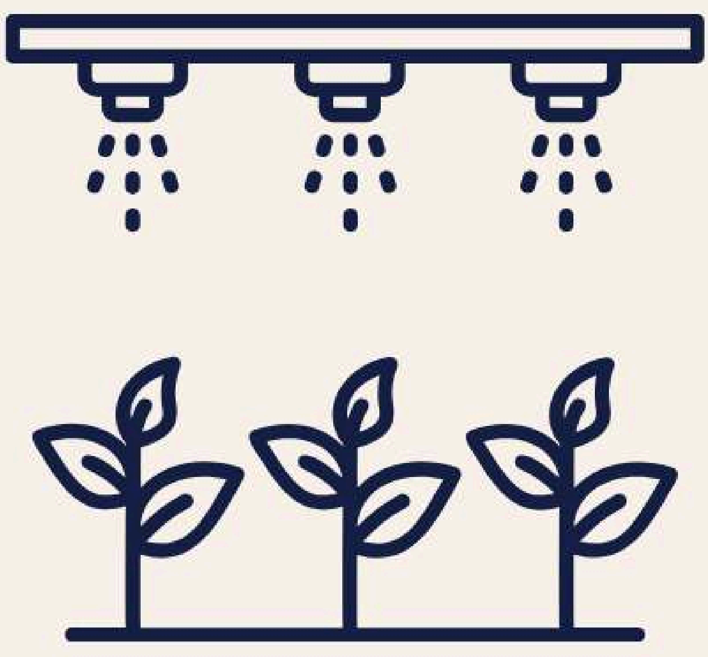
Drip Irrigation system Design Template



Maximize Crop Yield and Profits with
Expert Irrigation Solutions

By Naresh Kumar

FarmZen

Chapters

Source : Netafim's training manual

Source : Netafim's training manual

CHAPTER 1: IRRIGATION CONCEPT

IRRIGATION CONCEPT

Introduction: Although India occupies only a 3.29 million km geographical area, which forms 2.4% of the world's land area, it supports over 15% or 1/6 of the world's population, 1/50 of the world's land, and 1/25 of the world's freshwater resources.

India also has a livestock population of 500 million, which is about 20% of the world's total livestock population. More than half of these are cattle, forming the backbone of Indian agriculture. The total utilizable water resources of the country are assessed as 1086 km3.

Recently, the National Commission for Integrated Water Resources Development estimated the basin-wise average annual flow in Indian river systems as 1953 km3. The utilizable annual surface water of the country is 690 km3. The annual potential natural groundwater recharge from rainfall in India is about 342.43 km3, which is 8.56% of the total annual rainfall of the country.

The annual potential groundwater recharge augmentation from the canal irrigation system is about 89.46 km3. Thus, the total replenishable groundwater resource of the country is assessed as 431.89 km3. After allotting 15% of this quantity for drinking, and 6% for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource for irrigation is 361 km3, of which the utilizable quantity (90%) is 325 km3.

The ultimate irrigation potential of India has been estimated at 140 mha. Out of this, 76mha can be irrigated from surface water and 64mha from groundwater sources. The quantum of water used for irrigation by the last century was of the order of 300 km3 of surface water and 128 km of groundwater, a total of 428 km3.

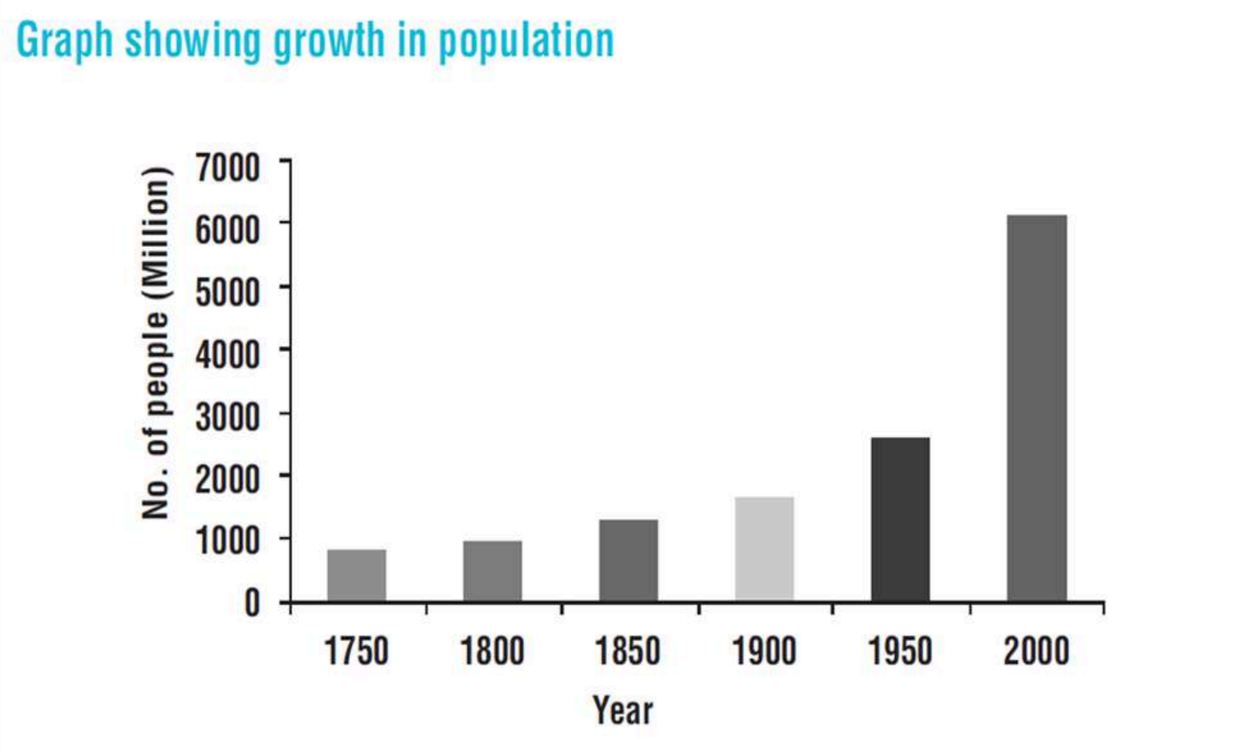
The estimates indicate that by the year 2025, the water requirement for irrigation will be 561 km3 for low-demand scenarios and 611 km3 for high-demand scenarios. These requirements are likely to further increase to 628 km3 for the low-demand scenario and 807 km3 for the high-demand scenario by 2050. Day by day as the world population is increasing at a very fast rate to meet the food requirements of the increased population it becomes essential to increase food production at the same rate.

To enhance the food production more land should be brought under cultivation & irrigation, so efficient use of available water resources becomes achievable. To tackle this issue, adoption of micro irrigation (like a drip system) is one of the best solutions.

Irrigation is the artificial application of water to the soil usually for assisting in growing crops. In general irrigation it is mainly used in dry areas and during periods of absence of rainfall. Also in cold areas, it is used for frost protection. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed farming. Irrigation is often studied together with drainage, which is the natural or artificial removal of surface and subsurface water from a given area. Irrigation can also be used for flushing/draining the contaminated soil because of excessive application of chemical fertilizers, weedicides, pesticides, etc. Heavy irrigation for draining undesirable constituents from the soil is called leaching.

Today worldwide many countries are experiencing severe water scarcity even for drinking purposes. The growing world population is leading to increased freshwater demand but the amount of freshwater nearly remains constant.

To meet the need for increased water demand, efficient water management is essential. In agricultural irrigation, the adoption of drip irrigation technology is the best option for efficient water use and management.



In addition to water scarcity, the world is facing other environmental challenges like global warming, food supply shortages, energy crisis, etc. and in all these challenges somehow, we can help by adopting of micro irrigation technology like drip irrigation

Irrigation efficiency (Ea)

Irrigation efficiency (Ea) is the amount of water stored in the crop root zone compared to the amount of irrigation water applied, expressed as a percentage. The overall efficiency of the surface flood irrigation methods is well below 60%.

Irrigation efficiencies	Methods of irrigation		
	Surface	Sprinkler	Drip
Conveyance efficiency	40-50 (canal) 60-70 (well)		
Application efficiency	60-70	70-80	90
Surface water moisture evaporation	30-40	30-40	20-25
Overall efficiency	30-35	50-60	80-90

Types of irrigation

Various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water. There are many types of irrigation as listed below:

Conventional surface irrigation - Flood irrigation, furrow irrigation, basin irrigation, check basin irrigation, border irrigation, etc.

Micro irrigation –

Spray irrigation - Sprinkler irrigation, Centre pivot irrigation, etc.

Drip irrigation - Surface and subsurface drip irrigation.

The basic difference between conventional flood and drip irrigation methods

In the conventional flood irrigation method it is general practice to apply water to soil once a week or so. In such irrigations, soil moisture content reaches saturation on irrigation and recedes to the wilting point till the next one. In these situations, most of the time plant roots suffer either due to saturation or moisture stress which results in uneven plant growth and yield. On the other hand drip irrigation with daily water application to the root zone of the crop, tries to maintain the soil moisture nearly at field capacity. Due to frequent application and optimum moisture levels in the root zone, i.e. all the time with favorable moisture conditions, the plant grows well and yields good produce with excellent quality. In addition to this drip irrigation wets only the root zone volume of soil mass, which enhances repellence and creates hostile conditions for most pests and diseases.

Drip Irrigation System Design Template

Drip irrigation:

Drip Irrigation, also known as trickle irrigation is a method which minimizes the use of water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly into the roots zone, through a network of valves, pipes, tubing, and emitters and tries to maintain the soil moisture content always at or near the field capacity.

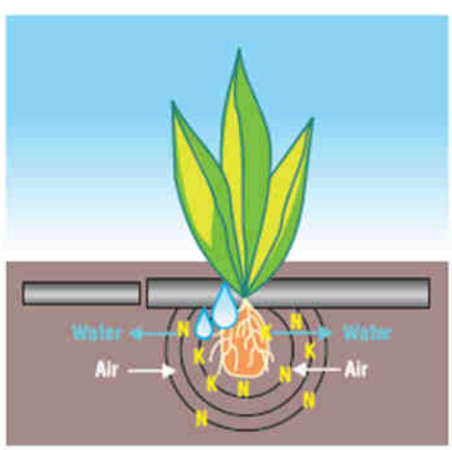
Particular	Conventional flood irrigation	Drip irrigation
Water use efficiency	Less than 40%	Above 80%
Fertilizer use efficiency	Very less	Excellent
Labour requirement	Higher	Less
Weed emergence	Very high	Rare
Leaching and deep percolation	Very high	Nil
Surface runoff and soil erosion	Liable	Nil
Uniform crop growth	Rare	Constant
Uniform yield and crop quality	Rare	Constant
Maintenance	Higher and difficult	Very less and easy
Intercultivation	Not possible on irrigation	At any time
Land leveling and shaping	Essential	Not necessary
Suitability to soil type	Not suitable for heavy soils	Suitable for any soil
Automation	Not possible	Possible
Emergence of pest and disease	Higher	Less
Soil moisture at root zone	Varying between saturation and wilting point	Always near field capacity
Irrigation frequency	Once in a week or so	Daily

Drip Irrigation System Design Template

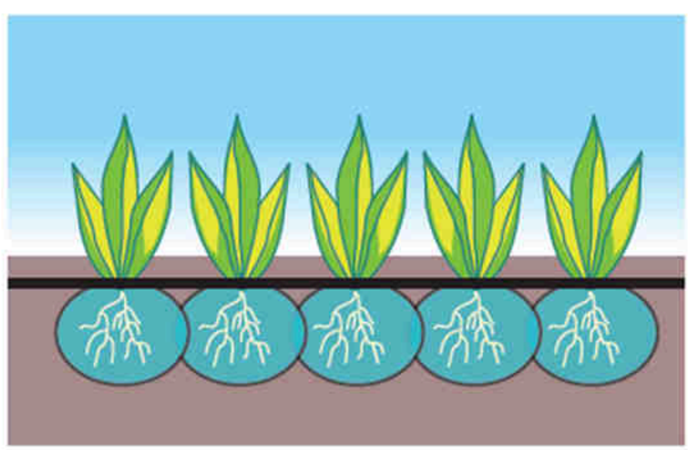
Principles of drip irrigation

Drip irrigation involves dripping water onto the soil at very low flow rates from a system of small-diameter plastic pipes fitted with outlets (drip emitters). The basic concept underlying the drip irrigation method is to supply the amount of water needed by the plant within a limited volume of soil and as often as needed. Water is applied directly at the plant root zone. The volume of soil irrigated by each drip emitter and the water flow along the soil profile is a function of the characteristics of the soil (texture and hydraulic conductivity) and the discharge rate of the drip emitter. Applications are usually as frequent as daily to provide a favorable moisture level for the plants to flourish.

Soil composition for ideal crop growth

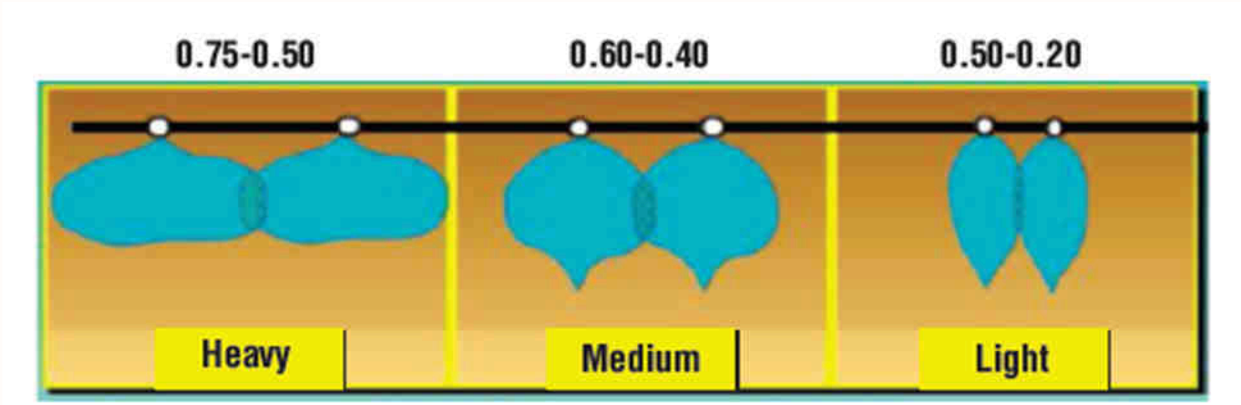


Ideal soil combination under drip irrigation


Uniform wetting pattern along the row

Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!

General emitter spacing recommendations for different soil types.



Features of drip irrigation

Drip irrigation utilizes the concept of applying a small amount of water, slowly for a longer period at frequent intervals through emitters or orifices to the specific areas of application i.e. crop root zone.

That means the principle of drip irrigation is characterized by the following features:

- Water is applied at a very low rate
- Water is applied over a longer time
- Water is applied at frequent intervals
- Water is applied directly into the crop root zone
- Water is applied via a low-pressure delivery system

Features of drip irrigation

The concept has gained wide acceptance, proving to be particularly valuable in areas that are arid and have high labor costs. An unforeseen benefit is that the system works well with highly saline water, as water in arid regions often is.

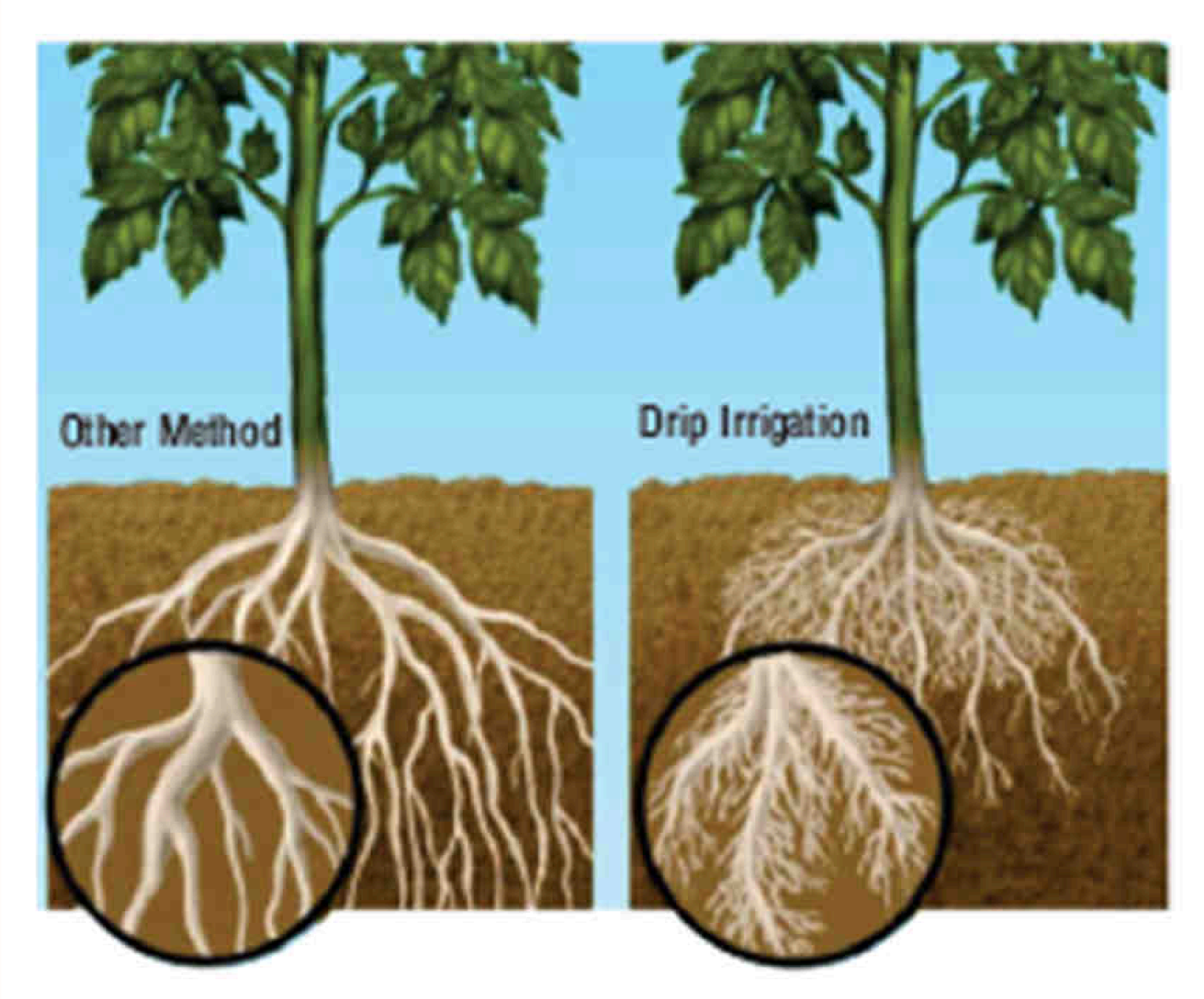
What makes drip irrigation more attractive economically in many agricultural situations is that it provides more benefits than other methods of irrigation. The following is a comprehensive list of advantages divided according to various fields.

