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Review article

ROLE OF DRIP IRRIGATION IN PLANT HEALTH MANAGEMENT, ITS IMPORTANCE AND MAINTENANCE

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ABSTRACT

Applying sufficient amount of water to the root zone of the crops is very important to get sustainable crop yields globally. When water applied through irrigation is in excess or deficient this may invite several fungal and bacterial diseases along with the pests and weeds which in turn reduces the crop quality and quantity. Soil moisture content and leaf wetness duration plays significant role in plant disease cycles, for an example some pathogens survive in soil in the form spores, they may disperse from one place to another place through irrigation water and infect the crops cultivated in that area. Thus we can say irrigation as a most important cultural practice in plant health management, especially in the context of less chemically dependent agriculture, paving the way for sustainable agriculture. Hence we can say irrigation has an important role to play in managing plant disease severity and dispersal of pests. Out of which drip irrigation system is of prime importance. In this review we will see how important is drip irrigation system in managing plant health, Importance, components, installation & maintenance of drip irrigation system to increase the life time of drip system.
Keywords – Drip irrigation system, Plant health management, Leaf wetness, Components, Acid treatment, Chlorine treatment, Maintenance.

Introduction

Drip irrigation means the drop by drop application of water directly to the plant root zone. Drip irrigation saves up to 50% of water on comparison to flood and furrow system of irrigation, fertigation via Drip is 30% more effective than Flooding, the combination of drip irrigation and fertigation increases the productivity by up to 200% and in sugarcane by 133%. Drip irrigation saves the energy, reduces the weed growth, reduces the incidence and transmission of pests and diseases.

Agriculture is influenced by an array of biotic and abiotic stresses. Plant health is an undermounting pressure due to increase in the number and frequency of new and re – emerging pests. The looming threat of climate change, globalization, intensification and trade development may further exacerbate the crop losses due to the pests. The introduction and spread of plant pests to new areas, cause a serious environmental, social and economic consequences. The indiscriminate use of agricultural chemicals also leads to resistance and resurgence of insect pests, environmental pollution, loss of biodiversity, loss of consumer confidence in food (food safety issues). The global population will almost reach 9.7 billion by 2050, according to U. N's Department of Economic and Social Affairs. The intensive use of the ecosystem to enhance the productivity will affect the agro-ecosystems through soil erosion, water contamination, water depletion, loss of bio diversity, which will have a bearing on plant health and plant bio security. According to U. N's Food and Agriculture Organization, the pests destroy upto 40% of food crops worldwide causing 220 billion USD trade losses annually. To feed the world's growing population, agriculture production must increase by about 60% by 2050, according to U. N's estimates. That means we have to do everything to protect plant health from destructive invasive pests. Plant health management is vital for sustainable agriculture, food safety, food security, nutritional security and world's economy. Therefore environmentally sustainable plant health management practices should be promoted to reduce the excessive reliance on agricultural chemicals.

Plant diseases are one of the main constraints that limit agricultural production throughout the globe (Oerke E-C, 2006). World 30 –40% of total food production comes from irrigated agriculture (Martinelli, 2005 & Ondrasek, 2014). The importance of irrigation can be found from a potato production report, where 10% variation in potato water need resulted in significant yield losses, either from water deficiency which lead to deformation and reduced tuber size or excess water which increased the intensity of various pathogens (King *et al*., 1997).

Hence mode of irrigation directly affects the development of plant as well as onset of plant diseases, dispersal of pathogen or its fruiting bodies and disease progress. For instance furrow irrigation system demands large amount of water and nitrogen fertilization which can expose the plant to several diseases, here along with water flow in furrows the soil borne pathogens easily disseminate (Lopes *et al.*, 2006).

Drip irrigation system is highly recommended due to its water use efficiency, in addition to it, the wetting of aerial plant parts is usually avoided which results in less foliar disease incidence (Baht *et al.*, 2001).

Irrigation timing must also be taken into consideration because most fungal plant pathogens produce spores during nighttime, being dispersed after dawn. Consequently, morning irrigations are prone to dislodge and disperse spores, also offering humidity and free water for germination at the leaf surface. Some fungal pathogens may form spores or propagules later in the day and are thus favored by afternoon irrigations, while night irrigation will reduce spore dispersion, as reported for *Phytophthora infestans* (Rotem *et al.*, 1969).

Leaf wetness duration is also considered as an important factor because fungi and bacteria need free water on the surface of the leaves to initiate infection (exception : Ascomycota) (Lee *et al.*, 2016). Establishing of pathogens in aerial parts of the plant is dependent on foliar wetting duration, which is directly affected by timing of irrigation (Wang *et al.*, 2015).

