

# Unit



## Irrigation and Fertigation in Greenhouses

### INTRODUCTION

An efficient irrigation system, preferably micro irrigation, combined with fertigation system is required for any type of greenhouse cultivation. The quality of water is an important parameter to be considered when micro irrigation systems are used. Poor quality water may clog the emitting points of micro irrigation systems. In micro irrigation systems, less quantity of water is used precisely to meet the crop water requirement. In this Unit, quality and the quantity of irrigation water required, the types of micro irrigation systems, types of fertiliser and fertigation methods are discussed with reference to flower cultivation under greenhouses. Besides, processes for cleaning and maintenance of fertigation equipment have also been discussed.



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### SESSION 1: MICRO IRRIGATION SYSTEMS AND THEIR APPLICATION

#### **Quality and Quantity of Water required for Irrigation in Greenhouse**

Water quality can be defined as the quality that influences its suitability for specific use, i.e., whether the quality is suitable for drinking, irrigation, industrial

**EC:** the electrical conductivity of water estimates the total amount of solids dissolved in water, i.e., TDS, which stands for Total Dissolved Solids. TDS is measured in ppm (parts per million) or in mg/l.

**pH:** it is a measure of how acidic or basic water is. The range goes from 0–14, with 7 being neutral. A pH of less than 7 indicates acidity, whereas a pH greater than 7 indicates a basicity. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water.

use, etc. For successful flower crop production in a greenhouse, attention must be given to the quality of water. Drip fertigation requires good quality water, i.e., it should be free of suspended particulates, solids or micro-organisms that can possibly choke small openings (orifices) of the emitters. For cultivation of flowers in a controlled environment, water quality plays a pivotal role in the production of cut flowers for its colour, stem length and bud size along with climatic conditions. Normally, a pH between 6.5–7 is recommended for irrigation, and electrical conductivity (EC) should be less than 0.7ds/m. In such a case, after addition of fertilisers, the pH goes up, EC goes more than 1 ds/m and we have to maintain the uptake of fertilisers.

Generally, the requirement of water is based on the following factors.

- (i) Plant spacing
- (ii) Canopy (covering) area
- (iii) Rate of evaporation and transpiration
- (iv) Soil type
- (v) Age of plants (growth stage) and fertiliser requirement
- (vi) Stage of plants: vegetative growth and harvesting stage
- (vii) Season

**Table 4.1: The general quality of irrigation water and water requirement for flower cultivation**

S. No.	Description	Rose	Gerbera	Carnation
1.	Number of plants per sq m	6	6	20
2.	Spacing	30 × 37.5 cm	30 × 37.5 cm	15 × 15 cm
3.	Water pH	6.5–7.0	6.5–7.0	6.5–7.0
4.	Electrical Conductivity (EC)	<0.7	<0.7	<0.7
5.	Life-cycle	50–60 months	30–36 months	24 months
6.	Water requirement per day	3–4 litres sq m/day	3–4 litres sq m/day	3–5 litres sq m/day



Depending upon the peak water requirement of the plant and the number of plants, a storage tank or source of the desired capacity is made available for proper irrigation.

## Micro Irrigation Systems and their Application

The selection of irrigation systems with a fertigation arrangement is important for protected cultivation. The selection of drip system depends on the following factors.

- (i) Crop spacing
- (ii) Crop water requirement
- (iii) Soil type
- (iv) Growing media
- (v) Where to grow: beds/trough/pots
- (vi) Discharge rate of emitter
- (vii) Distances of emitters on drip line
- (viii) Bed size
- (ix) Water quality
- (x) Electricity availability
- (xi) Fertigation requirements of crop

### **Benefits of Drip System**

- (i) More efficient water use.
- (ii) More efficient use of fertilisers.
- (iii) Less pumping cost.
- (iv) Less chemical usage.
- (v) Less labour required.
- (vi) Significantly higher yield.
- (vii) Better crop quality.
- (viii) Better uniformity of application.