Drip Irrigation has proven to be the most efficient method of delivering water and nutrients directly to the plant's root zone according to its needs. By direct & controlled application of water & nutrients in the root zone, it is possible to save significant water & fertilizer in drip irrigation and improve aeration in the root zone, thus reducing overall production costs and also improving plant growth conditions.

Advantages of drip irrigation system

- Increased yield and better quality over the years
- Early maturity or early harvest
- Water saving
- Fertilizer saving
- Increased water & fertilizer efficiency due to compact root zone
- Energy saving
- Use of saline water for irrigation is possible
- System automation possible
- Facilitates growing of crops in minor undulated areas without land leveling
- Greater ability to manage crop production
- Less incidence of disease and pests as plant foliage remains dry
- Problematic soils like heavy soils with less infiltration rate can be irrigated
- Less weed growth
- Less inter-cultural operations required
- Reduced tillage costs
- Flexibility to work & irrigate at the same time
- Less labour costs
- Favorable soil temperatures
- Field sanitation
- Adaptation to undercover plants

Conceptual clarity on advantages of drip irrigation

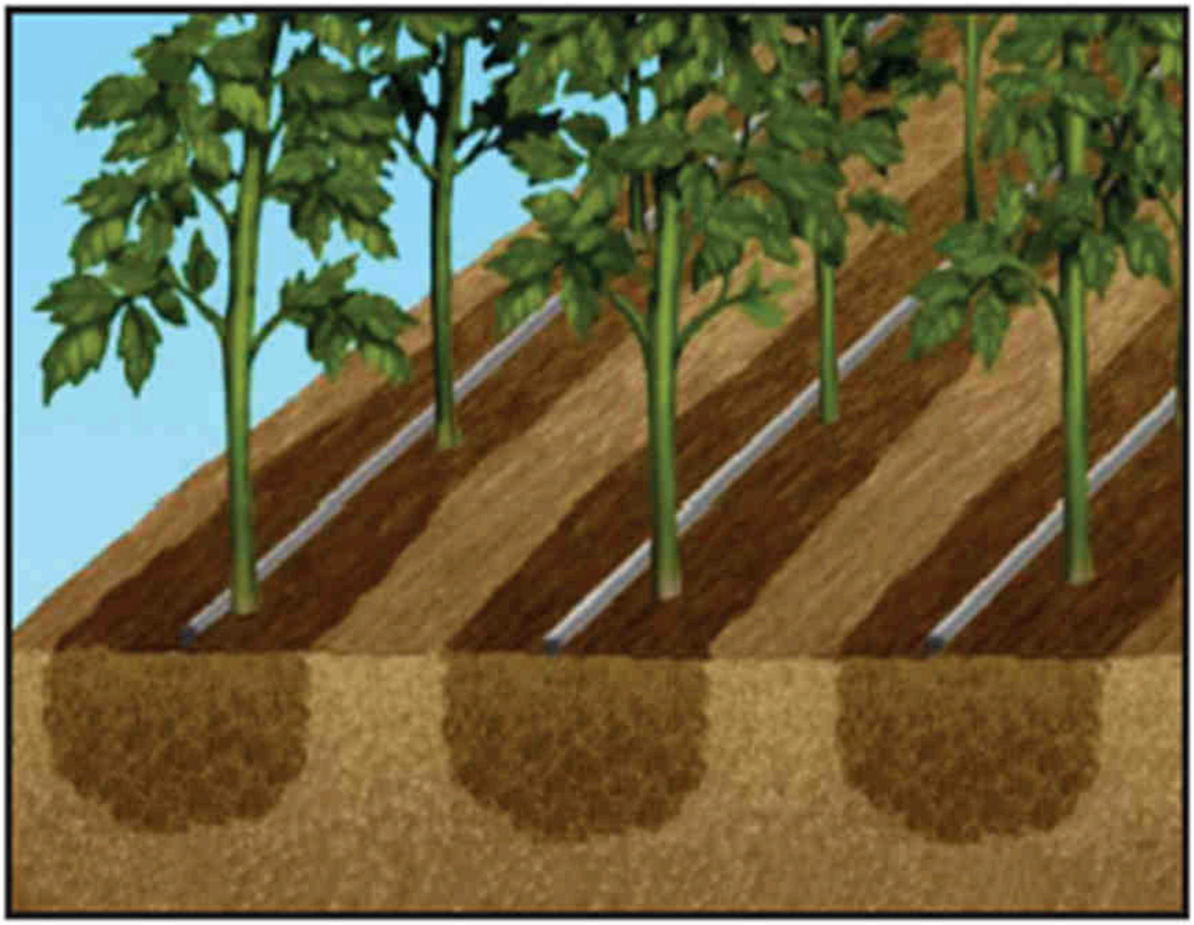


Compact & effective root zone

- The system concentrates the roots in a defined volume of soil
- Improving the uptake efficiency of water and minerals
- Develops optimal moisture and aeration conditions
- Compact root zone saves the plant`s energy
- Better intake of nutrition

- Development of white & fibrous root hair system

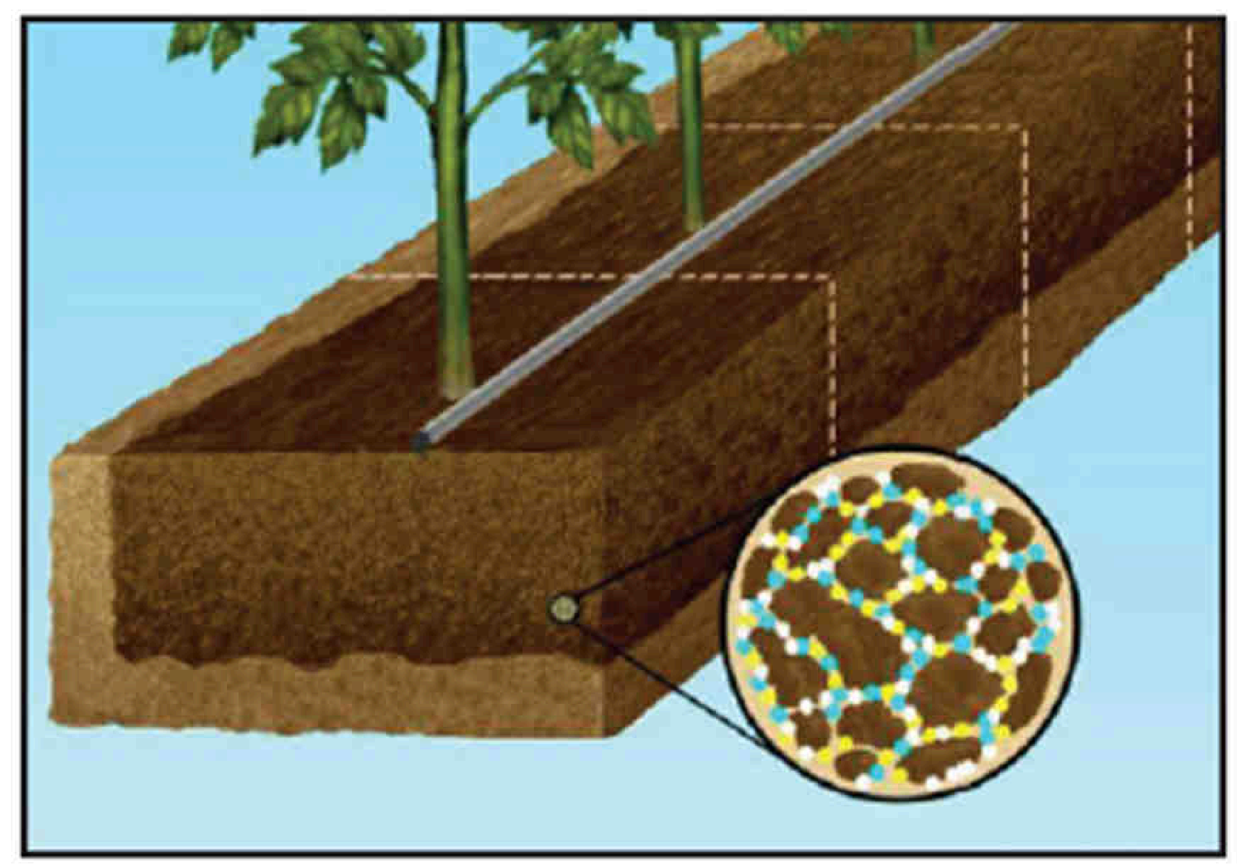
Conceptual clarity on advantages of drip irrigation



Advantages of the dry zone

- No weeds can develop
- Saving weed control expenses
- Easy transport of farm equipments on the field
- Prevention of the soil erosion between plants

Conceptual clarity on advantages of drip irrigation

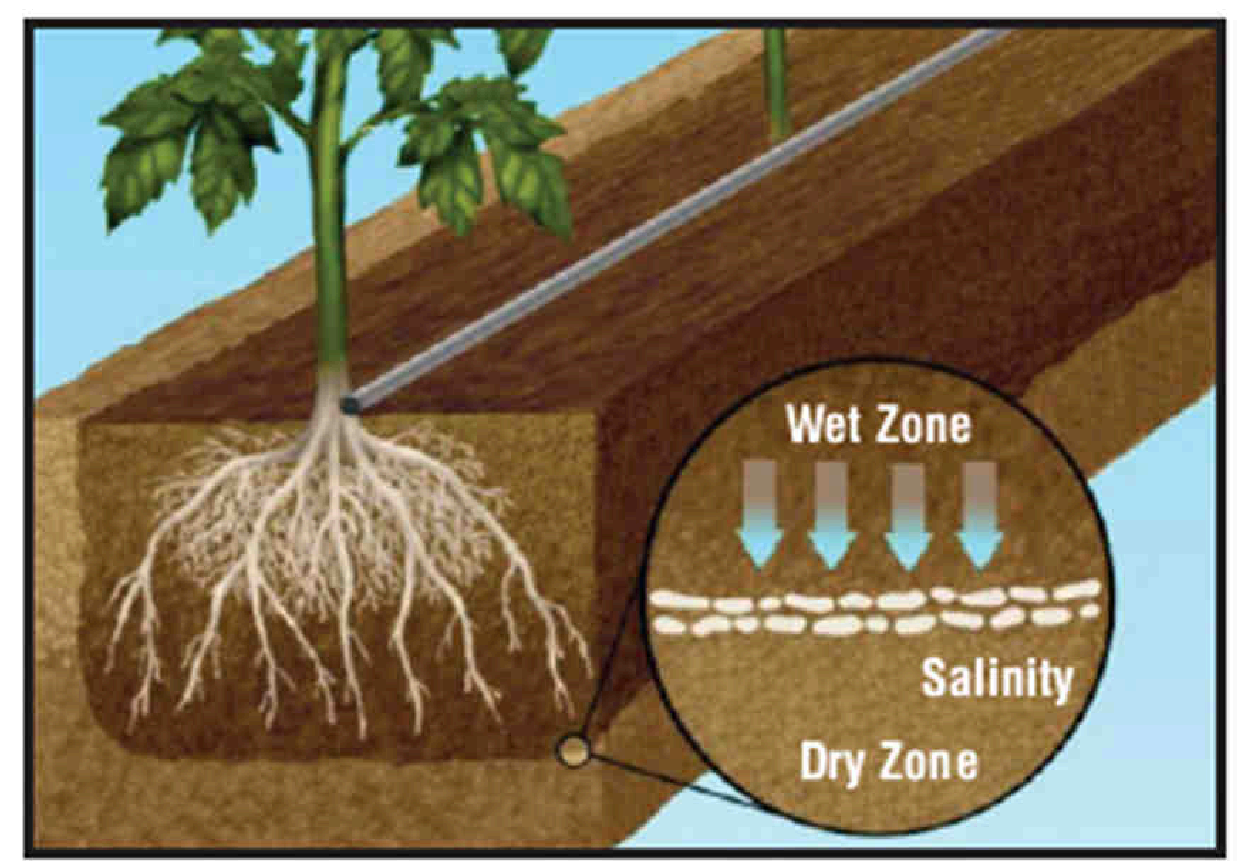


Soil water air relation

- Optimal and uniform moisture
- Excellent aeration conditions
- Efficient uptake of water
- Effective absorption of nutrient elements

Optimal and uniform moisture

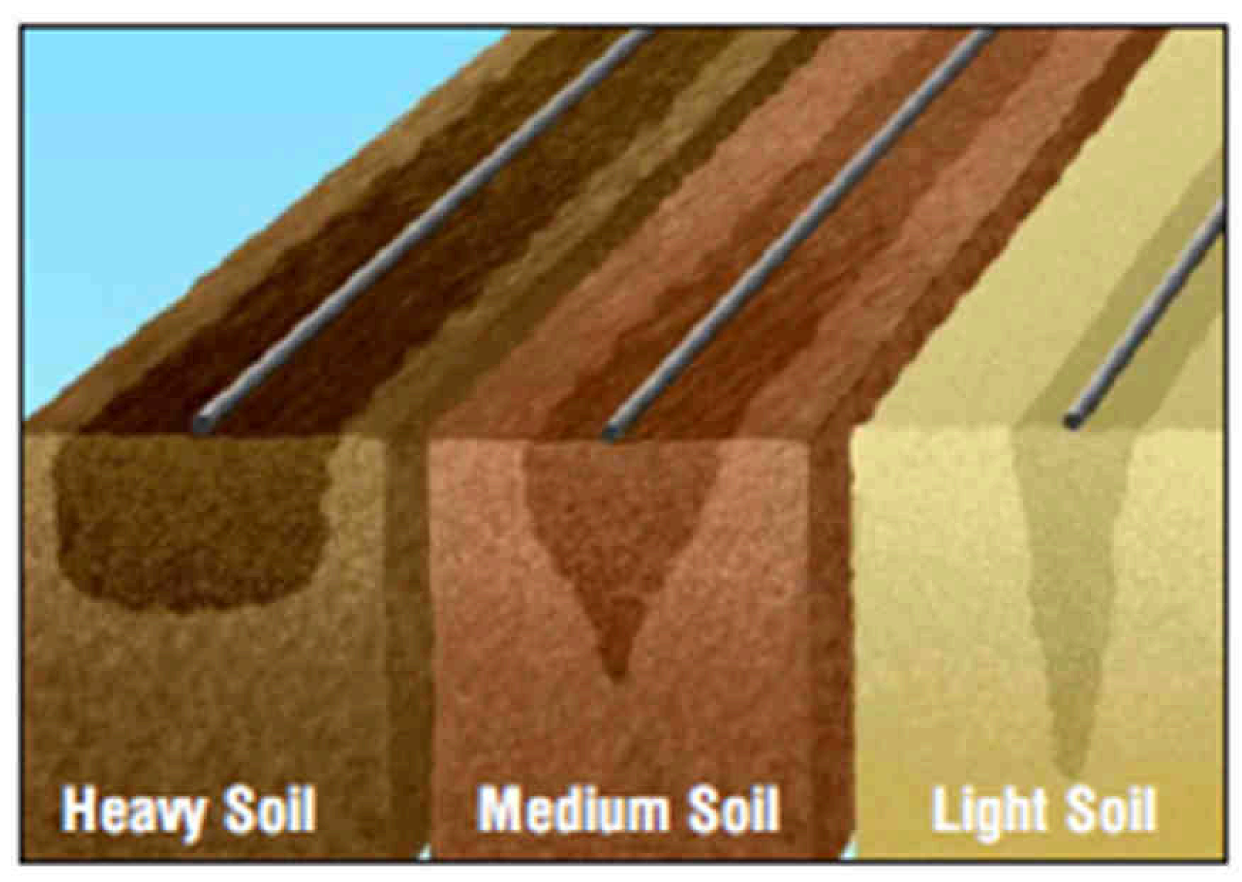
Excellent aeration conditions



Wet zone concept

- Continuous moisture along the plant's roots
- Allows air to remain in the wetted area
- Concentrates the plant's roots within the wetted area
- A continuous wet strip builds sufficient root volume
- Prevents the buildup of salinity within the wetted strip

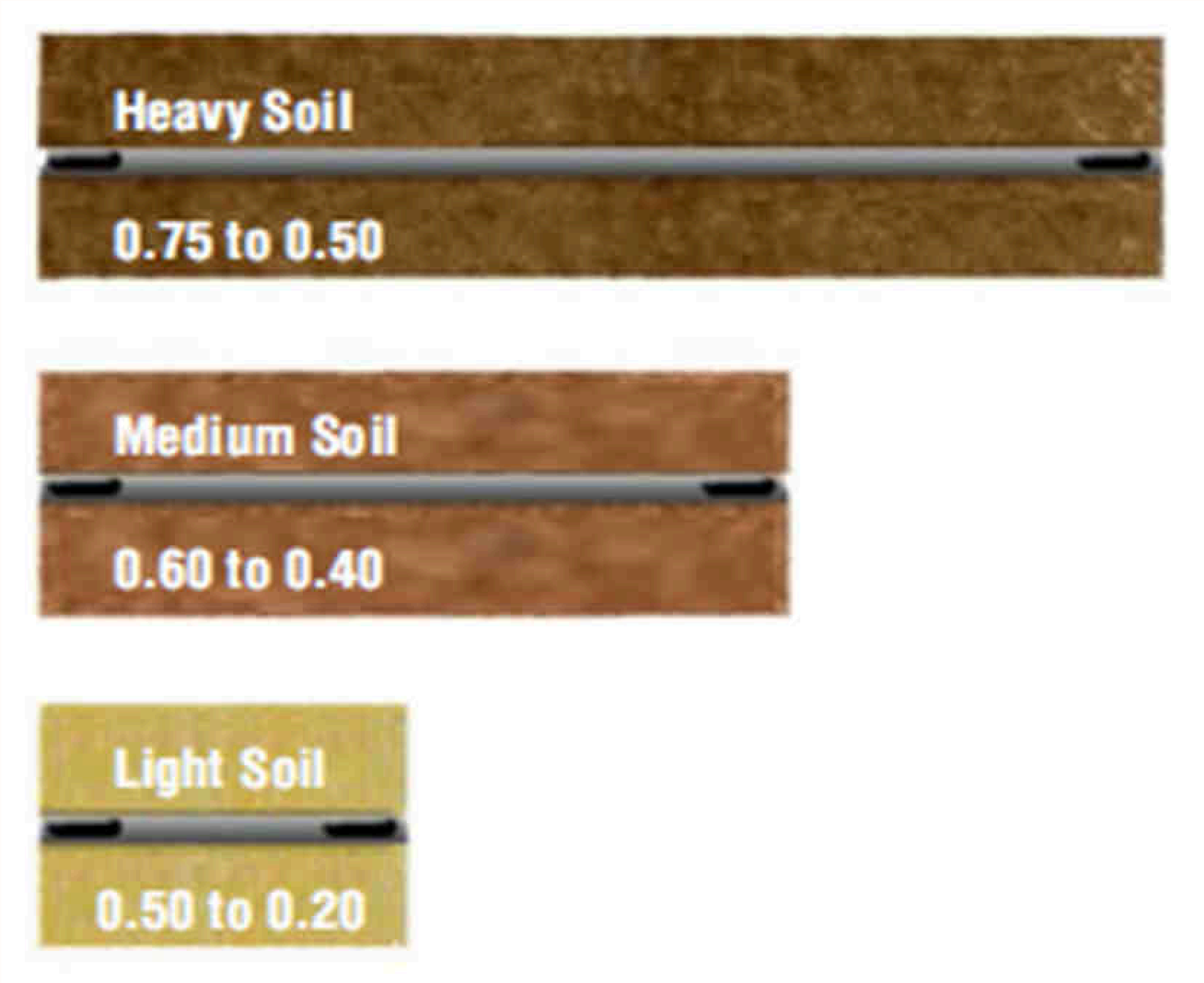
Conceptual clarity on advantages of drip irrigation



Soil types suitability

- The shape of the wetted zone depends on the physical properties of the soil
- In light soils, the distribution of the water will be narrower and deeper
- In heavy soils the distribution of the water will be relatively spherical in shape

Conceptual clarity on advantages of drip irrigation



Emitter Spacing

- Recommended distance for heavy soil: 0.75 to 0.50 meter

- Recommended distance for medium soil: 0.60 to 0.40 meter
- Recommended distance for lighter soil: 0.50 to 0.20 meter

Conceptual clarity on advantages of drip irrigation

Advantages in water distribution

Efficient use of water can prevent wastage. It has been found that the efficiency of water distribution using drip irrigation is over 90%, as compared to 65- 80% using sprinklers and 30-60% using flooding.