The flooding or furrow systems of irrigation can also carry the eggs of insect-pests from one location to another location through the water flow, which can increase the pest attacks.

Excess soil moisture content is found when crops are irrigated through furrow or flooding system of irrigation which helps the weeds to grow easily. The weed seeds are transferred from one corner of the field to another corner leading to the weed growth, along with water flow the nutrients are also lost, hence this soil moisture and nutrients favors the growth of weeds.

Hence drip irrigation system can reduce the incidence of pests, diseases and weeds, which in turn provides higher yield with good quality. Usage of drip irrigation system for increasing water use efficiency and supplying nutrients to crop root zone has acquired significant importance since a decade. To run the drip irrigation system efficiently one should have the knowledge on maintenance of drip irrigation system.

Drip irrigation and its importance

Drip irrigation system is also called as trickle irrigation system where water is applied drop by drop directly to the root zone of the crop at very low rates 2-20 LPH (liters per hour), through a small diameter pipes called laterals fitted with an outlets called as drippers or emitters. In other irrigations systems the whole soil profile is wetted, unlike in drip irrigation only root zone is wetted (Plusquellec, 2009).

In common irrigation systems such as flooding water is lost through evaporation but in case of drip irrigation system the water loss through irrigation is eliminated (Ahadi *et al.*, 2013). Drip irrigation system is highly suitable for crops with wider spacing such as vegetables, soft fruits, vines and trees (Lecina *et al.*, 2010). If the climatic conditions are not suitable for crop cultivation then one has an option of choosing polyhouses or shade nets and if we lack good soil we can go for hydroponic system but if there is no water there is no any alternative (Gonzalez, 2015). The usage of fertilizers can be optimized through the drip irrigation system due to less water requirement and high water usage efficiency (smith *et al.*, 2016). The nutrient uptake efficiency is also high in case of drip irrigation system. This helps in usage of crop or plant protection products or systemic plant protection products to improve the plant health (Wu *et al.*, 1983 and Najafi *et al.*, 2007). To ensure that there is good water use efficiency and to improve the life time of drip irrigation system, periodical maintenance of drip irrigation system is required. Periodic maintenance includes repairing and replacing drip system parts, washing of filters, cleaning of laterals to prevent salt accumulation and blockage of emitters (Lamm *et al.*, 1995).

Advantages of Drip Irrigation System

1. Drip irrigation saves up to 50% of water on comparison to flood and furrow system of irrigation.
2. Fertigation via Drip is 30% more effective than Flooding.
3. The combination of drip irrigation and fertigation increases the productivity by up to 200% and in sugarcane by 133%.
4. Drip irrigation saves the energy
5. It reduces the weed growth
6. It reduces the incidence and transmission of pests and diseases.
7. It saves the labor and operational costs.
8. High water and fertilizer use efficiency
9. No soil erosion problem.
10. Maximum crop yield
11. Improved infiltration
12. No run off of fertilizers into ground water
13. Less evaporation losses of water on comparison to surface irrigation
14. Improves seed germination
15. Decreased tillage operations

Disadvantages of Drip irrigation system

As ever coin has two sides, there are some disadvantages of drip irrigation systems too

1. Sensitivity to clogging
2. Moisture distribution problem
3. Salinity hazards
4. High cost compared to furrows
5. High skill is required for design, install and operation

World history of drip irrigation in brief

1. Fan sheng- chih shu, written in Chinese during the 1st century, describes about use of buried, unglazed clay pots filled with water (referred as Ollas).
2. Modern drip irrigation began its development in Germany in 1860 – used clay pipes to create a combination of irrigation + drainage, by 1920 perforated pipes were introduced.
3. Use of plastic bags to hold and distribute water was developed in Australia by Hannis Thill.
4. Usage of plastic emitter in drip irrigation was developed in Israel by simcha blass and his son Yeshyahu.
5. As these tiny holes were blocked by tiny particles, larger holes with longer passages and slow water velocity were

developed inside plastic emitter, this type of experimental system was established in 1959 by blass, he partnered with K Hatzerim to create irrigation company “NATAFIM”.

6. Blass and Hatzerim together developed and patented first practical surface drip irrigation emitter.
7. In 1960s the 1st drip tape(called Dew hose) was developed by Richard Chapin of Chapin watermatics in united states, this Chapin watermatics was acquired by Jain irrigation in 2006.
8. Use of drippers in sub surface irrigation network was 1st experimented with in Germany in 1869.
9. The drip system was developed for field crops in Israel, Australia, North America(1960s).
10. Area under drip irrigation in USA was 1M ha, followed by INDIA, Spain, Israel.