The drip system should be easily serviceable, economical, user-friendly with higher emission uniformity and lower coefficient of variation, to maintain optimum moisture level in the soil. For different crops, different discharge and spacing options available in the market can be used. The diameters of laterals depend on the total discharge in specific length and frictional loss. Though there are different diameters available in the market, the most common are 12 mm and 16 mm. The discharge for closed spacing crop should be lower,



*Fig. 4.1: Drip Irrigation System*

like for carnation: 1 litre per hour (LPH)/2 LPH @ 20 cm spacing. Generally, for rose and gerbera, a 16 mm diameter 2 LPH @ 20 cm/30 cm spacing inline drippers are used. For potted plants, stake drippers of 1 LPH for each pot are used.

There are various type of drip systems available in the market based on land topography and usage. These systems are used for performing the following functions.

- (i) Non Pressure Compensating (NPC)
- (ii) Pressure Compensating (PC)
- (iii) Pressure Compensating cum Non-Leaking (PCCNL)/  
Pressure Compensating with Anti-leak



Fig. 4.2: Accessories of drip line  
(1) Start connector  
(2) Rubber grommet  
(3) Lateral control valve  
(4) Lateral end plug  
(5) End Cap  
(6) Start connector  
(7) Tee  
(8) Elbow  
(9) Mini sprinkler

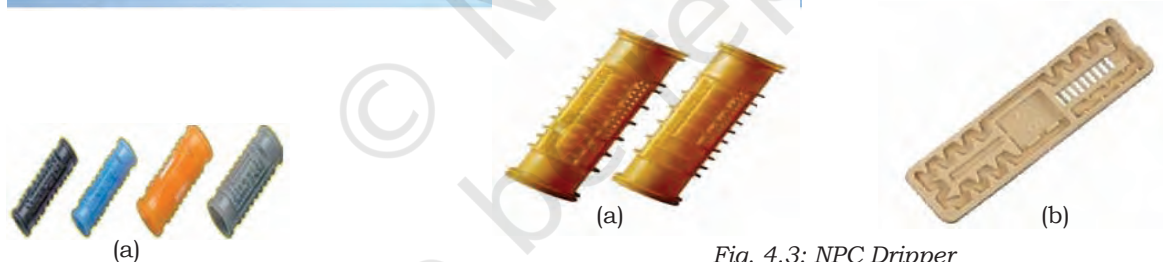


Fig. 4.3: NPC Dripper

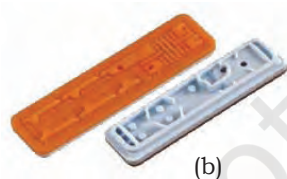


Fig. 4.4: PC Dripper



Fig. 4.5: PCCNL Dripper



Fig. 4.6: PCCNL Dripper with Stake



## Sprinkler System

This system is more popular for nurseries like seedling units where the spacing remains very close, plants are too small and density is very high. Nowadays, overhead, anti-leak sprinklers (hanging like foggers) are more popular in India because they have several advantages as being overhead it facilitates better working space. Moreover, since it is anti-leak, cyclic use and greater uniformity of application is possible.

Also, nowadays people are using sprinklers at the roof of greenhouse/polyhouse because due to dust formation at roof, the transparency of light remains lower and it helps to clean the roof. Please note that this operation should be done at night so that during sunshine, the film remains dry, otherwise there may be algae formation.



Fig. 4.7: Water sprinkler

### Practical Exercises

#### Activity 1: Identify components of drip irrigation system.

*Material required:* notebook, pen, etc.

*Procedure*

- Visit a drip irrigation unit
- Observe the types of drip system
- Note down the different components of the unit
- Identify different types of valves, drippers, lateral, etc
- Write the functions of different components

#### Activity 2: Visit a greenhouse and note down plant spacing of different flower plants.

*Material required:* pen, pad, measuring tape, etc.

*Procedure*

- Note down the flower crop grown in protected structure.
- Observe the flower plantation/spacing.
- Measure at three different places and take average of plant-to-plant and row-to-row distance.
- Calculate the total number of plants per sq. metre and total number of plants in protected structure.