Prevention of run-off

- No water leakage under the root system
- Minimal evaporation of water from the exposed soil surface
- Equal distribution of water to the plants in the field
- No influence of wind on the distribution of water

Conceptual clarity on advantages of drip irrigation

Technological advantages

- Low consumption of energy
- Efficient nutrition of plants

- No interference with other agricultural operations even during the irrigation period
- Labour saving
- Simplicity of operation

Advantages for the plants

- Favorable plant reaction
- Facilitates greater density of trees/plants per unit area

Suitable crops in drip Irrigation system

The drip irrigation system is suitable for all crops. However, at present the system pays back its investment majorly in the following crops:

- **Commercial crops**: Sugarcane, Cotton, Tobacco, Gherkin and Baby corn
- **Vegetable crops**: Tomato, Brinjal, Beans, Lady's finger/Okra, Capsicum, Pumpkin, Cucumber, Gourds, Peas, Cauliflower, Cabbage and Drumstick
- **Root and tuber crops**: Tapioca, Carrot, Radish, Potato, Sweet potato, Elephant foot yam
- **Bulb crops**: Onion, Coleus and Garlic
- **Leafy vegetables**: Curry leaf, Fenugreek, Spinach
- **Fruit crops**: Mango, Banana, Citrus, Pomegranate, Guava, Ber, Apples, Almond, Strawberry, Pear, Plum, Peaches, Grapes,

Avocado, Litchi, Phalsa, Papaya, Sapota, Pineapple, Watermelon and Date palm

- **Plantation crops**: Coconut, Cashewnut, Betelnut, Arecanut, Coffee, Tea, Rubber and Oil palm
- **Spices and condiments**: Cardamom, Black pepper, Tamarind, Turmeric, Ginger and Chillies
- **Tree crops**: Teak, Neem and Casuarina
- **Medicinal plants**: Annota, Patchouli and Palmarosa
- **Flowers**: Rose, Jasmine, Marigold, Gladiolus, Gerbera, Carnation, Gypsophylia, etc.

Vegetables: Drip irrigation vs. conventionnel irrigation

Crop	Yield (kg/acre)			Water use (m^3/acre)		
	Surface	Drip	% More	Surface	Drip	% More
Cucumber	6200	9000	45.1	1544	960	52.1
Bittergourd	7981	13301	66.6	3040	1320	56.6
Bottlegourd	15200	22320	46.8	-	2160	35.7
Ashgourd	4320	4800	11.1	3360	2960	11.9
Tomato	9808	25050	155.4	1901	1007	47.0
Capsicum	5340	8900	66.6	2041	1161	23.1
Lady's finger	3144	7187	128.5	1683	1043	38.0
Brinjal	5044	8569	69.9	2483	1488	40.0
Beans	2255	4100	81.8	1776	1120	36.9
Babycorn	2292	3952	72.4	1462	820	43.9
Gherkin	9720	19500	100.6	1343	856	36.2
Carrot	5460	10500	92.3	1965	1301	33.8
Cauliflower	6840	10960	60.2	1562	1040	33.4
Cabbage	8550	18750	119.2	1504	1016	32.4

Drip Irrigation System Design Template

Fruits: Drip irrigation vs. conventional Irrigation

Crop	Yield (kg/acre)			Water use (m^3/acre)		
	Surface	Drip	% More	Surface	Drip	% More
Banana	23000	35000	52.1	7040	3880	44.8
Grapes	8000	12000	50.0	3520	2320	34.0
Pomegranate	6050	11700	94.5	3920	2196	43.9
Sweet lime	4000	6000	50.0	6640	2560	64.8
Mango	3000	5400	80.0	5100	3324	34.8
Papaya	5200	9200	76.9	9120	2920	68.0
Watermelon	9610	15500	61.3	1680	1000	40.5
Plum	13.7	18.0	31.3	15.4	12.5	18.8
Kinnow	2720	3920	44.1	884	692	21.7
Guava	160	220	37.5	6.4	5.2	18.7

Components of micro irrigation system

Drip Irrigation System Design Template

Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!

Drip Irrigation System Design Template

[Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!]

Drip Irrigation System Design Template

Drip Irrigation System Design Template

[Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!]

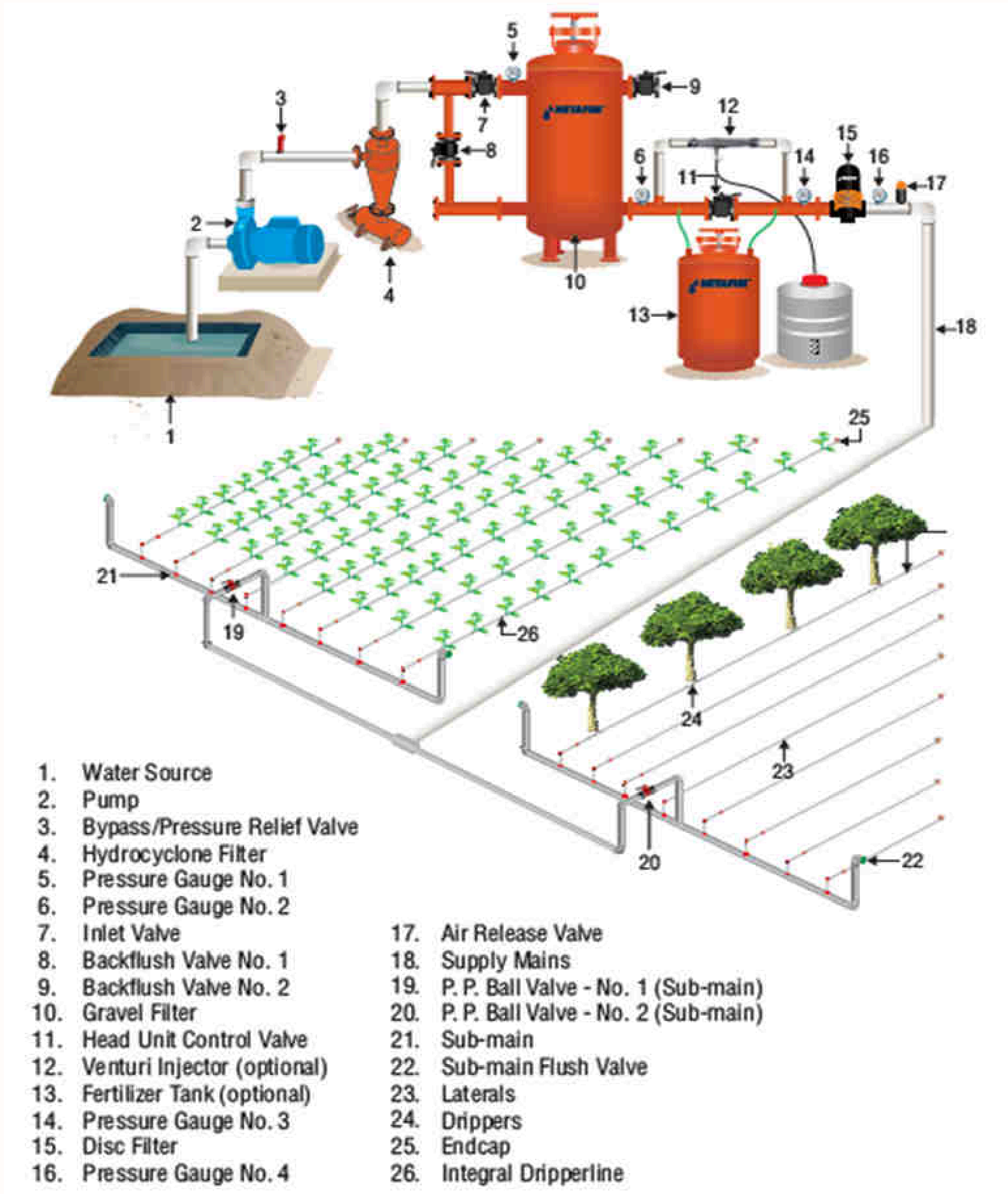

Automation Products
NMC - Pro
NMC - Junior
NMC - Nano
Fertikit
Netajet

Drip Irrigation System Design Template

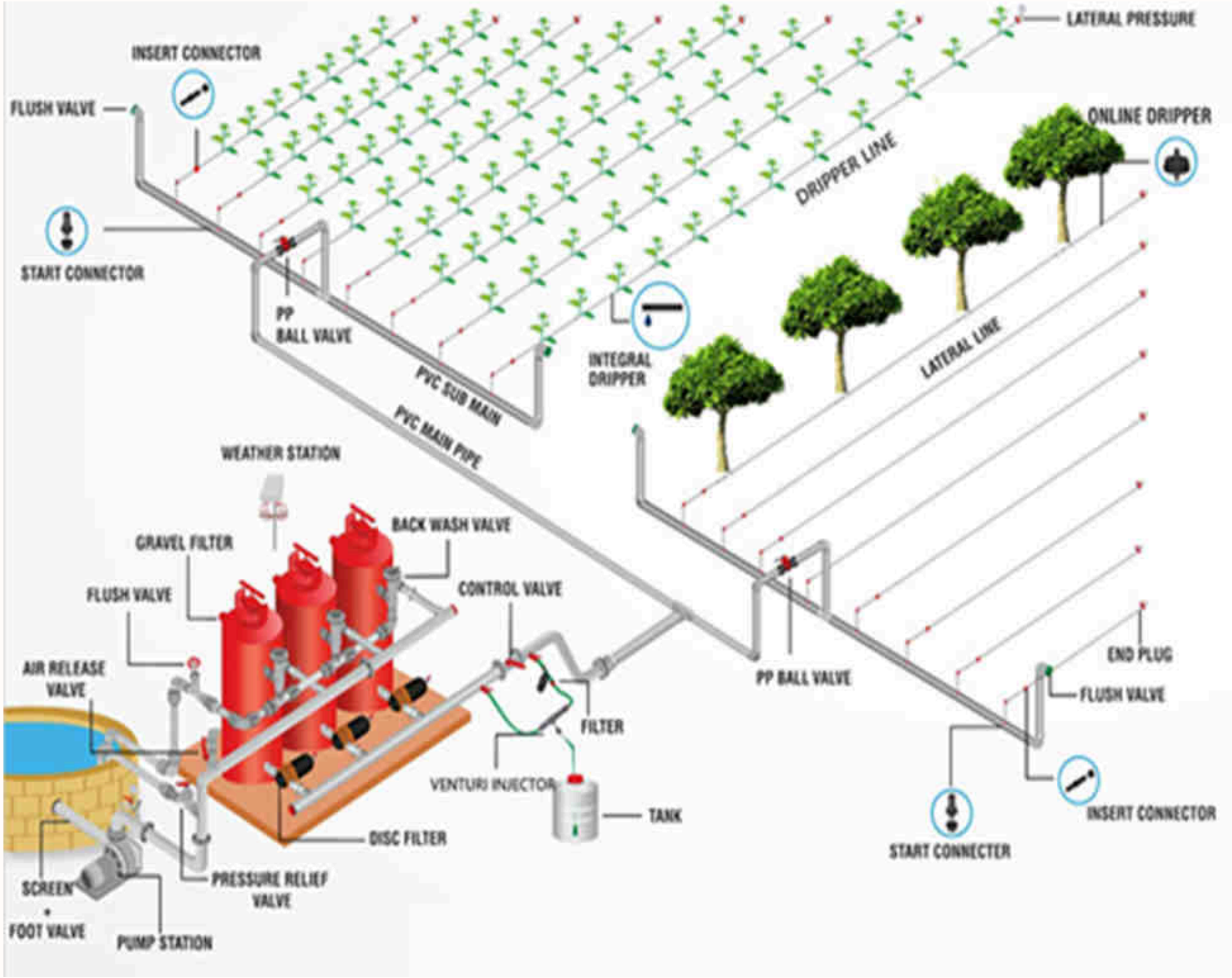
Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!

Drip Irrigation System Design Template

General layout of drip irrigation system



Drip Irrigation System Design Template

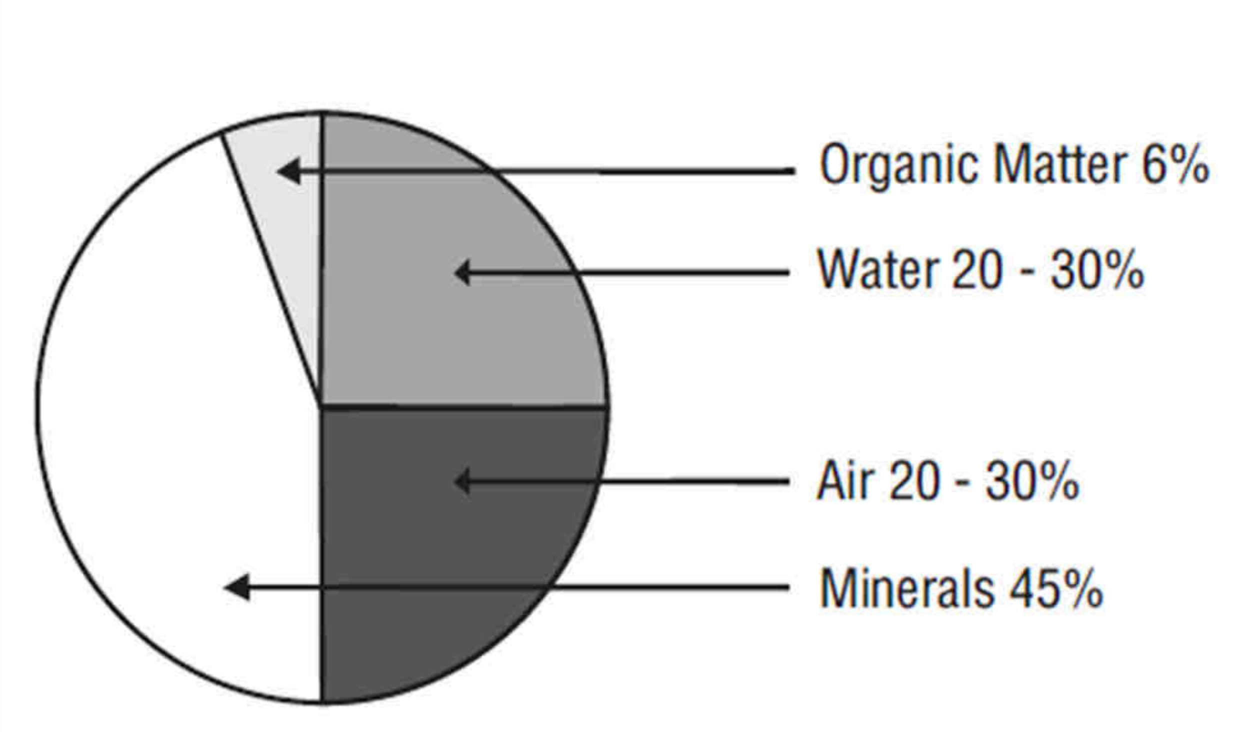


Click here to Boost Profits, cut costs, and grow smarter. Naresh's expertise will get you there. Book your call today!

CHAPTER 2: SOIL-WATER-PLANT RELATIONSHIP

Drip Irrigation System Design Template

Soil



The soil is heterogeneous & polyphasic viz., solid, liquid and gaseous, particulate, disperse, and porous.

The solid phase constitutes the soil matrix, the liquid phase consists of soil water, which always contains dissolved substances hence it should properly be called the soil solution and the gaseous phase is the soil atmosphere.

Soil Depth

Soil depth (cm)	Class
Less than 7.5	Very shallow
7.5 - 22.5	Shallow
22.5 - 45.0	Moderately deep
45.0 - 90.0	Deep
More than 90	Very deep

Soil depth refers to the thickness of soil cover over hard rock or hard substratum below which roots can't penetrate.

The soil depth is directly related to the development of root system, water storage capacity, nutrient supply, and feasibility for land leveling and landscaping.

Soil texture

Common name	Texture	Basic soil textural class
Sandy soils	Coarse	1. Sand 2. Loamy sand
Loamy soils	Moderately coarse	1. Sandy loam 2. Fine sandy loam
	Medium	1. Very fine sandy loam 2. Loam 3. Silt loam 4. Silt
	Moderately fine	1. Sandy clay loam 2. Silty clay loam 3. Clay loam
Clayey soils	Fine	1. Sandy clay 2. Silty clay 3. Clay

Soil texture is the most fundamental property of the soil that is most intimately related to the soil-water relationship.

It refers to the relative proportion of mineral particles of various sizes in a given soil i.e., the proportion of coarse, medium, and fine particles, which are termed sand, silt, and clay respectively.

Various combinations of these fractions are used to classify soil according to its texture.

Soil structure

The arrangement of the soil particles and the adhesion of smaller particles to form large ones or aggregates is called soil structure. In other words, it may be defined as the organization and mutual orientation of primary soil particles sand, silt, and clay into aggregates.

The dominant shape of aggregates in a horizon determines their structural type, such as spheroidal (granular or crumb-like subtypes), platy, prism-like (columnar or prismatic subtypes), and block-like (cube and sub-angular subtypes).

On the surface, the soil structure is associated with the tilth of the soil.

Pore space

Total soil porosity is an index of pore volume in the soil. It is the space in a given volume of soil that is occupied by air and water or not occupied by the soil solids. The amount of pore space is primarily a function of the arrangement of the soil solids.

If they lie close together as in sands or compact sub-soils, the total porosity is low. If they are arranged in porous aggregates, as is often the case in medium-textured soils high in organic matter, the pore space per unit volume will be high.

The total porosity value generally lies in the range of 30 to 60% for arable soils. Coarse textured soils tend to be less porous (35 - 50%) than the fine textured soils (40 - 60%).