Indian history of drip irrigation in brief

1. Started by irrigating a Tulsi plant kept in courtyard.
2. During summer months this plant was irrigated by hanging a pitcher containing water and a minute hole at its bottom to allow trickling of water on to the plant.
3. Tribal farmers of Arunachal Pradesh have practiced a primitive form of drip irrigation using slender bamboo for water flow.
4. At present around 3.51 lakh ha area is under drip irrigation in India by the efforts of GOI, earlier it was only 40ha in 1960.
5. Maharashtra(94,000ha), Karnataka(66,000ha), Tamil Nadu(55,000ha) are top 3 in drip irrigation area.
6. TREE crops occupy maximum percentage of total area under drip irrigation followed by vine crops, vegetables, field crops, flowers and other crops(24%).

Components of drip irrigation system

The components of drip irrigation are classified into two, namely: Control head and Distribution network.

Control head - Control head basically includes Pump or overhead tank, fertilizer or chemical application device and filters. Various parts that comes under the control head are as follows:

a) Water Source: Well, reservoir or streams etc..
b) Pump: Creates pressure and makes the discharge.
c) By Pass Valve: it is provided so that pumped water can be used for other activities when irrigation is not going on.Bypass valve is responsible for operating pressure maintenance in drip irrigation, because of that only pressure gauge is present on it.By pass valve also sends back excess water.
d) Fertilizer Applicator: To add fertilizer to the water directly in the pipeline.
e) Pressure Gauge: measures the pressure head.
f) Sand Filter: To remove coarse impurity of water coming from water source or clogs from fertilizer.
g) Gate Valve: To regulate the flow of water in the main pipe line.
h) Screen Filter: A line filter is placed at the end of control head to avoid clogging in drippers

Distribution network – it is responsible for distributing the water to the crop that has been received from control head. Distribution network includes the following

a) Main Line: It is made of HDPE or PVC having diameter in the range of 50 - 75mm and is able to withstand a pressure head of at least 4 - 6kg/cm2.
b) Sub main: It is made of HDPE or PVC having diameter in the range of 37 - 63mm and can withstand 2 - 5kg/ cm2 pressure.
c) Ball Valve: To engage or disengage a specific sub-main.
d) Flush Valve: These are provided at the end of sub mains. Due to continuous irrigation, calcium present in water gets stuck. It is used for flushing out garbage. In standing crop we should use phosphoric acid, where as in the off season or land with no crops we can use Sulphuric acid, this process is called as CHEMIGATION
e) Laterals: These are made of LDPE/ LLDPE (because they can be easily removed during ploughing) and having diameter in the range of 12 - 16mm. It has an ability to withstand 2 kg/ cm^2 pressure.
f) Drippers: These are small emission devices having small flow rates and are made of poly propylene.

Different types of filters

Drip irrigation system filters are divided into two namely Primary filter and secondary filter.

Primary filter – This filters are the first filter to be present in a drip irrigation system, they are used to remove coarse particles such as small stones and sand and trap algae, other organic and inorganic impurities. There are two different kinds of primary filters where one can be selected based on the source of water.

1) Gravel/Media/Sand filter: This filter is used when there is open water source (water exposed to sun) like rivers etc... It removes both organic and inorganic impurities. It has gravels and sand(silica sand). It also traps the algae.
2) Hydrocyclone filter : They use the centrifugal force to spin sand out of water. It is often used when water source is well or bore which contains more sand. Hydrocyclone causes spinning action which causes heavier sand particles to separate from water and trapped in storage tank at the base.

Secondary filter – Usually the secondary filters are present in conjunction with primary filters. They are used to remove finer impurities that are not filtered by primary filters. There are two different kinds of secondary filters.

1. Disc filter Disc filters are excellent on most types of contaminants. They consists of number of grooved discs stacked on top of each other. This gives 3D filtering effect which works effectively on sand and organic matter such as decaying weeds and algae.
2. Screen filter Screen filter works well with inorganic matter such as silt and sand. They generally consists of very fine stainless steel mesh that traps particles. These are cheaper to purchase than any other filter used in drip irrigation.

Types of drippers

There are two types of drippers namely

1. In – line drippers
2. On – line drippers

If emitters are present inside the laterals they are called as In - line drippers.

If emitters are present outside the laterals they are called as On - line drippers.

Fertigation/Drip fertigation

Application of fertilizers along with irrigation is called as fertigation. Fertigation increases both water and fertilizer use efficiency, it enhances both the yield and quality of crops.