Soil moisture tension

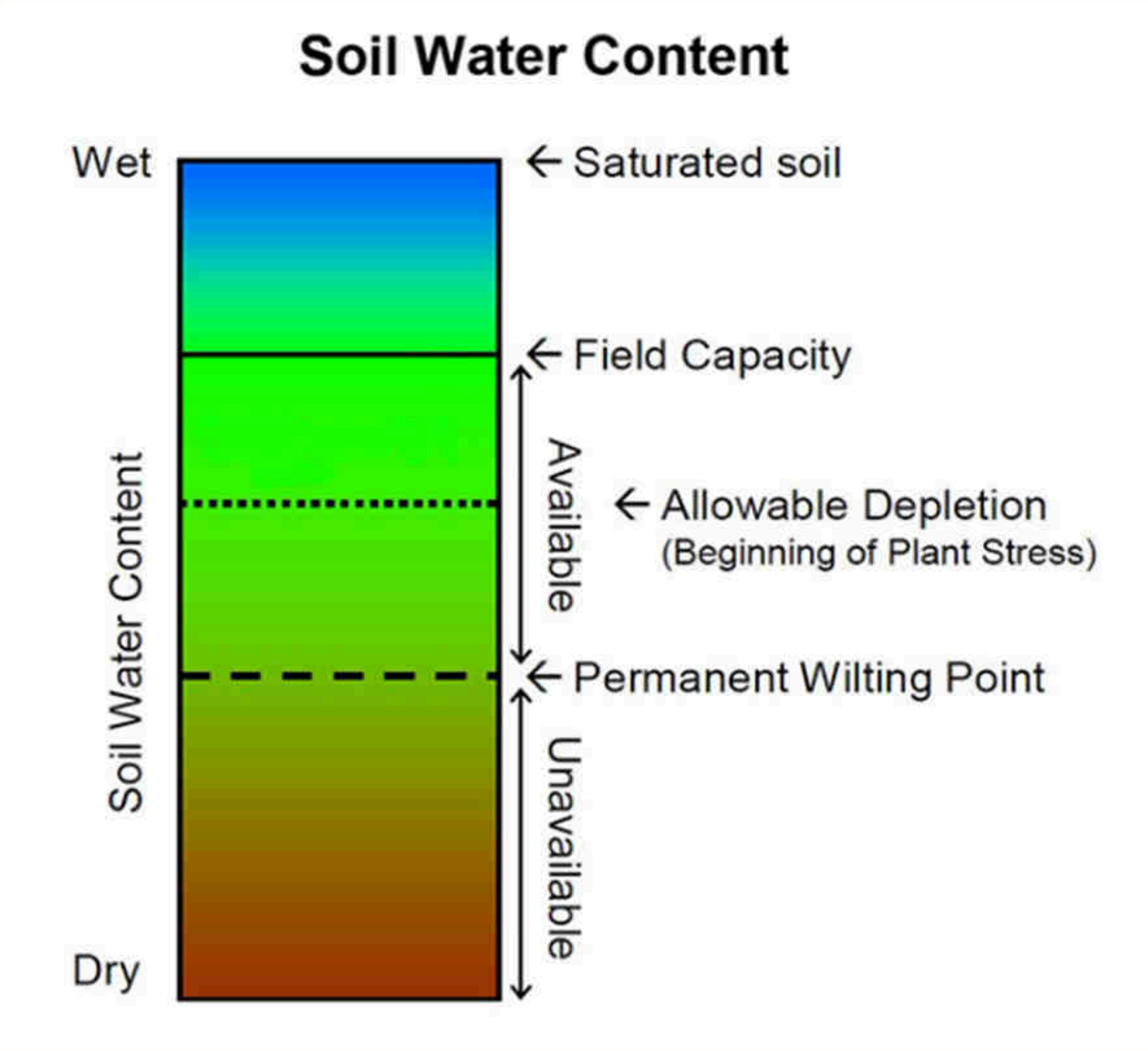
The moisture held in the soil against gravity may be described in terms of moisture tension.

Thus, soil moisture tension is a measure of the tenacity with which water is retained in the soil and reflects the force per unit area that must be exerted to remove water from the soil.

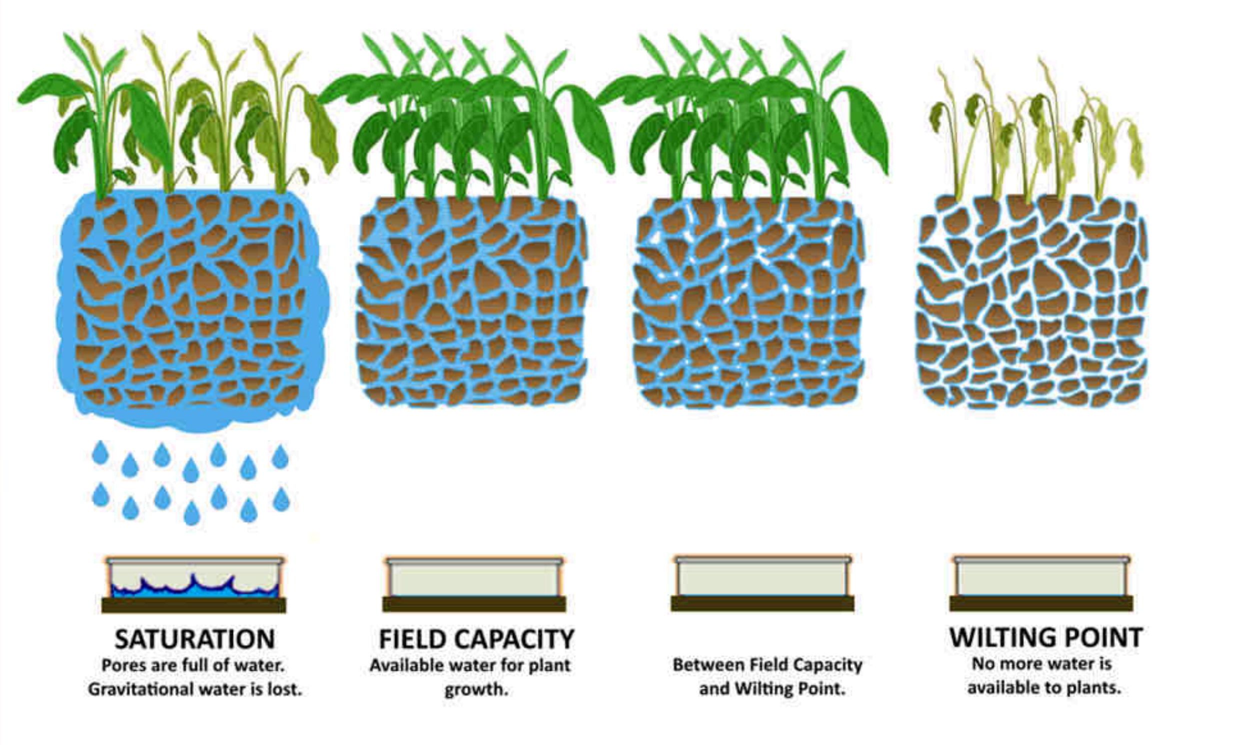
Several units have been used to express the force (energy) with which water is held in the soil.

A common means of expressing tension is in terms of a bar, which equals the pressure exerted by a vertical water column.

Total Available Water (TAW)

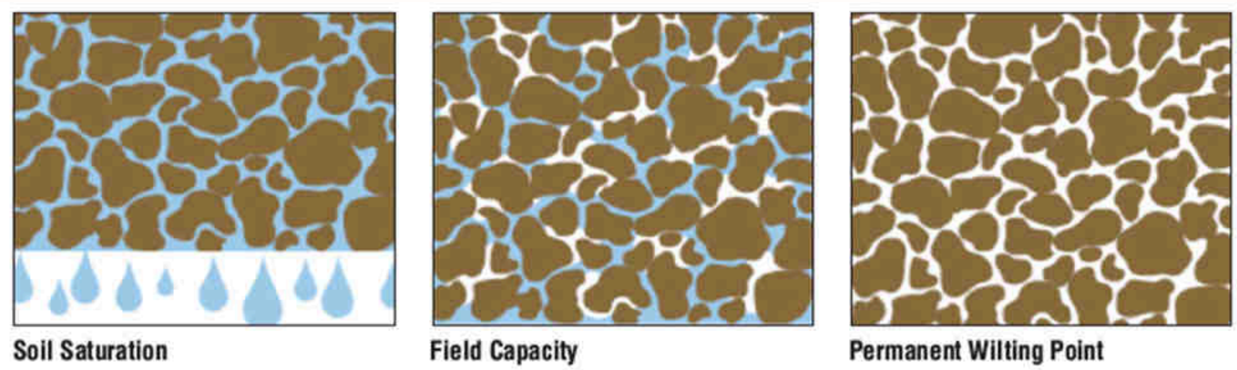


Field capacity



Field capacity

According to Veihmeyer and Hendrickson (1950), field capacity is the amount of water held in the soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2-3 days after a rain or irrigation in pervious soils having uniform texture and structure.



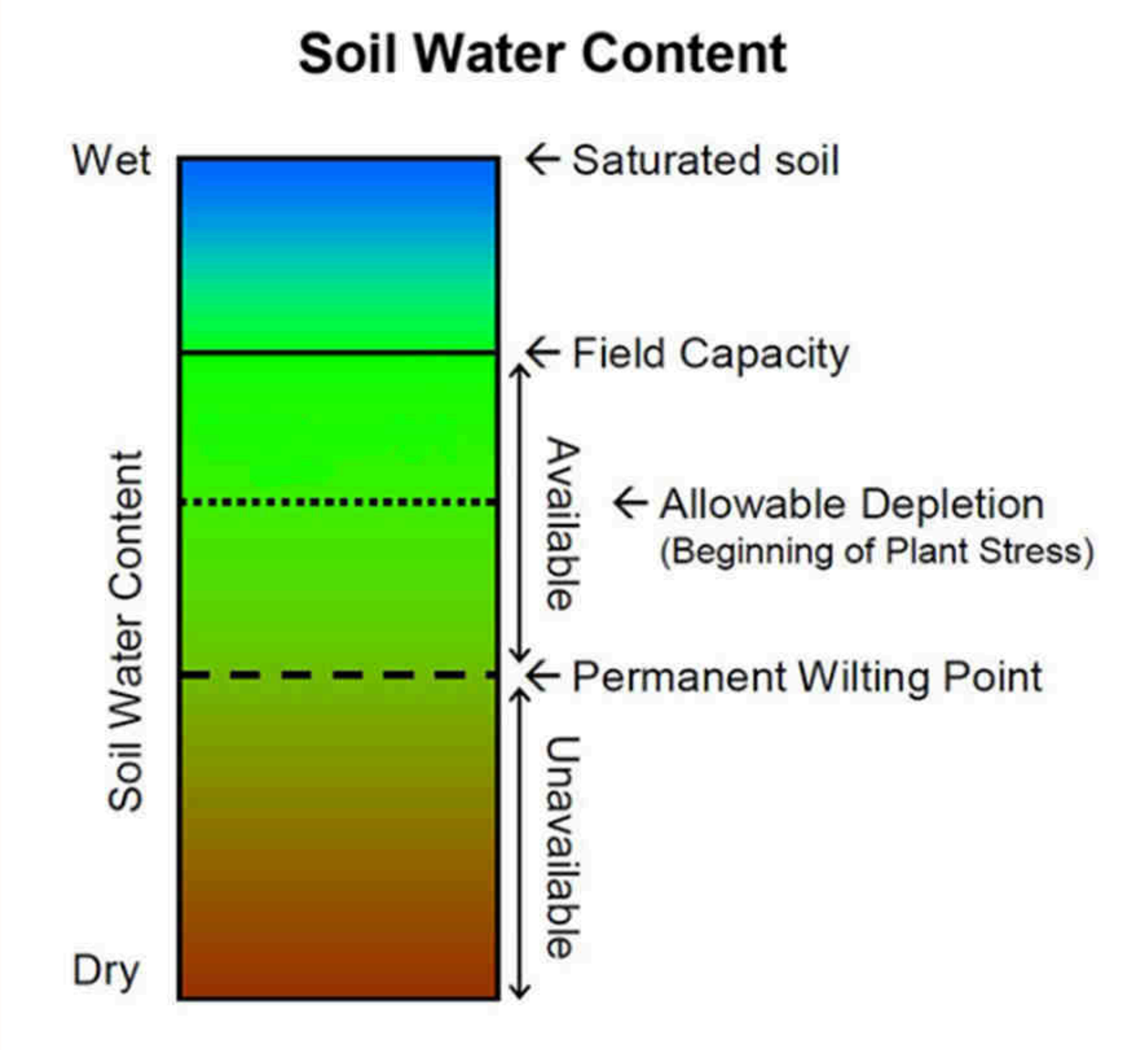
Permanent wilting point

Removal of water either by the plant roots of a biologically active crop or due to soil evaporation from an initially wet soil causes the water films surrounding the soil particles to become thinner and thinner with the result that most of the water held between soil particles in the pores is being consumed.

Finally, a condition is reached where the water is held so tightly by the soil particles that the roots cannot extract it at a sufficiently rapid rate to prevent the leaves from wilting.

When this condition is reached the soil is said to be in a state of permanent wilting point, at which nearly all the plants growing on such soil show wilting symptoms and do not revive in a dark humid chamber unless water is supplied from an external source.

Total Available Water (TAW)



It has been a convention and now it is customary to consider the amount of soil moisture held between the two cardinal points viz., field capacity and permanent wilting point as available soil moisture.

The field capacity, moisture content, permanent wilting point, and available soil moisture in different soil textural classes are presented below:

Field capacity, Permanent wilting point and Available soil moisture in varying textural soils

Soil Type	Textural Fraction (% by weight)			Field Capacity (%)	Permanent Wilting Point (%)	Available Soil Moisture (mm/m soil depth)
	Sand	Silt	Clay			
Sandy	85	15	10	5-10	2-6	5-10
Sandy loam	45-85	50	20	10-18	4-10	9-16
Loam	25-50	30-50	10-25	18-25	8-14	14-22
Clay loam	20-45	15-50	30-40	24-32	11-16	17-25
Clay	45	40	40	32-40	15-22	20-28

Infiltration

Infiltration is the entry of fluid from one medium to another. In irrigation practice, it is the term applied to the process of water entry into the soil, generally by downward flow through all or part of the soil surface. Water may enter the soil through the entire surface uniformly, as under ponding or rain, or it may enter the soil through furrows or crevices.

Deep percolation

The post-infiltration water movement downward within the soil profile under the influence of both gravity and hydrostatic pressure is termed deep percolation. Sandy soils facilitate greater percolation when compared to clayey soils due to the dominance of macro pores. Likewise, the loss of water by percolation in cropped fields is generally less than that in bare soils.

Permeability

It indicates the relative ease with which air and water penetrate or pass through the soil pores.

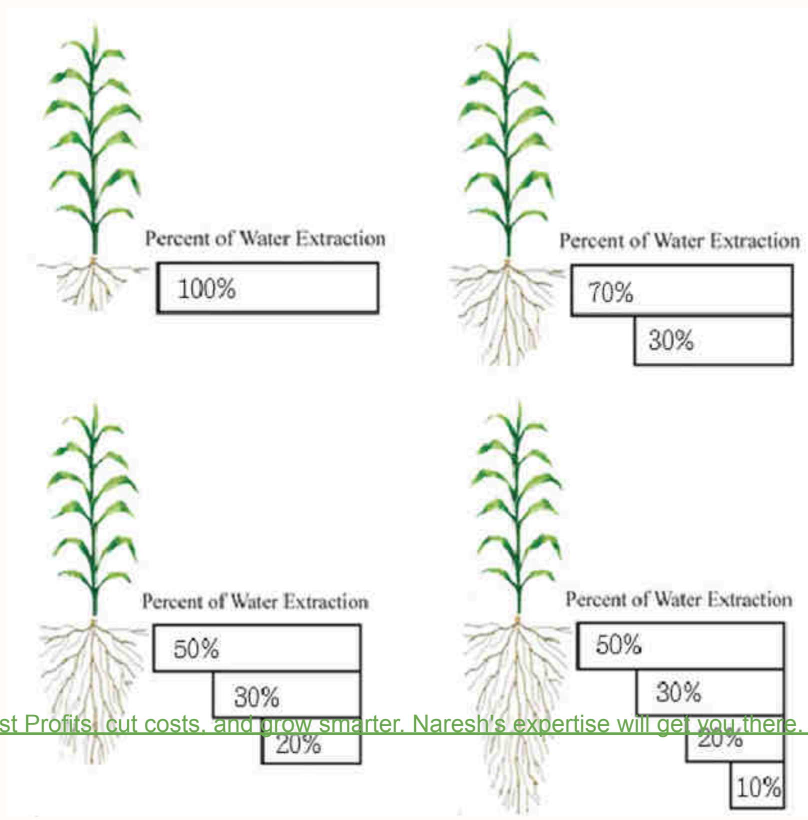
The permeability of soil is generally described in general terms as rapid, moderate, and slow. Thus the permeability is rapid in coarse-textured soil and slow in fine-textured soil.

Seepage

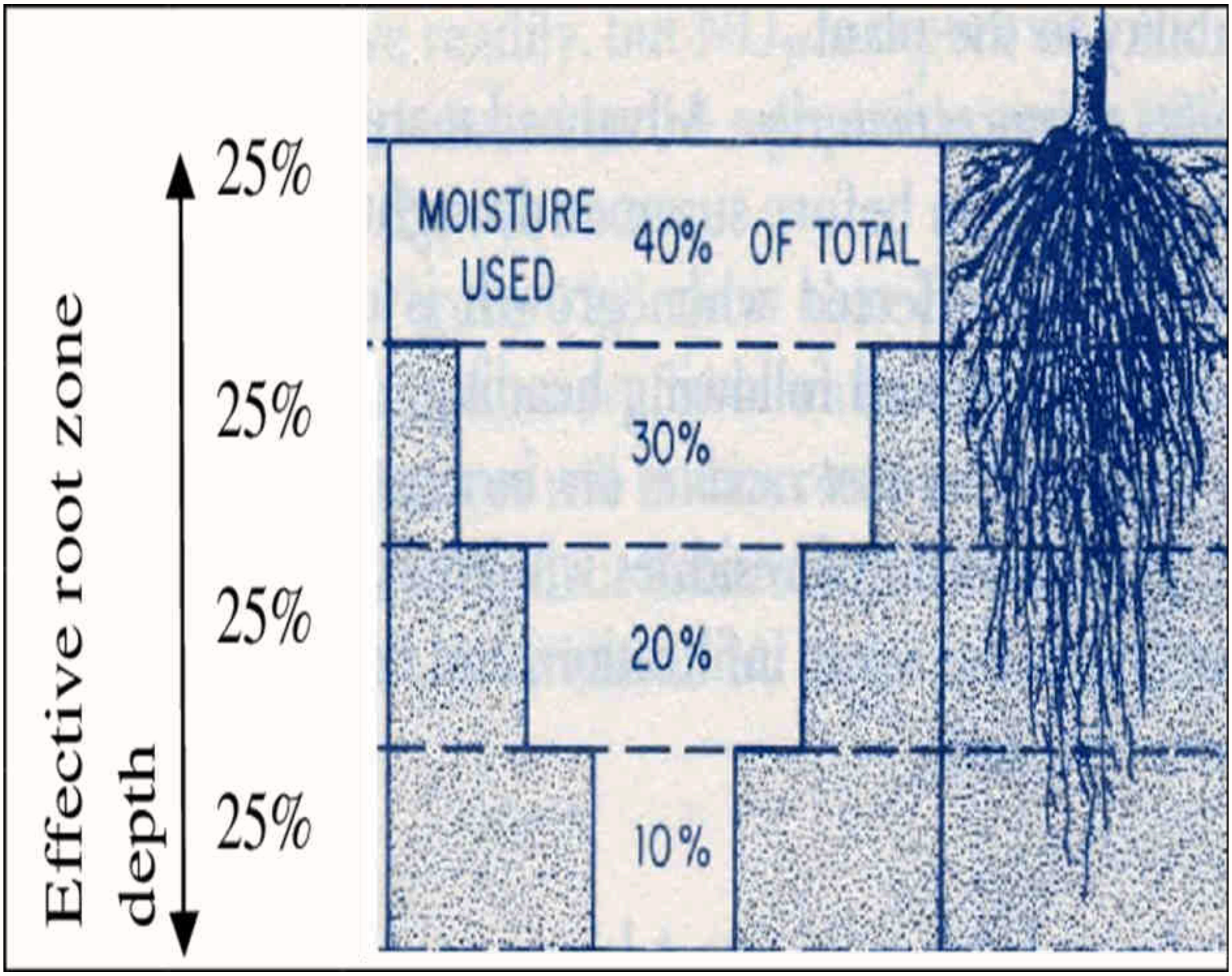
The slow lateral movement of water through soil pores or small cracks in the soil profile under unsaturated conditions is known as seepage.

Moisture extraction pattern

The moisture extraction pattern refers to the amount of soil moisture expressed as a percentage extracted from different layers in the soil profile. Extraction of water is most rapid in the zone of greatest root concentration and under the most favorable conditions of temperature and aeration. The usual extraction pattern shows that about 50% of the soil moisture extracted is contributed from the upper quarter of the root zone, 30% from the second quarter, 20% from the third quarter, and 10% from the bottom quarter. Values for individual crops may vary within the range of 10%.



Effective root zone depth



It is also referred to as design moisture extraction depth. This is the soil depth from which nearly 90% of the crop water requirements are met.

This soil depth is normally taken into account to determine the irrigation water requirements for scheduling irrigations.

For best results, it should be the depth from which the roots of an average mature plant are capable of reducing soil moisture to the extent that it should be replaced by irrigation.

It is not necessarily the maximum rooting depth for any given crop, especially for plants that have a long tap root system.

Water Evapotranspiration

Evapotranspiration is a combined loss of water from the soil (evaporation) and plant (transpiration) surfaces to the atmosphere through the vaporization of liquid water and is expressed in depth per unit time (for example mm/day).

Quantification of evapotranspiration is required in the context of many issues:

- Management of water resources in agriculture
- Designing irrigation projects on a sound economic basis

- Fixing cropping patterns and working out the irrigation requirements of a crop
- Classifying regions climatologically for agriculture

Water requirement

It is defined as the quantity of water regardless of its source, required by a crop or diversified pattern of crops in a given period for its normal growth under field conditions at a given place.

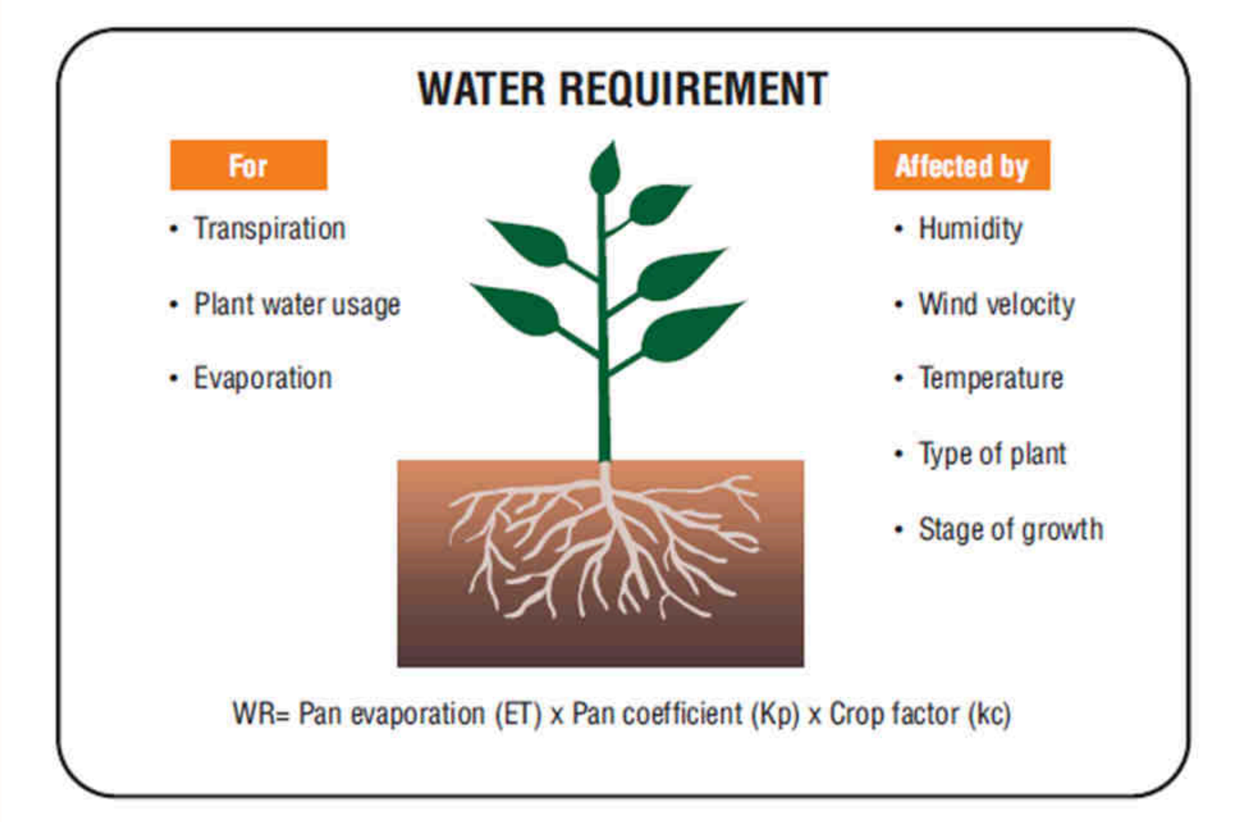
In other words, it is the total quantity of water required to mature an adequately irrigated crop. It is expressed in depth per unit of time.

Net irrigation requirement

It is the amount of irrigation water just required to bring the soil moisture content in the effective crop root zone depth to field capacity.

Thus, the net irrigation requirement is the difference between the field capacity and the soil moisture content in the root zone just before the application of the irrigation water.

Water requirement



Irrigation scheduling

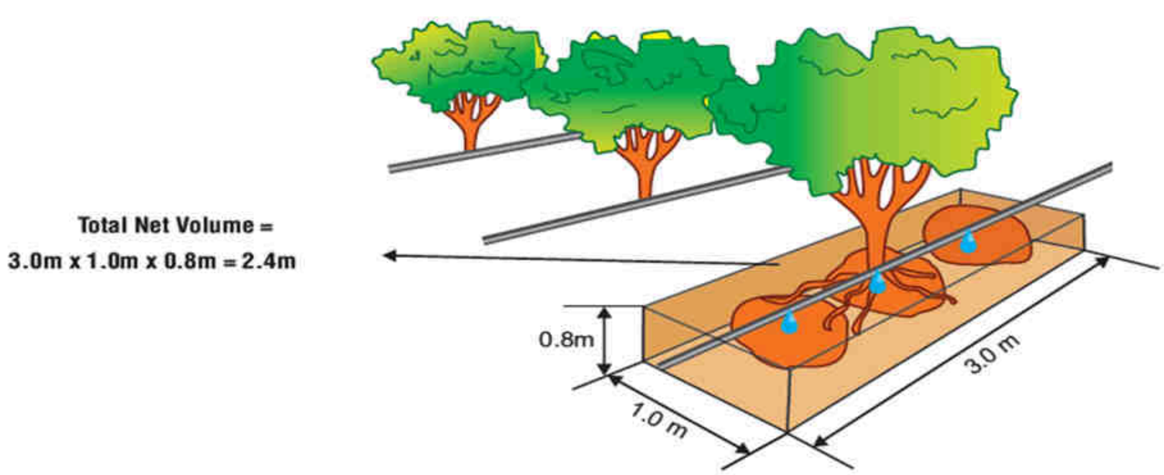
Scientific irrigation scheduling is a technique providing knowledge about the correct time and optimum quantity of water application at each irrigation to optimize crop yields with maximum water use efficiency and at the same time ensure minimum damage to the soil properties.

Guidelines for determination of irrigation interval

- Water should reach the desired soil depth
- Desired moisture must be kept in the profile until the next water application
- Maintenance of optimal aeration level
- The desired wetted volume must be met

Amount of Water Capacity

Type of soil	% of water field capacity	Amount of water capacity in 50% field
Heavy soil	30% = 720 litres	360 litres
Medium soil	20% = 480 litres	240 litres
Light soil	10% = 240 litres	120 litres



Drip Irrigation System Design Template

Drip Irrigation System Design Template

Critical growth stages of crops for water requirement

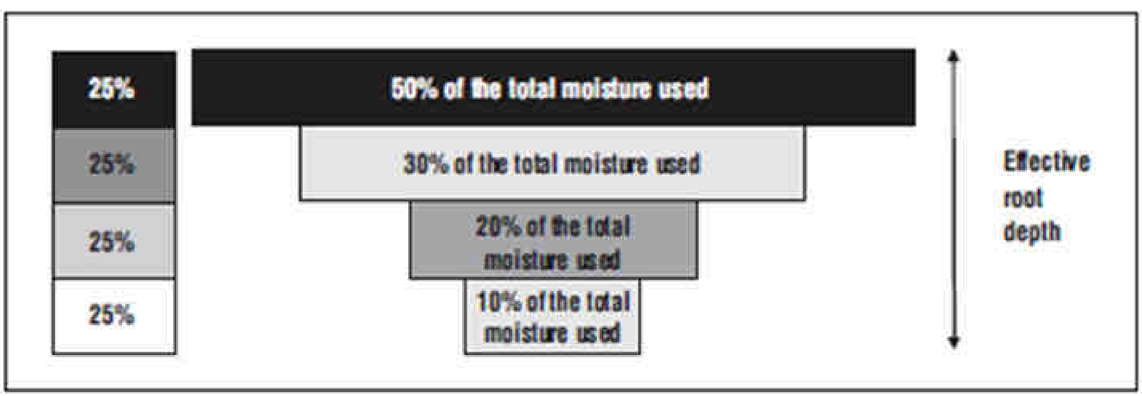
Crop	Critical stages
Bajra	Heading & flowering
Banana	Adequate soil moisture throughout growth period & fruit development
Barley	End of shooting stage & earring
Chillies	Flowering & fruit development
Citrus	Flowering, fruit set and fruit enlargement
Cotton	Flowering & boll development
Groundnut	Flowering, peg penetration & pod development
Maize	Tasseling, silking & pollination
Mango	Flowering & fruit development
Onion	Bulb enlargement to ripening
Peas	Flowering and pod development
Pomegranate	Flowering & fruit development
Potato	Tuber initiation to tuber maturity
Ragi	Primordial initiation & flowering
Rice	Primordial development, heading & flowering
Safflower	Rosette, flowering and seed development
Sesamum	Flowering to maturity
Sorghum	Booting, blooming, milky & dough stages
Soybean	Flowering & seed formation
Sugarcane	Formative & stem elongation
Sunflower	Star formation, flowering & seed development
Tobacco	Rapid growth & topping stage
Tomato	Flowering & fruiting
Wheat	Crown root initiation, shooting & earring

Drip Irrigation System Design Template

Quality criteria for clogging potential of different water sources

Clogging factor	Clogging hazard		
	Slight	Moderate	Severe
1. Physical			
a) EC (mmhos/cm)	< 0.75	0.75 - 3.0	> 3.0
b) Suspended solids (mg/litre)	< 50	50 - 100	> 100
2. Chemical			
a) pH	< 7.0	7.0 to 8.0	> 8.0
b) Dissolved solids (PPM)	< 500	500 to 2000	> 2000
c) Manganese (PPM)	< 0.1	0.1 to 1.5	> 1.5
d) Iron (PPM)	< 0.2	0.2 to 1.5	> 1.5
e) Hydrogen Sulphide (PPM)	< 0.2	0.2 to 2.0	> 2.0
f) Hardness (PPM)	< 150	150 to 300	> 300
g) Sodium Adsorption Ratio (SAR)	< 3.0	3.0 - 9.0	> 9.0
h) Residual Sodium Carbonate (RSC)	< 1.25	1.25 - 2.50	> 2.50
3. Biological			
a) Bacterial population (number/ml)	< 10000	10000 to 50000	> 50000

Average moisture extraction pattern of plants



Crop factors for different crops

Crop	Crop development stages					
	Initial	Crop develop-ment	Mid season	Last season	At harvest	Total growing period
Alfalfa	0.3-0.4				1.05-1.2	0.85-1.05
Almond, Apricot						0.75
Apple, Walnut						0.85
Banana tropical	0.4-0.5	0.7-0.85	1.0-1.1	0.9-1.0	0.75-0.85	0.7-0.8
Banana sub tropical	0.5-0.65	0.8-0.9	1.0-1.2	1.0-1.15	1.0-1.15	0.85-0.95
Bean green	0.3-0.4	0.65-0.75	0.95-1.05	0.9-0.95	0.85-0.95	0.85-0.9
Bean dry	0.3-0.4	0.7-0.8	1.05-1.2	0.65-0.75	0.25-0.3	0.7-0.8
Cabbage	0.4-0.5	0.7-0.8	0.95-1.0	0.9-1.0	0.8-0.95	0.7-0.8
Carrot						1.0
Citrus, Guava, Mango						0.65-0.75
Corn						1.1
Cotton	0.4-0.5	0.7-0.8	1.05-1.29	0.8-0.9	0.65-0.7	0.8-09
Grape	0.35-0.55	0.6-0.8	0.7-0.9	0.6-0.8	0.55-0.7	0.55-0.75
Groundnut	0.4-0.5	0.7-0.8	0.95-1.1	0.75-0.85	0.55-0.6	0.75-0.8
Lettuce						0.95
Maize sweet	0.3-0.5	0.7-0.9	1.05-1.2	1.0-1.15	0.95-1.1	0.8-0.95
Olive						0.4-0.6
Onion dry	0.4-0.6	0.7-0.8	0.95-1.1	0.85-0.9	0.75-0.85	0.8-0.9
Onion green	0.4-0.6	0.6-0.75	0.95-1.05	0.95-1.05	0.95-1.05	0.65-0.8
Pea, Fresh	0.4-0.5	0.7-0.85	1.05-1.2	1.0-1 15	0.95-1.1	0.8-0.95
Pepper, Fresh	0.3-0.4	0.6-0.75	0.95-1.1	0.05-1.0	0.8-0.9	0.7-0.8
Plum, Peaches						0.75
Potato	0.4-0.5	0.7-0.8	1.5-1.2	0.85-0.95	0.7-0.75	0.75-0.9
Rice	1.1-1.15	1.1-1.5	1.1-1.3	0.95-1.05	0.95-1.05	1.05-1.2
Safflower	0.3-0.4	0.7-0.8	1.05-1.2	0.65-0.7	0.2-0.25	0.65-0.7
Sapota						0.65-0.75
Sorghum	0.3-0.4	0.7-0.75	1.0-1.15	0.75-08	0.5-0.55	0.75-0.85
Soybean	0.3-0.4	0.7-0.8	1.0-1 15	0.7-0.8	0.4-0.5	0.75-0.9
Sugar beet	0.4-0.5	0.75-0.85	1.05-1.2	0.9-1.0	0.6-0.7	0.8-0.9
Sugarcane	0.4-0.5	0.7-1.0	1.0-1.3	0.75-0.8	0.5-0.6	0.85-1.05
Sunflower	0.3-0.4	0.7-0.8	1.05-1.2	0.7-0.8	0.35-0.45	0.75-0.85
Tobacco	0.3-0.4	0.7-08	1.0-1.2	0.9-1.0	0.75-0.85	0.85-0.95
Tomato	0.4-0.5	0.7-0.8	1.05-1.25	0.8-0 95	0.6-0.65	0.75-0.9
Watermelon	0.4-0.5	0.7-0.8	0.95-1.05	0.8-0.9	0.65-0.75	0.75-0.85
Wheat	0.3-0.4	0.7-0.8	1.05-1.2	0.65-0.75	0.2-0.25	0.8-0.9

Note: The range of values include maximum and minimum values depending on climate conditions.

Drip Irrigation System Design Template

Approximate duration of growth stages for various crops (days), min. & max.

Crop	Initial	Crop development stage	Mid season stage	Late season stage	Total growing period
Barley/Oat/Wheat	15	25	50	30	120
	15	30	65	40	150
Bean (green)	15	25	25	10	75
	20	30	30	10	90
Bean (dry)	15	25	35	20	95
	20	30	40	20	110
Cabbage	20	25	60	15	120
	25	30	65	20	140
Carrot	20	30	30	20	100
	25	35	70	20	150
Cotton	30	50	55	45	180
	30	50	65	50	195
Cucumber	20	30	40	15	105
	25	35	50	20	130
Groundnut	25	35	45	25	130
	30	40	45	25	140
Melon	25	35	40	20	120
	30	45	65	20	160
Onion (green)	25	30	10	5	70
	25	40	20	10	95
Onion (dry)	15	25	70	40	150
	20	35	110	45	210
Potato	25	30	30	20	105
	30	35	50	30	145
Tomato	30	40	40	25	135
	35	45	70	30	180

Chapter 3

FUNDAMENTALS OF FERTIGATION

Drip Irrigation System Design Template

Introduction

Agriculture that is based on advanced technology requires a level of soil fertility that will enable reaching high yields at a quality demanded by the marketplace.

Full control over the amount and distribution of fertilizer application during the season will have an important and direct influence on the final results.

Fertigation refers to the application of both water and fertilizers to crops simultaneously through a drip irrigation system. The climax of low-volume irrigation technology is fertigation.

The word fertigation suits its description as the optimal technique of nurturing the crop by providing water enriched with the proper concentration of nutrients required by the plant at any stage of life cycle.

Fertilizer is released proportionally in coordination with plant requirements so that it is possible to control and optimize the growth of plants. It is possible to make changes in the nutrients provided in real-time, according to crop requirements, retarding or supplementing growth.

Fertilizers are not flushed down to underground water or soil layers since percolation is eliminated under drip irrigation. The result is a substantial increase in crop yield and quality. Almost no work is required for fertilization. Both irrigation and fertilization can be executed by automatic control to save labor and precision.