Characteristics of fertilizers for fertigation

Success of fertigation primarily depends characteristics of fertilizers used for fertigation.

1) Must be completely water soluble(< 0.02% insoluble in water) and have quick dissolution in water with minimum content of conditioners.
2) Must not react with dissolved elements in water especially calcium and magnesium salts.
3) High nutrient content in saturated solution, must not get leached down easily from soil
4) Should not change the pH of the water leading to precipitation and clogging
5) Should avoid corrosion of the system
6) Should be safer for field use and for mixing with other chemicals.

Source of nutrients

1. Use only the recommended fertilizers in recommended quantity
2. Liquid fertilizers are pure and they do not precipitate, they are acidic (pH 5.5 – 6.5), they are also used for correcting soil pH, and to some extent they also help in prevention of clogging of emitters.
3. Use chloride free fertilizers for chlorine sensitive crops like tobacco, grapes, citrus, arecanut and vegetables
4. Aqueous ammonia, Calcium nitrate, Calcium ammonium nitrate, Potassium sulphate, Zinc nitrate, Ferric sulphate – these fertilizers are not suitable for fertigation because of precipitation and clogging problems.

Precautions that are to be taken during fertigation

1) Every emitting point must deliver same amount of water
2) Material used should not cause corrosions
3) Constant operation pressure to facilitate uniform mixing of water and fertilizers
4) Selection of most appropriate fertilizers, injection systems and crops
5) Fertilizers/pesticides/chlorine should not be injected at the same time

Fertigation time

1) Frequency of fertigation depends upon nature of crop + duration of crop + growth habit + yielding ability.
2) Generally fertigation is done weekly/ fortnightly depending upon the crop needs.

Types of Fertigation Systems

There are 4 types of fertigation:

1. Through Venturimeter
2. Through Fertilizer tank
3. Through Ferti - jet pump
4. Through Gravity

Fertigation through venturimeter - It is based on Bernoulli's theorem (pressure is inversely proportional to velocity). If pressure is increased the velocity decreases, if the pressure is decreased the velocity increases. In venturi meter at the center a narrow passage is created, this narrow passage makes the pressure difference which is lower than the atmospheric pressure. This narrow passage is connected with the liquid fertilizer bucket. Due to negative pressure, suction is created and liquid fertilizer is mixed with the irrigation water (Figure 1).

Fig. 1 : Venturi Meter (Source - Jain Irrigation Systems Limited)

<u>**Fertigation through fertilizer tank**</u> - In a fertilizer tank, one control valve and two gate valves (are used, with which irrigation water are controlled. The irrigation water is mixed with fertilizer in fertilizer tank and supplied to the main line.

<u>**Fertigation through Fertijet pump**</u> - Venturi and Fertilizer tank does not require external power and they are not precise in application of fertilizer. Ferti – jet pump requires external power, controlled amount of fertilizer is added and it is precise in application of fertilizer. In general positive displacement pump (piston type) is used in ferti – jet pump. It is used in automated drip irrigation system and hi – tech green houses.

<u>**Fertigation through gravity**</u> - An overhead tank is used, which is placed at sufficient height. This tank is connected through pipe line with the main line. A control valve is used to control the amount of fertilizer.

Advantages of fertigation or drip fertigation

1) Improves efficiency in fertilizer use, generally 60-80% of recommended dose of fertilizers through water

soluble form was observed to be sufficient and secure equivalent yields of crops as obtained with the application of 100% straight fertilizers.

2) High nutrient availability due to maintenance of soil moisture near field capacity under drip irrigation.

3) Fertilizers could be applied as frequently as possible and at those stages of crop growth when demand is maximum.

4) Higher water use efficiency and 30-40% economy in use of irrigation.

Disadvantages of fertigation or drip fertigation

1) Uneven nutrient distribution occurs when the irrigation system is faulty

2) It leads to over fertilization or leaching of nutrients when excess water is applied to the crops.

3) Chemical reactions of the fertilizer with calcium and magnesium bicarbonates in water leads to clogging.

4) Suitable for readily soluble or liquid fertilizers

5) Phosphatic fertilizer and some micro nutrients may precipitate in micro irrigation system

6) Corrosion resistant fertigation equipment's are needed

7) Potential chemical backflow in water supply source

Designing of drip irrigation system

Pressure of drip irrigation system ranges from 1.5 to 2.0 Kg/cm^2. While designing the drip irrigation system the factors such as region, topography, soil type, water quality, type of crop, spacing, stage & age of the crop. Another most important factor that has to be considered while designing drip irrigation system is the pump outflow should be equal to the outflow of the drip system. If out flow of pump is less and there is more area to be irrigated then the area to be irrigated is partitioned by placing the valves (Arshad *et al*, 2014).

Quality of the material

The quality of the material used in designing various components of drip system is very important because it remains on soil exposed to several climatic conditions (Bosch *et al.*, 1992) and rodents. The material used should be of ISI mark (Indian Standards Institute) and this mark should be clearly labelled.

Tips prior to and during installation

Prior to the installation, the water availability and the amount of water required by the crop should be determined. Suitable water pump should be installed depending upon water yield and pressure required by drip irrigation system. The pressure required for drip irrigation is in range of 1.5 to 2.0 Kg/cm^2 (Bucks *et al.*, 1981). As mentioned earlier the filters required for drip irrigation system should be determined by the water source (Open water source or bore well). Main line and sub-main should always be installed in a telescopic manner (Pipes with larger diameter are connected with the pipes with smaller diameter) (Camp *et al.*, 1993). This facilitates the maintenance of uniform pressure in the system, thereby providing water uniformly to all the plants, As the diameter of the pipes is gradually reduced the cost is also reduced. The main and sub-main lines should be buried at least 50cms deep to prevent them from getting damage during the mechanical and intercultural operations (if heavy vehicles move in case of orchards, it is advised to bury even deeper). Based on crop, spacing and water availability 12mm or 16mm laterals should be installed.

16mm laterals (it approximately discharges 450 – 500 liters of water per hour) can be used for closely spaced crops and 12mm (250 – 300 liters of water per hour) laterals can be used for widely spaced crops. Laterals should always be installed across the slope (Hills *et al.*, 2001).

Depending on the soil characteristics and the type of crop, the discharge capacity and number of dippers are determined. Usually for widely spaced crops, four drippers are provided at different places at the base, two drippers for crops with medium spacing and for closely spaced crops like vegetable and flower crops drippers are provided at every 30 to 45 cm intervals all along the lateral pipe (Lamm *et al.,* 1997).

End caps should be placed at the end of each section at about 2 ft above the surface to facilitate the removal of physical impurities from the drip system. For every section of the pipe, an air release valve should be connected at a height of 1 meter from the ground surface to prevent the sucking of mud by the drippers. After the connection is complete open the end-caps of all laterals in all the sections and runs the water for about half an hour later close all the end-caps of laterals and check for leakage and rectify if any (Najafi *et al.,* 2007).

Management of drip irrigation system

The water that is been used for irrigation is not always pure, it contains several physical (sand, silt, clay etc..), chemical (Carbonates, Bicarbonates etc.…) and biological (microorganisms, algae etc.…) impurities, When the drip irrigation system is not maintained properly, Several problems arise, They may be Reduction in irrigation efficiency, Blocking or clogging of Drippers or emitters and Blocking or clogging of Lateral pipes, if this problem is not rectified, the life span of the drip irrigation system reduces significantly, leading to the collapsing of entire drip system, So, in order to get rid of such kind of problems Proper and Regular maintenance of Drip irrigation system is necessary. For optimum performance of drip irrigation system, the maintenance schedule can be divided into daily, fortnightly, monthly and half-yearly maintenance activities

1. Daily maintenance

To maximize the irrigation efficiency and to prevent clogging of primary filter, secondary filter, laterals and emitters daily maintenance activity is essential. The below steps should be followed for the regular maintenance activity.

A. Cleaning

1. Switch on the pump, open the drain valves of Hydrocyclone filter and screen filter for the duration of 5 minutes and then close the drain valves of both the filters. (Hydrocyclone filter is used when the source of irrigation is borewell or tube well).
2. In case of sand filter (sand filter is used when the source of irrigation is open water source like rivers, canals, wells etc.) Backwashing is necessary. Generally the irrigation water enters the sand filter from the top through the inlet valve and then water flows down

through the sand bed where the algae and other organic and inorganic wastes are trapped, then the partially purified water leaves the sand filter via the outlet valve. Whereas the backwashing is the process in which the flow of direction of irrigation water is reversed so that water flows upwards through the sand bed, where the inlet valve is closed and bypass valve is opened. Through the bypass valve the water flows upwards. In this process due to the pressure exerted by the water on the sand, the sand gets lifted up and expands, therefore the dirt which is arrested in it is released. This released dirt is driven out of the sand filter through the backwash valve. If the backwashing is not done regularly, the impurities will accumulate in the sand bed which reduces the efficiency of the sand filter and the system does not get water at the desired pressure.