Fertigation is the method for improving both yield and quality at the lowest price: A small investment for a large return! With fertigation, the fertilizer elements are injected into the water continuously, in concentrations in accordance with the plant's requirements.

Fertigation ensures that essential nutrients are supplied precisely at the area of most intensive root activity.

Advantages of fertigation

Fertilizer is applied in the required quantities where the root system is active, which is in the moistened area so that almost all the applied fertilizer is utilized (efficiency is > 95%) this way, during the initial growth period, concentrations are lower (except phosphorus, which is applied in large quantities to encourage better root penetration and proliferation).

During the productive growing period, the concentration of elements is increased. The N-P-K ratios should be selected taking into account the physiological stages of the crop so that plant roots are never lacking in nutrients. The fertilizer quantities over the growing season are divided into various periods of growth and are supplied daily.

Classification of essential nutrients

- Basic nutrients: Carbon, Hydrogen, Oxygen
- Macronutrients:
- a. Primary nutrients: Nitrogen (N), Phosphorus (P), Potassium (K)
- b. Secondary nutrients: Calcium (Ca), Magnesium (Mg), Sulphur (S)
- Micronutrients:
- Iron (Fe), Zinc (Zn), Copper (Cu), Boron (B) Molybdenum (Mo), Manganese (Mn), Chlorine (Cl)

Fertilizers suitable for fertigation

- Urea (46% N)
- Ammonium Sulphate (21% N)
- Phosporic Acid (60% P)
- Muriate of Potash (60% K)
- Potassium Nitrate (13% N, 46%K)
- Potassium Sulphate (50% K)
- Ammonium Nitrate (33% N)
- Calcium Nitrate (15% N)
- Mono Ammonium Phosphate (12% N, 61 % P)
- Other water-soluble speciality fertilizers

Fertilizers should be completely water soluble.

- The quality of the irrigation water decides the fertilizer to be used. For example, fertigation with Ammonium Sulfate in hard water causes the formation of insoluble Calcium Sulphate which may clog the dripper
- Compatibility of the fertilizers should be considered while mixing different fertilizers
- While dissolving the fertilizers in the water, their water solubility % should be considered

Nutrient deficiency symptoms

Nutrient	Deficiency symptoms	Occurance
Nitrogen (N)	Yellowing, stunted growth, premature leaf fall, poor size of fruits	Light soil where leaching is more due to heavy rainfall
Phosphorus (P)	Poor root development, dark or blue green coloured leaves, purple pigmentation on leaves and stem, delayed flowering and maturity	Acidic soil, cold and moist soil
Potassium (K)	Weak stem, scorching of leaf margins, leaf edges may be curled	Light soil
Calcium (Ca)	Young leaves small, distorted & twisted, die back at the tips. Stem weak & brittle, root tips die. Blossom end rot in some vegetables.	Acidic soil, sandy soil, very dry soil & soil with high K & N
Magnesium (Mg)	Interveinal chlorosis in older leaves, then bleach & turn to orange, red or purple colour some times cupping of leaves	Acidic soil, sandy soil, soil with high K
Sulphur (S)	Uniform yellowing of young leaves, stem is stiff,woody & brittle	Soil with low organic matter, sandy soil
Iron (Fe)	Young leaves show interveinal chlorosis, later on they turn yellow & white	If pH is >6.8, soil having high Na & Ca, calcareous soil and high P application
Zinc (Zn)	Middle leaves are mottled, chlorotic. Rosette growth due to shortened internodes	Alkaline soil, heavy P application. calcareous soil
Boron (B)	Death or curling of shoot tip, young leaves are light green, fruit cracking	If pH is >6.8, high P level in soil, acidic soil, sandy soil
Manganese (Mn)	Interveinal chlorosis, chlorotic and necrotic spots in interveinal areas, leaves smaller	If pH is > 6.7, sandy soil, peat and muck soil, and calcareous soil
Molybdenum (Mo)	Deformation of shoots, interveinal yellowing with necrotic margins in older leaves	Very acidic and sandy soil having pH < 5.2
Copper (Cu)	Yellowing, rusting of young leaves, leaves elongated and tips may be curled	High organic matter containing soil, acidic as well as alkaline soil under intensive cultivation

Ref: Technology for vegetable production and improvement (Hazra and som, 1999/Page: 112 - 117)

Drip Irrigation System Design Template

Solubility of fertilizers (gm/lit)

Fertilizer	Temperature range (°C)		
	Cold	Luke warm	Hot
Ammonium Chloride	297 (°C)	-	7580 (100°C)
Ammonium Nitrate	1183 (°C)	1950 (20°C)	3440 (50°C)
Mono Ammonium Phosphate (MAP	227 (°C)	282 (20°C)	417 (50°C)
Di Ammonium Phosphate (DAP)	429 (°C)	575 (10°C)	1060 (70°C)
Ammonium Sulphate	706 (°C)	760 (20°C)	850 (50°C)
Muriate of Potash	280 (°C)	347 (20°C)	430 (50°C)
Potassium Nitrate	133 (°C)	316 (20°C)	860 (50°C)
Potassium Sulphate	69 (°C)	110 (20°C)	170 (50°C)
Calcium Nitrate	1020 (°C)	3410 (50°C)	3760 (99°C)
Phosphoric acid	-	5480 (25°C)	-
Urea	780 (5°C)	1139 (25°C)	-

Values in the paranthes are solution temperatures

Ref: Advances in Agronomy/Page: 54 (Chapter: Advances in Agronomy, Bar Yosef)

Fertigation schedule

- The fertigation schedule is done based on:
- Soil fertility status
- Nutrient removal by the crop
- Variety of the crop & crop duration
- Target yield
- Climatic conditions
- Specific nutrient requirements for a specific produce

Drip Irrigation System Design Template

Nutrient removal by some of the vegetables

Crop	Yield (ton/ha)	Nutrient removal for this yield (kg/ha)			Nutrient removal per ton (kg)		
		N	P	K	N	P	K
Potato	40	175	80	310	4.37	2.0	7.75
Tomato	50	140	65	190	2.80	1.3	3.8
Brinjal	60	175	40	300	2.91	0.66	5.0
Cabbage	70	370	85	480	5.38	1.21	6.85
Cauliflower	50	250	100	350	5.00	2.0	7.0
Onion	35	120	50	160	3.42	1.42	4.5
Muskmelon	15	54	16	97	3.60	1.06	6.46
Okra	20	60	25	90	3.00	1.25	4.5
Carrot	30	125	55	200	4.16	1.83	6.66
Beans	15	130	40	160	8.66	2.66	10.66

Ref : Technology for vegetable production and improvement (Hazra and Som, 1999 Page:110)

Salinity classes of irrigation water

Salinity class	Electrical conductivity (milli mhos/cm)
C1 - Low	< 0.25
C2 - Medium	0.25 - 0.75
C3 - Medium to high	0.75 - 2.25
C4 - High	2.25 - 5.0
C5 - Very high	> 5.0

Water quality criteria for irrigation

Concentration of soluble salts			Water quality
S.No	Mmhos/cm	TSS (PPM)	
1	< 1.5	< 960	Fresh, normal, non-saline water of high quality
2	1.5 - 3.0	960 - 1920	Slightly saline, good quality water
3	3.0 - 5.0	1920 - 3200	Moderately saline water to be used with safely measures
4	5.0 - 10.0	3200 - 6400	Saline, poor quality water to be used rarely with all precautions
5	10.0 - 15.0	6400 - 9600	Highly saline, poor quality water, should not be used for irrigation
6	> 15.0	> 9600	Toxic water unfit for irrigation

Sodium adsorption ratio

$$\text{Sodium Adsorption Ratio (SAR)} = \frac{Na^{+}}{\sqrt{(Ca^{++} + Mg^{++}) / 2}}$$

Sodicity classes of irrigation water

Sodicity class	SAR value
S1 - Low	< 10
S2 - Moderate	10 - 18
S3 - High	18 - 26
S4 - Very High	> 26

Residual Sodium Carbonate (RSC) =$(CO^{3}+HCO^{3}) + (Ca^{++} + Mg^{++})$

RSC classes of irrigation water

Class	RSC value
Safe	< 1.25 meq/lit
Marginal	1.25 - 2.50 meq/lit
Unsuitable	> 2.50 meq/lit

Permissible limits of Boron in irrigation water

Class	Permissible Boron limit in PPM		
	Sensitive crops	Semi-tolerant crops	Tolerant crops
Safe	< 0.33	< 0.67	< 1.00
Medium	0.33 - 0.67	0.67 - 1.33	1.00 - 2.00
Toxic	0.67 - 1.00	1. 33 - 2.00	2.00 - 3.00
Highly toxic	1.00 - 1.25	2.00 - 2.50	3.00 - 3.75

Fertigation - Technical aspect

- Make sure that your fertilizer is completely soluble and free of impurities.
- Never use fertilizers containing calcium (such as calcium nitrate) or basic fertilizer when the irrigation water is neutral or basic (pH>7).
- When the water has an acidic reaction (pH<6), fertilizers containing calcium may be used.
- In the case of acid water (pH<5) it is recommended to use basic fertilizers if available and calcium nitrate if calcium concentration in the soil is low.
- Never inject ionic iron into the drip system. Remember, ionic iron endangers the system.
- Use iron chelate only. Make sure that the chelate you use is of high quality (stable & strong). Avoid cheap products that can

decompose into the system. This can cause ineffective feeding for plants and plugged drippers.

Fertigation - Technical aspect

Phosphoric fertilizers can cause serious difficulties:

a. Avoid high concentration in the water
b. Never turn off irrigation & fertilization at the same time. Turn off the fertilization pump 30 minutes before the end of
the irrigation to flush phosphate remains from the system.
c. Never use fertilizers based on polyphosphate use orthophosphate only.
d. When the irrigation water is basic or the water hardness is high, use acidic phosphoric fertilizer.

Tolerance levels of different crops to water quality

Tolerant	Semi-tolerant	Sensitive
Fruit crops Date palm, Coconut, Falsa	Pomegranate, Fig, Olive, Grape, Guava, Mango, Ber, Kagzilime	Apple, Orange, Almond, Peach, Strawberry, Lemon
Vegetable crops Turnip, Amaranthus, Spinach, Asparagus, Beet root	Tomato, Cabbage, Cauliflower, Potato, Carrot, Onion, Cucumber, Brinjal, Bitter gourd, Garlic Bottle gourd, Sweet potato, Sponge gourd, Watermelon, Chilli, Muskmelon, Fenugreek	Radish, Celery, Cumin, Mint, Peas, Lady's finger
Field crops Sugar beet, Barley, Sesbania(Dhaincha), Cotton, Safflower, Sugarcane	Sorghum, Maize, Rice, Sunflower, Wheat, Bajra, Jowar, Pigeonpea, Castor, Soybean, Linseed, Cluster bean, Cowpea, Groundnut, Mustard, Tobacco, Rye, Oat	Moong, Urd, Bengal gram, Bean, Sunhemp, Lentil
Forage crops Bermuda grass, Salt grass, Berseem Barley (hay), Rhodes grass	Sudan grass, Alfalfa, Orchard grass, Senji, Oats	Red clover

CHAPTER 4:

DRIP IRRIGATION SYSTEM

DRIP IRRIGATION SYSTEM OVERVIEW

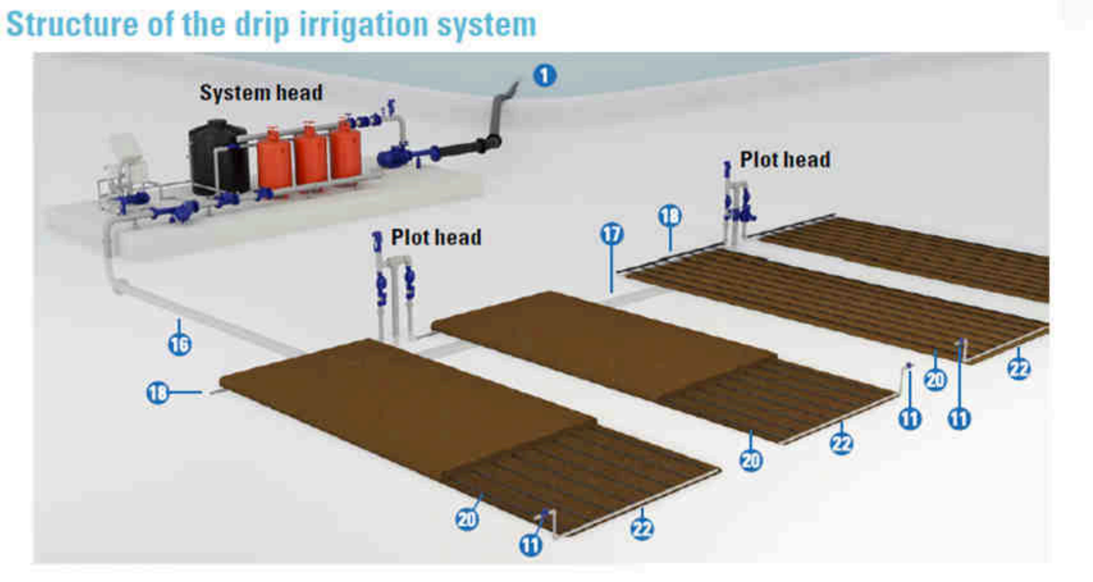
Drip irrigation is a specific type of micro-irrigation system. Drip irrigation is the most efficient water and nutrient delivery system for growing crops. It delivers water and nutrients directly to the plant's root zone, in the right amounts, at the right time, so each plant gets exactly what it needs, when it needs it, to grow optimally.

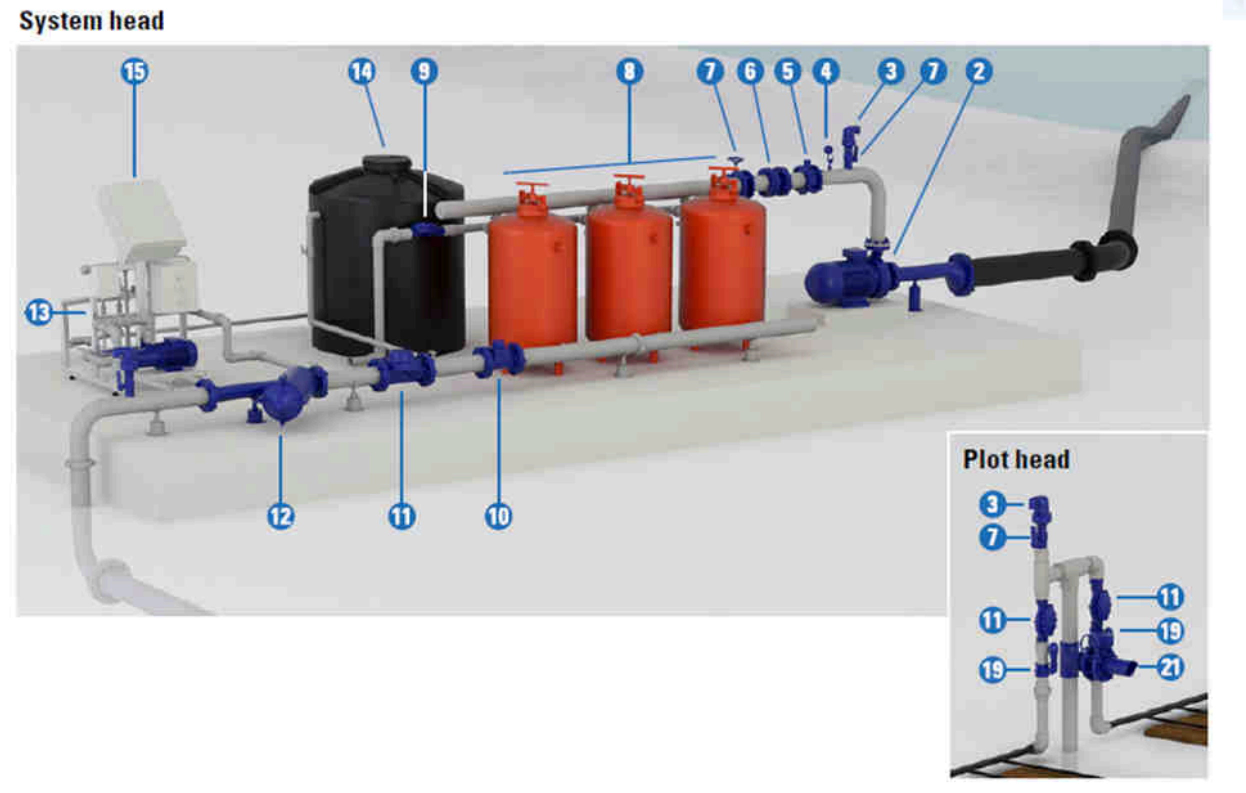
Thanks to drip irrigation Systems, farmers can produce higher yields while saving on water as well as fertilizers, energy, and even crop protection products.

A drip irrigation system comprises many components, each important in operating the system.

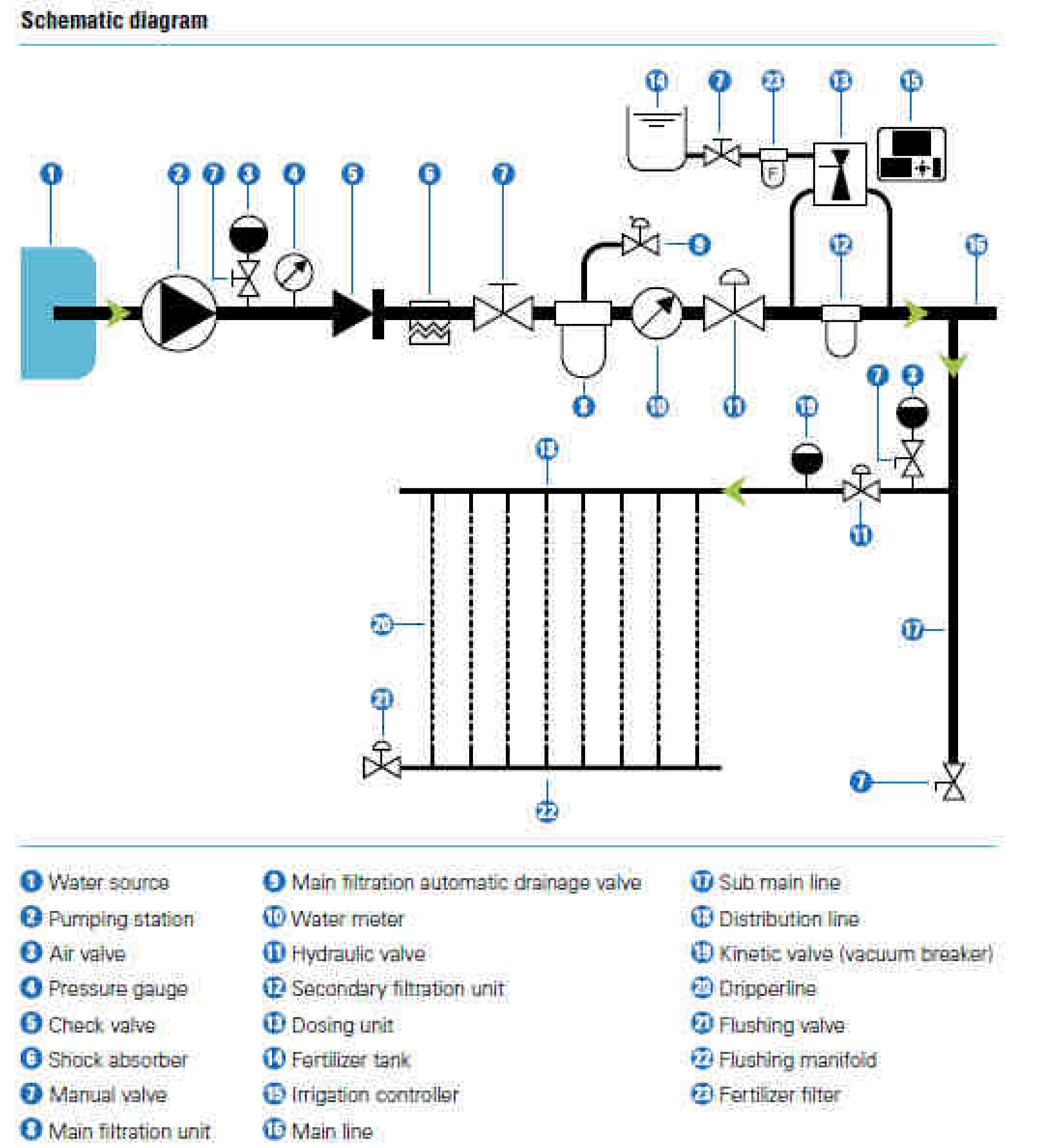
The aim of this chapter is to provide an overview of the drip irrigation system components, their functions, and properties.