3. Steps for backwashing of the sand filter
   1. Open the backwash valve
   2. Close the outlet valve
   3. Open the bypass valve
   4. Close the inlet valve
   5. Start the pump

4. As soon as the pump is switched on we can see the dirty water coming out from the backwash valve. The end process of backwashing of sand filter is when the clean water comes out. When the clean water comes out from the backwash valve the normal filtration process should be resumed again.

5. Steps for resuming the normal filtration process
   1. Open the inlet valve
   2. Close the bypass valve
   3. Open the outlet valve
   4. Close the backwash valve
   5. Start the pump

B. Other maintenance activities

Now the filters are cleaned, after cleaning the filters go round the field and check for the Leakages or damages, if any defects are reported then replace that particular component With the spare parts. Remove the folds or kinks on the laterals and make them straight check the drippers for the uniformity in discharge, the drippers that are not emitting the water properly open and clean them.

1. Checkout the dripper positions, if they are misplaced place them properly at correct location.
2. Before flushing the laterals a small test should be carried out, remove the endcap of the lateral and then wrap a clean white cloth and allow the water to pass through it for 1 minute, this helps in identifying the problem in drip system and also plays vital role in decision making for the maintenance problem (based on the impurities we can decide whether we should perform Acid treatment or chlorine treatment) (Acid treatment helps in removing the precipitated salts whereas chlorine treatment helps in removing the algal and microbial growth)
3. Remove the endcaps and flush out the laterals for about 2 minutes, while flushing the laterals controlling the valves is necessary to get high pressure, operate the ball valves in such a way that water flows with high velocity in the laterals where thorough cleaning takes place.
4. Flush the sub-mains via the flush valves, because the impurities are also accumulated at the end of the sub-mains, if these impurities are not flushed regularly, it leads to the clogging of the drippers.

The above steps are related to the daily maintenance activities that has to be performed.

2. Fortnightly maintenance

Fortnightly maintenance means the maintenance activities that has to be conducted once for every 15 days.

A. Sand filter

The pressure difference between the inlet and outlet valves of the sand filter acts as an indicator suggesting whether sand filter needs cleaning or not. If the pressure difference is greater than 0.5kg/cm2, this suggests that sand filter needs cleaning.

The salts that are present in the water are deposited on the top of the sand bed, where the upper surface of the sand bed becomes hard like a stone, in this case backwashing of the sand filter is not effective. Therefore for every 15 days clean the sand filter as per the below process.

1. On the sand filter there is a lid, open that lid of the sand filter.
2. Allow the water to come out of the sand filter via that opened lid, using the bypass valve adjust the flow of irrigation water so that the sand does not come from the opening.
3. Gently stir the sand by moving the hand from top to bottom in the sand filter, make sure that you does not disturb the position of the black filter candles that are present at the bottom of the sand filter, if those candles are disturbed the sand enters the screen filter.
4. Break the sand lumps by squeezing them in the hand.
5. Ensure that half of the filter is filled with the sand, the level is marked on the filter, if the amount of sand inside the filter is less than the marked level, then add the new sand upto the marked level.
6. Allow the water to flow till the fresh and clean water starts flowing out of the opening.
7. Now put that lid in its position and fix it tightly.
   NOTE – Don't add ordinary sand into the sand filter because the ordinary sand has rounded particles which is unfit for trapping the dirt. In sand filter we use a special type of sand called silica sand which has angular particles say sharp edges. As the particles of silica sand are angular, they interlock with each other, hence the dirt is arrested in this sand.

B. Screen filter

The silt and the fine particles of dirt that escapes the sand filter are arrested on the filtering element on the screen filter (mesh in the screen filter). This affects the filtration process. Hence cleaning the filtering element of the screen filter once for every 15 days is necessary.

To perform this operation, open the lid of the screen filter and take out the filtering element, remove the rubber seals from both the ends of the filtering element, invert them and clean it with fresh water and then fix them again. Now clean the filtering element under the running water with the help of old tooth brush or hand. If you are using the tooth brush rub slowly to avoid any sort of damages. Don't use wired brush as wired brushes damages the screen.

3. Monthly Maintenance

If the salts, algae and other impurities that are present in the irrigation water enter into the drip irrigation system, the laterals and drippers will get clogged and may stop emitting water. Based on the irrigation water quality and the observations made from daily and fortnightly maintenance activities, the acid or chlorine treatments might be necessary once in an month.

1. Acid treatment helps in removing the precipitated salts from the pipeline network and drippers.
2. Chlorine treatment helps in removing any sort of biological contamination (Bacterial slime, algae etc.)
3. Inspect all the components of the drip irrigation system for physical abuse, mechanical abuse (damage by machinery) and damage by rats and squirrels.
4. Don't perform Acid and Chlorine treatments Simultaneously.

4. Half yearly maintenance

1. Replace the media of the sand filter with the new one as the sand particles that are angular turn into round due to continuous abrasion during operation.
2. Replace the components with the spare parts where ever necessary.
3. Provide adequate lubrication to the pump and the motor because if the pump works efficiently, it generates the adequate pressure head and discharge required to operate the system satisfactorily. Follow the maintenance activities for pump as prescribed by the pump manufacturer.

Importance of operating drip irrigation system at correct pressure

The minimum pressure required to operate the drip irrigation system is 1.5Kg/cm^2. Always maintain a pressure of 1.5Kg/cm^2 at the sub-main. Maintaining proper pressure is important as it directly affects the plants performance that is the plants growth and yield.

Do not keep the system pressure very high or very low. The higher pressure results in discharging more water than required by the plants. This causes runoff and the soil in the root zone will be fully saturated. This kind of over irrigation results not only in wastage of water and nutrients, but also disturbs the air-water balance in the plant root zone. As the plant roots are deprived of oxygen, root growth and the plant growth will be poor, thus there is reduction in the yield.

If the system pressure is lower than 1Kg/cm^2, the drippers tend to supply much less water than the required amount, here in this case the plant will be subjected to water stress, if this condition prevails for longer period of time the growth of the plant will stop or even the plant may die. Therefore always run the drip irrigation system at 1.5Kg/cm^2 (optimum operational pressure).

Acid treatment for drip irrigation system

Drip irrigation systems are prone to clogging or blockage due to improper maintenance, There are Several factors that are responsible for the clogging of drip irrigation system, They include

1. Presence of Microorganisms in the system (Bacterial slime, Algal growth).
2. Presence of Large Particles and the suspended particles (Clay and silt) in the water source, which enter and Block the Drip system.
3. Presence of Certain dissolved salts (Carbonates and Bicarbonates, Calcium and Magnesium, iron) where they precipitate and form deposits within the lateral pipes but sometimes they also lead to the blockage of the emitters.

Filtration of the water through the Primary (Sand Filter (open water source) and Screen Filter (Borewell)) and Secondary Filters (Disc Filter (Costly) and Screen Filter (Cheaper)) do not remove the microorganisms and dissolved salts. The microorganisms interact with the sand particles and they lead to the clogging of the drip irrigation system. To rectify the problem of clogging, Acid or chlorine (chemicals) is injected along with the irrigation water. Hence this process is called as chemigation or Chemical treatment.

Acid treatment is used for rectifying the problem caused by the dissolved or precipitated salts, whereas Chlorine treatment is used for rectifying the problems caused by the microbial growth In the drip system. These Chemicals can be injected by using Venturi System, Fertigation tank and Fertijet Pump, frequently the Problem of clogging arises due to the dissolved or precipitated salts. So Acid treatment is necessary for rectifying this problem.

Calculation test for determining the duration of acid treatment

This test is performed only once to determine the duration of acid treatment. In this test we need to observe the time taken by the color dye to reach the last lateral and the last emitter. When the Color dye reaches the last emitter, that time is recorded and it is the proper duration for carrying out the acid treatment, Steps involved in this test are :

1. Run the drip irrigation system
2. Create a pressure difference for desired suction using the Throttle valve
3. Mix a color dye in the water and use it as an injection liquid
4. When the Suction starts then Switch on the stop watch for recording the time
5. Measure the time required by the color solution to reach the last lateral and last emitter
6. After recording the time, flush out the color solution by opening the end caps
7. Then perform the same test if there are any other sections in your field
8. In case of the Multiple Sections, Note Down the section number and time required for the acid treatment

Acids that can be used for acid treatment

For Acid treatment any of the following acids can be used. Only phosphoric acid can be used in the standing crop, whereas the other three acids should be used in the Off season, where there is no crop.

S NO	Name of the Acid	Concentration Required
1	Hydrochloric acid (HCl)	35%
2	Nitric acid (HNO_3)	33%
3	Sulphuric acid (H_2SO_4)	65%
4	Ortho Phosphoric acid (H_3PO_4)	85%

Hydrochloric Acid is readily Available in the market. It should be used only when 50% of the emitters are clogged or blocked. Hydrochloric Acid Should not be used for the chlorine sensitive Crops. This Should not be used in the standing crop.

Nitric Acid can be used in the Standing Crop. This is Recommended when the Clogging or Blocking severity is less, They also provide the Nutrients.

Ortho Phosphoric Acid can be used in the Standing Crop. This is Recommended when the Clogging or Blocking severity is less, They also provide the Nutrients. If ortho phosphoric acid is used to meet the Phosphorus Content (when used as a Nutrient source/ Fertilizer), There is no need of any acid treatment.