Drip Irrigation System Design Template





Drip Irrigation System Design Template



Drip Irrigation System Design Template

Basic Components

Following are the four basic categories of components in the drip irrigation system. Based on the category, every individual component has a significant role in operating a drip irrigation system successfully for a longer period.

- Head Unit
- Water Carrying Unit
- Water distributing Unit
- Accessories and safety equipment.

Head Unit

The Head unit is that segment of the irrigation system that is responsible for controlling and monitoring filtration, fertigation, and irrigation.
A basic head consists of the following components, in order of their appearance from the water source (main valve) to the field.

- Water Source, Pumps and power
- Filtration equipment
- Fertigation equipment.

Water source

There are two main types of water sources: groundwater and surface water:

Many existing and potential water supply sources for irrigation systems are derived from surface water, which does not tend to have high levels of salts (except in some coastal areas), and thus systems are usually less prone to the formation of precipitates in drippers when using a surface water source.

Surface water, however, tends to introduce biological hazards. If wastewater is being considered as a source, quality, and clogging potential will vary depending upon the extent of treatment.

Groundwater is generally of higher quality than surface water. However, iron and manganese levels should be measured, as high levels may lead to dripper clogging, and treatment may be required.

Pumps & pumping stations

Unless the water at the source is supplied at an adequate flow rate and pressure (by municipal or other entity supply, a pre-existing pump upstream from the irrigation system, or gravitational pressure*), a pump will be needed to push water from the source through the pipes and drippers.

Drip Irrigation System Design Template

Most irrigation systems include pumps as an integral part of the drip irrigation system.

Selecting a pump for an irrigation system requires an understanding of the water conditions and local system requirements.

Poor pump selection can lead to high operating costs and shortened pump life; this in turn impacts on the performance and reliability of the whole irrigation system.

When a pump site is selected it is necessary to consider a range of factors, including availability of power, proximity to the development site, and water quality issues.

Power source for the pump

The power source for the pump will depend on the availability and accessibility of the energy resource in the local area.

In most instances, electricity is preferred because of reduced labor requirements and higher efficiency, resulting in lower energy cost. Three-phase power is usually required to operate over 10 horsepower (hp) irrigation pumps.

If electricity is not available, alternative power sources such as diesel, gasoline, or solar may be used. The most common alternatives are gasoline engines for small pumps and diesel engines for larger pumps.

Types of filters

A well-planned drip irrigation system includes 2 stages of filtration:

Main (Primary) filtration

• Responsible for filtering relatively large particles near the water source.
• Comprised of a media or disk filter.
• A hydrocyclone sand separator should be placed before the main filter in cases where sand or other
heavy particles (50 microns or bigger) are present in the source water.

Secondary filtration

• Responsible for filtering relatively small particles remaining after the main filtration stage.
• Two types of filters can be used for secondary filtration: • Screen filter
• Disc filter

WATER SOURCE	PRIMARY FILTER	SECONDARY FILTER
Open Well / Tank / Reservoir / Lake / Canal / Dam / Pond Etc.	Gravel / Sand Filter	Disc / Screen Filter
River / Deep Bore Well	Hydrocyclone Filter	Disc / Screen Filter
Shallow Bore Well	Disc / Screen Filter	

Filter - GravPrimaryel / Sand Filter

20 m3/Hr

30 m3/Hr

50 m3/Hr

Primary Filter - Hydro-cyclone filter

- Hydrocyclone Sand Separators utilize a conical-shaped separator that accelerates the velocity of water maximizing separation of sand and other solid matter with greater than 90% efficiency.
- Flushing frequency is reduced due to the large holding capacity of our sedimentation tanks.
- Netafim Hydrocyclones protect the irrigation components from damage and abrasion caused

by debris and add years of performance to the life of your irrigation system.

Applications

- For separation of sand and other solid matter from water
- Protection of valves and irrigation systems from damage/abrasion caused by sand and other solid matter
- Pre-filtering of water with high loads of sand before gravel, disc and screen filters

Secondary Filter – Disc and Screen filter

Disc filters: Disk filters contain stacks of grooved, ring-shaped disks that capture debris and are very effective in the filtration of organic material and algae. During the filtration mode, the disks are pressed together. There is an angle in the alignment of two adjacent disks, resulting in cavities of varying size and partly turbulent flow. The sizes of the groove determine the filtration grade. Disc filters are available in a wide size range (25-400 microns). Backflushing can clean disk filters. However, they require back flushing pressure as high as 2 to 3 kg/cm2.

Screen filters: Screen filters are always installed for final filtration as an additional safeguard against clogging. While the majority of impurities are filtered by sand filter, minute sand particles and other small impurities pass through it. The screen filter, containing a screen strainer, filters physical impurities and allows only clean water to enter into the micro irrigation system. The screens are usually cylindrical and made of non-corrosive metal or plastic material. These are available in a wide variety of types and flow rate capacities with screen sizes ranging from 20 mesh to 200 mesh. The aperture size of the screen opening should be between one-seventh and one-tenth of the orifice size of the emission devices used.

Fertilizer applicator

The application of fertilizer into a pressurized irrigation system is done by either a bypass pressure tank or by a venturi injector or direct injection system.

- Extremely uniform injection rate at nominal system flows rates.

- Operated by hydraulic pressure in the irrigation system, doesn't need an external energy source.
- Can be connected as inline or bypass.
- Includes no moving parts and requires little maintenance, high reliability.

Water Distribution Network

The water distribution network constitutes the main line, sub-mains line, and laterals with drippers and other accessories

Mainline

The mainline transports water within the field and distributes it to sub-mains. Mainline is made of rigid PVC or High-Density

Polyethylene (HDPE). Pipelines of 65 mm diameter and above with a pressure rating of 4 to 6 kg/cm2 are used for mainline pipes.

Submains

Submains distribute water evenly to several lateral lines. For sub-main pipes, rigid PVC, HDPE, or LDPE (Low-Density Polyethylene) of diameter ranging from 32 mm to 75 mm having a pressure rating of 2.5 kg/cm2 are used.

Laterals

Laterals distribute the water uniformly along their length using drippers or emitters. These are normally manufactured from LDPE and LLDPE.

Generally, pipes having 10-, 12-, and 16-mm internal diameters with wall thickness varying from 0.8 to 1.2 mm are used as laterals.

Emitters / Drippers

They function as energy dissipaters, reducing the inlet pressure head (0.5 to 1.5 atmospheres) to zero atmospheres at the outlet. The commonly used drippers are online pressure compensating or online non-pressure compensating, in-line drippers, adjustable discharge type drippers, vortex type drippers. These are manufactured from Polypropylene or LLDPE.

Ball valve

The ball valve is a quarter-turn valve. In a ball valve, the closing mechanism is a sphere (ball) with a port through the middle, connected to a lever in line with it that shows the valve's position.

Rotating the lever turns the ball so that when the port is in line with the pipe, flow will occur, and when perpendicular to the pipe, flow is blocked. Designed to be fully opened or closed and is not suitable for regulating the flow.

Check valve (One-way valve)

The function of the check valve is to prevent water flow in the opposite direction to that desired.

Installed at the outlet of a pump that pumps water to a field at a higher elevation - protects the pump from the back wave of the water hammer.

Pressure relief Valve

This is a pilot-operated, universal surge-relief valve, that is designed for the pressure-surge protection of pumps, and filtration systems.

The valve continuously senses the pressure in the system and keeps a drip-tight closed position if the pressure is low.

The valve instantly opens in case the upstream pressure has reached a set, critical value, allowing surplus flow out of the system.

The closing speed is regulated so to allow smooth and quiet attenuation of the pressure surges.

Air valves

Combination air release valve Evacuates large volume of air during pipeline filling and network draining and allows efficient release of air pockets from pressurized pipelines.

Flush Valve

Flush Valve offers manual operation and a UV-treated plastic construction for durability.

With an operating pressure range of 0-4 BAR and a plain socket design, this 1.25" (40mm) valve in bold orange provides reliable performance for any application.

Chapter 5: Fundamentals of Drip Irrigation system design

Drip Irrigation System Design Template

- **Objective of design**
- **Basic steps of design**
- **Points to be considered before design**

OBJECTIVE OF DESIGN

- To provide an optimum, frequent, and uniform water supply to each plant.
- Putting the Right PRODUCT in the right PLACE for the farmer's benefit.
- To enable the farmer to get the best out of his Field.
- To allow the Farmer to get maximum returns

Ideal Design

The Ideal design must be

- Technically Perfect
- Suitable to Field conditions
- Affordable to users.

Drip Irrigation System Design Template

Fundamentals of Drip Irrigation system design.

Distance (Length)	
1 Meter = 3.281 Feet	1 Foot = 0.3048 Meter = 12 Inches
1 Meter = 39.37 Inches	1 Inch = 0.0254 Meter
1 Centimeter = 0.39 Inch	1 Inch = 2.54 Centimeter
1 Meter = 100 Centimeters = 1000 Millimeters	1 Centimeter = 10 Millimeters

Area	
1 Hectare = 2.471 Acre	1 Acre = 0.4047 Hectare
1 Hectare = 10000 m^2 = 107639 $Feet^2$	1 m^2 = 0.0001 Hectare
1 Acre = 4047 m^2 = 43560 $Feet^2$	1 m^2 = 0.0002471 Acre

Flow	
1 $Meter^3$/hour = 1000 Litres/hour	1 Litre/hour = 0.000277778 Litres/second
1 Litre/second = 3600 Litres/hour = 3.6 $Meter^3$/hour	

Pressure	
1 Bar = 14.503774 PSI	1 PSI = 0.068947575 Bar
1 Bar = 100 Kilopascal	1 Kilopascal = 0.01 Bar
1 Atmosphere = 1.033227 Kg/cm^2	1 Kg/cm^2 = 14.22334 PSI
1 Bar = 1.0197163 Kg/cm^2	1 PSI = 0.07030696 Kg/cm^2

Volume	
1 $Meter^3$ = 1000 Litres = 35.314662 $Feet^3$	1 Gallon (Imp) = 4.546 Litres
1 $Foot^3$ = 28.31685 Litres	1 Gallon (US) = 3.785 Litres

Power	
1 Kilowatt = 1.341022 hp	1 hp = 0.7456999 Kilowatt

Drip Irrigation System Design Template

Farm Survey Questionnaire.

Drip Irrigation System Design Template

CORRECT & COMPLETE INFORMATION means BETTER DESIGN & ACCURATE ESTIMATE				
	Dealer name:		Date:	
1	Name & adderess of Netafim representative:(with present contact nos./District/State)			
	(1) Name:	Phone with STD code:		
	(2) Village:	Dist:		Pin:
	(3) Taluka/Mandal:	State:		
2	Name & adderesses of farmers/client : (with phone nos.)			
		Plot-1	Plot-2	
3	Crop			
4	Row to row spacing (meter)			
5	Plant to plant spacing (meter) add sketch of plantation if applicable			
6	Row direction for lateral			
7	Maximum water requirement (mm/day)			
8	Total area for drip (acre) Attach to the scale map in design format			
	Indicate any roads,building,wind break,north,future expansion area,mark water source,etc.			
9	Soil type (heavy,medium,light)			
10	Available operating hours for drip irrigation per day (* Including power cut)			
11	Power cut day/week (if any)			
12	Details of existing pump set :			
	(1) HP of the existing pump			
	(2) Head & discharge detail.			
	(3) Discharge at ground level (m^3/hour)			
	(4) Continuty of supply per day (hour)			
13	Details of water source:			
	(1)Type of water source:(well/bore/river/dam)			
	(2)Total vertical depth (meter)			
	(3)Depth of pumping set from ground level			
	(4)Quantity of water per day (m^3/day)			
14	Specific choice of on line/inline (if any)			
15	Specific choice of filter (if any)			
16	Future expansion area to be considered (acre)			
17	Remarks:			

BASIC STEPS OF DESIGN

Drip Irrigation System Design Template

- Understanding Field Survey Questionnaire.
- Drip product finalization – Based on the crop and soil type, selection of emitters flow, spacing, and number of emitters per plant.
- Comparing the Peak crop water requirement of the area with the least available water in that area. Peak crop water requirement should be less than the least available water.
- Calculation of irrigation rate.
- Calculation of irrigation time based on PWR.
- Calculation of the number of shifts based on available time.
- Calculation of design area.
- Calculating emitting pipe quantity, and number of emitters.
- Calculating the total flow of the plot.
- Calculating shift flow.

POINTS TO BE CONSIDER FOR DESIGN

- Selection of the required drip products as per the site condition.
- Existing pipe network.
- Design based on the existing pump or new pump.
- Checking of required flow rate as per standard calculation and flow rate available.
- If the available flow rate is more than the required flow rate, we can proceed as per standard procedure

If the available flow rate is less than the required flow rate, we have to reduce shift flow as available by

1. Reducing area

2. Reducing PWR by changing crop
3. Increasing operating time.

Technical Aspect of the Design

- Uniform Discharge throughout the area.
- Minimum discharge Variation -7.5 % to 10 % in NPC
- Product Selection – Inline / Online / NPC/ PC / Centralize / Semi Centralize /Decentralize
- Identify Max. permissible length.
- Calculation of Head Loss & velocity in lateral.
- Calculation of Head Loss & Velocity in Sub Main.
- Calculation of Head Loss & Velocity in Main Line.
- Selection of PVC pipe class & Diameter.
- Pump Duty Calculations & Pump Selection.

UNIT CONVERSIONS

Drip Irrigation System Design Template

Water Available = m3 / hr
Plant Water Requirement = mm / day
Application Rate = mm / hr 1 Meters 3/hour = 1000 Liters/hour
1 Liters/second = 3600 Liters/hour = 3.6 meters 3/hour
1 Liter/minute = 60 Liters/hour = 0.06 meters 3/hour
1 Cu Mec (1 meters 3/second) = 1000 Litres/second
1 Gallons/hour = 0.0038 Meters 3/hour
1 Kilometer = 0.621 Mile; 1 Mile = 1.609 Kilometer = 1609.344 Meters
1 Meter = 3.281 Feet; 1 Feet = 0.305 Meter = 12 Inches
1 Meter = 39.37 Inches; 1 Inch = 0.025 Meter
1 Centimetre = 0.039 Inch; 1 Inch = 2.54 Centimetre
1 Meter = 100 Centimeter = 1000 millimeter
1 Centimeter = 10 Millimeter

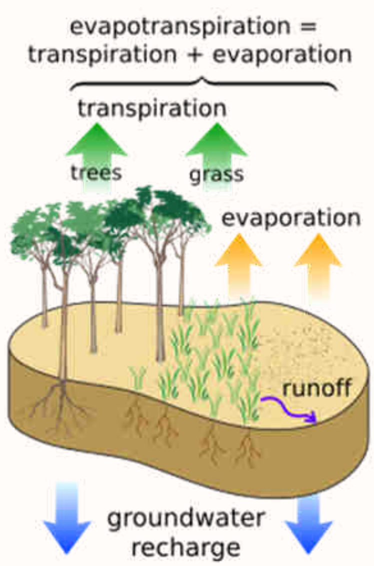
UNIT CONVERSIONS

Drip Irrigation System Design Template

1 Acre = 4047 m2; 1 Hectare = 2.47 Acre; 1 Acre = 43560 Feet2
1 Hectare = 10000 m2; 1 Hectare = 107639 Feet2
1 Meter3 = 1000 Liters = 35.31467 Feet3; 1 Gallon (Imp.) = 4.546 Litres
1 Feet3 = 28.316 Liters; 1 Gallon (US) = 3.785 Liters
1 KiloWatt = 1.341022 HP; 1 HP = 0.7456999 Kilowatt
1 Bar = 1.019716 Kg/cm2; 1 Kg/cm2 = 10 Meters
1 Bar = 100 Kilopascal; 1 Kilopascal = 0.01 Bar
1 PSI = 6.894757 Kilopascal; 1 Kilopascal = 0.145 PSI
1 Bar = 14.69595 PSI; 1 PSI = 0.06894757 Bar
1 Atmosphere = 1.033227 Kg/cm2; 1 Kg/cm2 = 14.22334 PSI

CROP WATER REQUIREMENT

The design of the irrigation system is based on peak water requirement also called maximum Evapotranspiration of crop. Evapotranspiration is the sum of moisture evaporation from the soil surface and transpiration from living vegetation. The peak water requirement of a crop is the one-day maximum water requirement throughout the year generally expressed as mm/day.



WATER REQUIREMENT

Drip Irrigation System Design Template

EVTc = EVTo * Kc

Calculation of the required irrigation time according to reference evapotranspiration:

EXAMPLE

The crop coefficient (Kc) is 0.8. If the EVTo, either measured by means of an evaporation pan or calculated with the Penman-Monteith equation, is 7.5 mm/day, then the crop will be using:

EVTc = 7.5 * 0.8 = 6 mm/day

EVTc = Evapotranspiration
EVTo = crop evapotranspiration
Kc = crop coefficient

APPLICATION RATE

Application rate is the rate of application of water per unit time expressed in depth.

Unit of AR is mm/hr.

$$\text{Application Rate (mm/hr.)} : \frac{\text{Emitter Discharge (lph)}}{\text{L/L Distance X Dripper to Dripper Spacing}}$$

$$: \frac{2 \text{ lph}}{1.52 \text{ Mtr.} \times 0.4 \text{ Mtr.}}$$

$$: \frac{2 \text{ lph}}{0.608 \text{ Mtr}}$$

Application Rate : 3.289 mm/Hr.