Sulfuric Acid should be used if the blockage due to salt Precipitation is severe. Sulphuric acid and Hydrochloric acids are most commonly used for the acid treatment as they are the strong acids.

Materials required for acid treatment

1. A Plastic Drum
2. Measuring Cylinder of 2 liter Capacity
3. Glass rod for stirring
4. A dropper with scale having the milli liters count
5. Litmus paper for observing the pH change
6. Any of the above Acid for Treatment
7. Goggles, Gloves, Full hands Shirt and Complete Trousers
8. Basic Medical kit (It can be used in case of Emergency)

Estimating the required volume of acid

1. Take a 2 Liter Measuring cylinder and Clean it. After cleaning dry it for some time& Then fill the Measuring cylinder up to 1 liter mark with the water that is used generally for the drip irrigation.
2. Wear the goggles, Gloves, Full hands Shirt and Complete Trousers
3. Add the acid drop by drop in this 1 liter water using the dropper
4. Stir the water well with the glass rod
5. Measure its pH value using Litmus paper (When litmus paper turns Light red or pink, the pH is 3)
6. Continue this process until the pH of the water is equal to 3
7. Note down the amount of acid (in ml) required to obtain pH 3
8. Note down the Nominal flow rate of the system that is written on the filter (like $25m^3/hr$)
9. Do the Final Calculation, For an example, if the amount of acid required to obtain pH 3 for 1 Liter of water is 2ml, As per the Calculation test (using Color dye) we came to know that within 20 minutes the acid is reaching the last emitter, the final calculation is as follows : • Total water flow in 20 mins as per nominal flow rate 25m3/hr – 25000/60 x 20 = 8334 liters of water approx.
10. Volume of acid required for 8334 liters of water – (8334 x 2ml)/ 1 liter = 16.6 liters of acid is required.

Injecting the acid into the system

1. Start the drip system.
2. Set the desired suction rate, so as to inject the acid within the calculated time of treatment.
3. Take the required quantity of acid in the plastic drum.
4. By closing the throttle valve allow the acid to get mixed with the irrigation water, check the pH of the Acidulated water at the nearest dripper and adjust the throttle valve, if the pH is more than 3, then increase the acid suction rate by slightly closing the throttle valve, if the pH is less than 2, then decrease the acid suction rate by slightly opening the throttle valve, therefore regulation of the throttle valve is important as the desired pH can only be maintained through it.
5. When the water mixed with acid has reached the last emitter, then turn off the drip irrigation system, Don't use the system for 24 hours, In that time the salts dissolve in the acid mixed water.
6. After 24 Hours open the end caps of the laterals, open the submain flush valve and then switch on the pump and flush out the entire acid water contents, where the salts that are dissolved in the acid water are driven out.
7. Close the Flush valves and end caps of laterals after complete flushing and then use the system carefully.

Chlorination or chlorine treatment

Chlorine treatment is usually a maintenance activity of drip irrigation system which is used to remove the biological impurities. It can be done by using Chlorine or Sodium hypochlorite or Calcium hypochlorite or Calcium hydrochloride (commonly called as bleaching powder).

Chlorination method

One day before the chlorine treatment soak the bleaching powder in the water. Send this solution into the drip system by using venturi or fertigation tank. Then allow that solution to stay in the system for about 24 hours. Thereafter open the endcaps of the sections & laterals and then run the drip irrigation system for 30 – 45 mins. Hence the impurities are thrown out of the system.

Note - when chlorine treatment is done at regular intervals 1-2mg of bleaching powder per liter of water is the dosage. When chlorine treatment is done once in 2-3 months then 10-20mg of bleaching powder per liter of water is sufficient where as in case of super chlorination (when there is complete clogging of emitters) 500mg of bleaching powder per liter of water will be sufficient (Arshad, 2020).

Conclusion

Drip irrigation system plays vital role in plant health management (PHM) because it reduces the incidence and transmission of pest and diseases, reduces the growth of weeds or unwanted plants (as water is provided at the root zone of the cultivated crop), it improves the fertilizer use efficiency and water use efficiency. Usage of drip irrigation system helps in reducing the loss through pest, pathogens and weeds to some extent. Therefore one should have complete knowledge on drip irrigation system, its importance, components and maintenance activities to increase the life span of the drip irrigation system and managing plant health. As a result the healthy plants provide higher yield with good quality which in turn increases farmers income and contributing to the UN's FAO sustainable development goals of ending hunger and reducing poverty.

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