Drip Irrigation System Design Template

Shift duration

It is the irrigation time required to meet the desired water requirement of crop with particular application rate. Unit of shift duration is hour/day.

$$\text{Shift duration (hr/day)} = \frac{\text{Peak water requirement (mm/day)}}{\text{Application rate (mm/hr)}}$$

Shift

Block or several blocks that are irrigated simultaneously by the same water source during an irrigation cycle.

Irrigation cycle

Period of time (in days or hours) required to complete all the irrigation shifts, interval between irrigations or irrigation frequency.

These are the breaks (in days or in hours) between irrigation cycles.

Shift per day

$$\text{Shift per day} = \frac{\text{Maximum operating hours per day}}{\text{Shift duration (hrs)}}$$

OTHER CALCULATIONS

- Plant Area
- Number of plants in a given area
- Area of plantation from given number of plants
- Length of lateral
- Number of emitters
- Total plot flow

Drip Irrigation System Design Template

LATERAL LINE QUANTITY

$$Lateral\ \ Qty, \mathrm{m} = \frac{Total\ Area\ (m2)}{Lateral\ Spacing, \mathrm{m}}$$

DRIPPER QUANTITY

$$Dripper\ \ Qty, \mathrm{nos} = \frac{Total\ Lateral\ Length\ (m)}{Dripper\ Spacing\ , \mathrm{m}}$$

PERMISSIBLE LENGTH

This is max. length of dripper line allowed (7.5% & 10%). Factors considered for Permissible length.

- Inner diameter of Emitting Pipe
- Emitter Spacing
- Emitter flow rate
- Emitter type
- Operating pressure / slope.

Chapter 6: Drip Irrigation System Design

Drip Irrigation System Design Template

Steps for Designing Drip irrigation

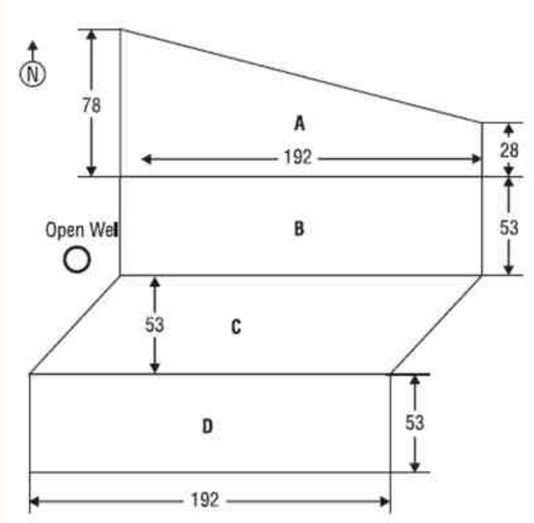
- Farm Survey Questionnaire
- Decide System Drip/Sprinkler
- Decide Product to be used
- Calculation of Application rate
- Calculation of number of Shifts
- Check permissible length of the selected product and find lateral head loss
- Divide area as per permissible length of the product and block flows
- Decide location of sub mains
- Connect all the valves to water source.
- Decide size of sub mains and main lines
- Calculate the total head required to operate the system
- Suggest pump set
- Prepare BOQ

Assignment

Design the Drip irrigation system for the sugarcane for the area of 10.04 Acres. The row spacing of sugarcane is 1.8 M. Mean maximum annual pan evaporation in the area is 10 mm/day. The Crop coefficient for sugarcane is 1, Power availability in the area is 18 hrs, Water resource is open well having depth of 8 M and its yield at critical time is 16m3/hr. Design the system with integral non pressure compensated 1.4 L/H emitters spaced at 0.5 M. Suggested row direction is East West.

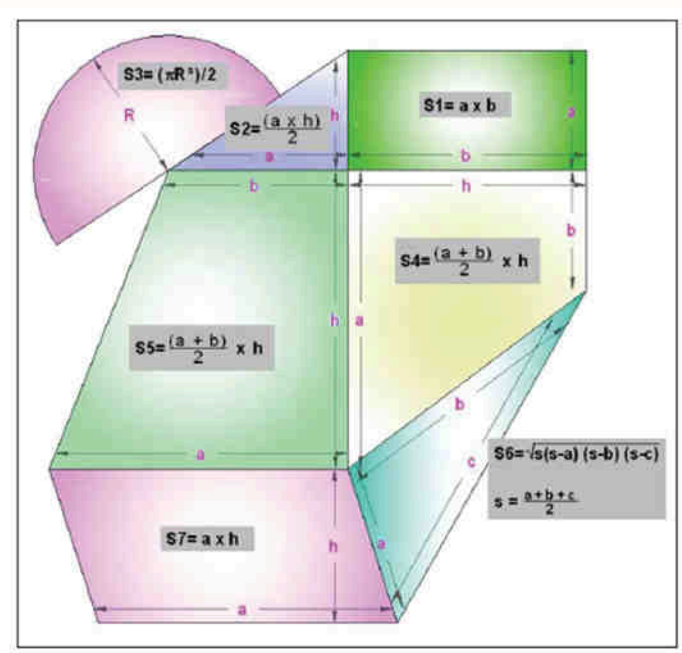
Drip Irrigation System Design Template

Methodology



Area calculation: Total area of an irregular can be found by dividing the plot area into number of sub areas.
following figure illustrates the formulae to calculate the areas of individual plots.

Area Calculation



$$\text{Area of A (Ac)} = \left\{ \frac{(78 + 28)}{2} \times 192 \right\} / 4047 = 2.51$$

$$\text{Area of B (Ac)} = \left\{ \frac{(192+192)}{2} \times 53 \right\} / 4047 = 2.51$$

$$\text{Area of C (Ac)} = \left\{ \frac{(192+192)}{2} \times 53 \right\} / 4047 = 2.51$$

$$\text{Area of D (Ac)} = \left\{ \frac{(192+192)}{2} \times 53 \right\} / 4047 = 2.51$$

Total area of plot = (A+B+C+D) = (2.51+2.51+2.51+2.51)

Total area = 10.04 Acres

Drip Irrigation System Design Template

Mean maximum annual pan evaporation in the area is 10 mm/day, also crop coefficient is given as 1.

By assuming pan coefficient is 0.7, peak water requirement (PWR) of crop will be

PWR (mm/day) = Pan Evaporation mm/day X Pan Coefficient X Crop Coefficient

= 10 X 0.7 X 1

= 7 mm/day

Drip Irrigation System Design Template

Check for flow and area

Can we irrigate given area with available flow in specified time?

$$\text{Area} = \frac{\text{Available water } (m^3/hr)}{\text{Peak water requirement (mm/day)}} \times \text{Time available (hr/day)}$$

Where, A = Area that can be irrigated

For area to be in

Hectare - divide the result by 10

Acre - divide the result by 4

m^2 - multiply the result by 1000

$$\text{Area} = \frac{16}{7 \times 4} \times 18 = 10.28 \text{ acres}$$

With the available water we can irrigate maximum of 10.28 acres area.

What should be the available flow to irrigate given area for specified crop in prescribed time period?

$$\text{Available water } (m^3/hr) = \frac{A \times PWR \times MF}{\text{Time available}}$$

Where, A = Area that can be irrigated (acre)

PWR = Peak water requirement (mm/day)

Time = Time (hours)

If area is in acre, MF = 4 & if area is in hectare, MF = 10.

To irrigate given crop and area in 18 hours, available flow should be around 15.56m^3/hr.

Drip Irrigation System Design Template

Irrigation data

Application rate (AR) (mm/day)

Application rate for 1.4 l/h emitter spaced at 0.5m for lateral spacing of 1.8m will be

$$AR\ (mm/hr) = \frac{\text{Dripper flow (l/h) x No. of laterals per row}}{\text{Dripper spacing (m) x Row spacing (m)}}$$

$$AR = \frac{1.4 \times 1}{0.5 \times 1.8}$$

$$AR = 1.556mm/hr$$

Shift duration

$$\text{Shift duration (hrs)} = \frac{\text{PWR}}{\text{AR}}$$

$$\text{Shift duration (hrs)} = \frac{7}{1.556} = 4.5\text{mm/hr}$$

No. of shifts in given time

$$\text{No. of shifts/day} = \frac{\text{Power available/day (hrs)}}{\text{Shift duration (hrs)}}$$

$$\text{No. of shifts/day} = \frac{18}{4.5} = 4 \text{ shifts}$$

So, the entire area can be irrigated in 18 hours with 4 shifts of 4.5 hours shift duration.

Drip Irrigation System Design Template

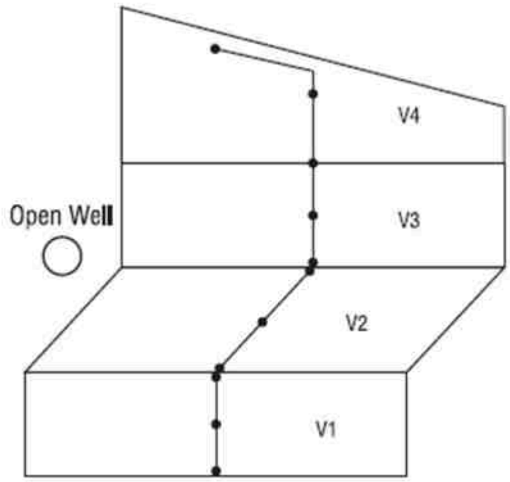
IRRIGATION DATA	
Crop	Sugarcane
System	Drip
Area (ac)	10.4
Emitter	DLN
Emitter discharge (lph)	1.4
Emitter spacing (m)	0.5
Lateral spacing (m)	1.8
Application rate (mm/hr)	1.6
PWR (mm/day)	7
Shift duration (hr)	4.5
No. of shifts/day	4
Actual operating hrs/day	18
Flow/ha (m^3/hr)	15.6
Flow/ac (m^3/hr)	6.3
Shift area (ac)	2.6
Shift flow (m^3/hr)	16.4

Drip Irrigation System Design Template

Choose location of sub-main& main pipeline

The location of sub-main can be fixed by generous consideration of permissible length of lateral, shortest length of sub-main and main pipeline and the operational ease. In the given plot we can have maximum of four shifts, so entire area can be divided in four equal or nearly equal sub areas called as blocks. Figure on the right side shows the convenient locations of sub-mains and control valves.

To minimize the pressure variation within plot, valves are located at center of sub-main. It will allow us to choose small sized pipes as sub-main (because when control valve is at center of sub-main the flow on either side of sub-main is part of the total flow through the valve).



Selection of pipe sizes

From the block areas, find out the block/shift flows by using the following formula.

Block flow (m^3/hr) = Area x Application rate (mm/hr) x MF

If area is in acres, MF = 4 & if area is in hectare, MF = 10

For the given plot, block flows are as-

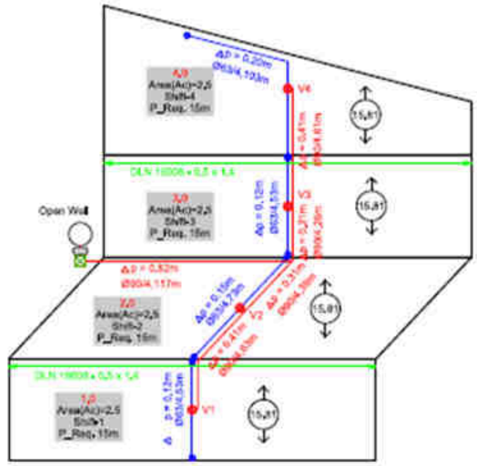
Block no.	Block flow (m^3/hr)
1	15.81
2	15.81
3	15.81
4	15.81

For these block flows, for the selected location and length of sub-main and mainline find the frictional head losses. HydroCalc can be used for the same. To be on safer side calculate the sub-main head loss for the highest flow or longest length of sub-main. Also for the mainline, calculate the frictional head loss for the furthest block as well as the block with marginally higher flow, the maximum of which should be considered for the total head calculations.

Drip Irrigation System Design Template

For this example the sub-main head loss is calculated for block no. 4 while mainline head loss is calculated for the block no. 1 which is furthest from water source with flow of 15.81m^3/hr. The sub-main and mainline head losses are 0.2m and 1.54m respectively.

Figure illustrates the design with technical details of emitting line, sub-main and mainline sizes, block areas and flows, operational schedule etc.



Design with technical details

Pump duty calculations

Sugarcane		Shift			
	Pump duty calculation	1	2	3	4
Sr. no.	Description	V1	V2	V3	V4
1	Emitter operating (m)	10	10	10	10
2	Lateral head loss (m)	1.07	1.07	1.07	1.07
3	Sub-main head loss (m)	0.12	0.15	0.12	0.2
4	Valve head loss (m)	2	2	2	2
5	Field fitting head loss (m)	2	2	2	2
6	Elevation + or - (m)				
7	Mainline head loss (m)	1.54	1.13	1.03	1.44
8	Primary filter head loss (m)	4	4	4	4
9	Secondary filter head loss (m)	4	4	4	4
10	Fertigation equipment head loss (m)	1	4	4	4
11	Water source depth (m)	8	8	8	8
12	Suction pipe (m)	2	2	2	2
13	Safety equipment head loss (m)	2	2	2	2
14	Other losses (m)	1	1	1	1
15	Total head required (m)	41.73	41.35	41.22	41.71
16	Valve flow (m^3/hr)	15.81	15.81	15.81	15.81
17	Shift flow (m^3/hr)	15.81	15.81	15.81	15.81
18	Shift flow (lps)	4.39	4.39	4.39	4.39

Suggest pump for the H= 42m and flow Q= 4.39lps

Drip Irrigation System Design Template

Operational schedule

Drip irrigation schedule				Shift		
Shift No	Valve No	Valve (ac)	Valve Flow (m^3)	Area (ac)	Flow (m^3)	Time (hrs)
1	V1	2.51	15.81	2.51	15.81	4.5
2	V2	2.51	15.81	2.51	15.81	4.5
3	V3	2.51	15.81	2.51	15.81	4.5
4	V4	2.51	15.81	2.51	15.81	4.5
Total		10.04		10.04		18

Bill of quantity (BOQ)

Lateral quantity (m)

$$\text{Lateral length (m)} = \frac{\text{Total area (m}^2\text{)}}{\text{Lateral spacing (m)}}$$

$$= \frac{10.04 \times 4047}{1.8} = 22{,}573.2\text{m}$$

Sub-main pipe length (m)

Sub-main pipe lengths (m)		
Valve no.	Pipe size (mm)	Length (m)
1	63/4	53
2	63/4	73
3	63/4	53
4	63/4	103
Total		282

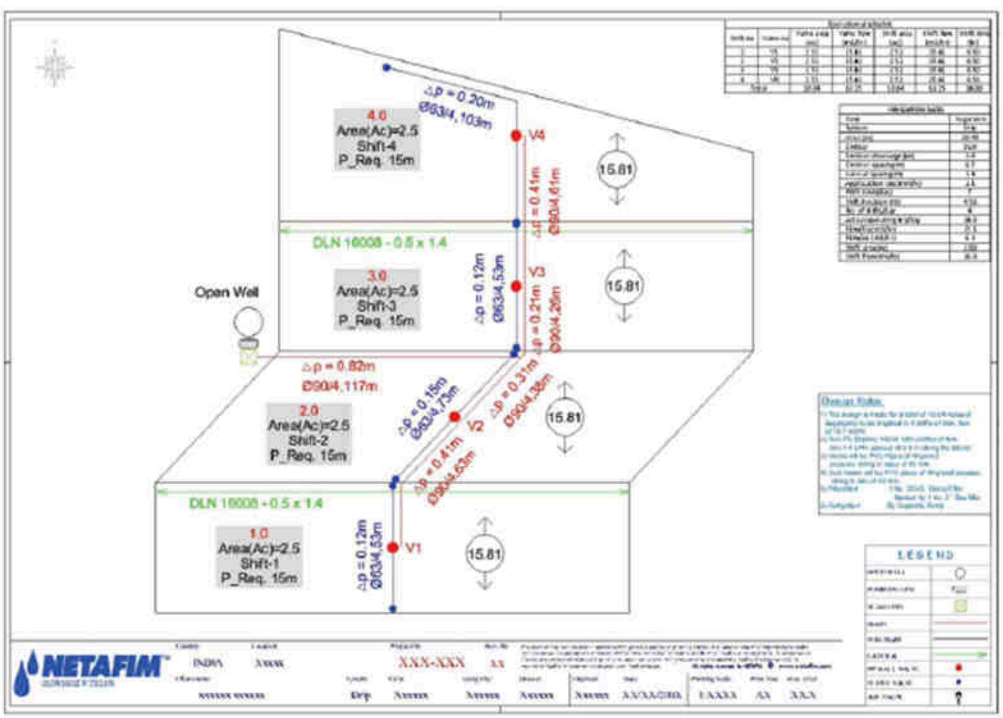
Drip Irrigation System Design Template

Mainline pipe length (m)

Mainline pipe lengths (m)			
From	To	Pipe size (mm)	Length (m)
Water source	V2-V3 Junction	90/4	117
V2-V3 junction	V2	90/4	38
V2	V1	90/4	63
V2-V3 junction	V3	90/4	26
V3	V4	90/4	61
Total			305

Final design

Final design which will be presented to customer should have all technical details of the design area. The following picture presents the ultimate design consisting of irrigation data, operational schedule, design notes and other essential details like name of sales representative, designer and customer with address, design area and crop, design number, printing paper size and printing scale, etc.



Drip Irrigation System Design Template

Bill of Quantities

To.			Date	18th March	
			Design No.	IN-178	
Lateral spacing 1.8m			Crop	Sugarcane	
Emitter spacing 0.5m			Area	5 Acre	
Quotation for drip irrigation system					
(A)	Head unit	Unit	Quantity	Rate	Amount
A.1	Gravel filter 2" x 20 m^3/hr	1			
A.2	Disc filter 2"	1			
A.3	Control valve 3"	1			
A.4	Bypass valve 2"	1			
A.5	Air release valve 1"	1			
A.6	Vaccum breaker valve 1/2"	1			
A.7	Fertilizer tank 60 litres	1			
A.8	Non return valve 3"	1			
A.9	Pressure gauge glycerine	2			
A.10	Head unit fittings	1			
		Sub total (A)			
(B)	Mainline				
B.1	PVC Fittings				
B.2	(a) PVC pipe 90/4 kg/cm^2	305			
		Sub total (B)			
(C)	Sub-mainline				
C.1	PVC fittings				
C.2	(a) PVC pipe 63/4 kg/cm^2	282			
C.3	PP ball valve 2"	4			
C.4	Flush valve 63mm	8			
		Sub total (C)			
(D)	Drip manifold				
D.1	Dripline 16008x0.5x1.4 l/h	22580			
D.2	Lateral 16mm	250			
D.3	Start nipple 16mm	250			
D.4	Rubber grommet	250			
D.5	End cap 16mm	250			
D.6	Reducer 17 x 16 mm	250			
D.7	Nipple 17 x 17 mm	100			
		Sub total (D)			
	Total (A+B+C+D)				
	Local taxes as applicable				
	Installation charges				
	Transportation charges				
	Grand total				

Source : Netafim's training manual