**A. Fill in the blanks**

1. Commonly available diameter of laterals in India is \_\_\_\_\_ and \_\_\_\_\_ mm.
2. For potted plants stake drippers of discharge \_\_\_\_\_ LPH for each pot is used.
3. Sprinklers used on the top of greenhouse helps in \_\_\_\_\_.
4. Normally pH of irrigation water should range between \_\_\_\_\_.
5. Normally, in greenhouse the number of carnation plants per sq m is \_\_\_\_\_.
6. Water requirement of rose plants is \_\_\_\_\_ per sq m/day.

**B. Mark the correct answers**

1. A method of irrigation in which use of less water precisely to the crop is \_\_\_\_\_.  
 (a) Flood irrigation  
 (b) Macro irrigation  
 (c) Basin irrigation  
 (d) Micro irrigation
2. Which of the following can adjust pressure but not control leakage?  
 (a) NPC dripper  
 (b) PC dripper  
 (c) PCCNL dripper  
 (d) None of these

**C. Descriptive questions**

1. What is quality of water?

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2. What is drip irrigation system? Write some of its benefits.

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3. Write in brief

1. Micro irrigation system and its application
2. Sprinkler system



**D. Match the columns**

<b>A</b>	<b>B</b>
1. Drip irrigation	(a) Nozzles and dripper
2. Emitters	(b) pH and EC
3. Water quality	(c) Trickle irrigation
4. Sprinkler	(d) Water let out

## SESSION 2: TYPES OF FERTILISERS AND THEIR SCHEDULING

Most greenhouse operations apply soluble fertilisers through irrigation systems, thus the use of the term 'fertigation'. This is accomplished by drip (pipes) where soluble fertilisers are injected using injectors at a calculated quantity of concentrated solution (stock solution) into the irrigation line so that the water from the hose (dilute solution) carries as much fertiliser as planned. Fertigation provides not only greater resource optimisation, but also better adaptability for suitable placement and delivery of inputs, thereby increasing nutrient uptake efficiency, predictability, precision as per the requirement of the plant or the media formulations. The fertigation method varies depending on the type of crop, irrigation required and the size and technological status of the greenhouse. The simplest method is to combine soluble fertiliser in a watering container or use a hose injector or sprinkler to water plants by hand. This method is tedious and time-consuming but may be best when growing a variety of species with different fertiliser needs in small area. Therefore, fertiliser injector is relevant for use where fertiliser requirements of large number of plants are nearly uniform.

### Fertigation

Fertigation is a precise, controlled and tested method of applying fertilisers, nutrients and other water-soluble products through drip lines and sometimes by micro-sprinkler irrigation systems as per crop requirements, its stage, canopy size, soil or season, etc.

## NOTES

### Advantages of Fertigation

- (i) Helps supply both water and fertiliser simultaneously.
- (ii) Increases yield by 25–30 per cent.
- (iii) Saving in fertilisers by 25–30 per cent.
- (iv) Application and distribution of fertilisers uniformly and accurately.
- (v) Modifications in nutrient requirement as per crop.
- (vi) Lower pH can help in avoiding clogging of drippers.
- (vii) Major and micro nutrients can be supplied together with irrigation.
- (viii) Requisite amount of fertilisers can be injected in concentration.
- (ix) Saves time, labour and energy.

### Points to remember for adopting Fertigation

Gravitational fertiliser tank or injection pump such as venturi (a short piece of narrow tube between wider sections for measuring flow rate or exerting suction) are utilised to inject the fertiliser as per plant requirements.

- (i) Pressure compensating drippers or inline drippers instead of micro tubes may be used for precision.
- (ii) Feeding frequency depends on crop, its stage of growth and season.
- (iii) Stock solution should preferably not be above 10 per cent.
- (iv) The fertiliser solution should be compatible with other ingredients detailed in subsequent session. Compatibility means mixing ability without precipitation.
- (v) Do not inject fertilisers in combination with pesticides or chlorine.
- (vi) The time taken by fertiliser supply should not exceed the time given for water supply.

Avoid excess water supply, which may cause the leaching (drain away from soil) of fertilisers.

### Fertilisers Suitable for Fertigation

There are a number of soluble fertilisers specifically developed for fertigation. Some of the soluble fertilisers have characteristics that are suitable to specific soil





conditions, while others can be used in general for different types of soils. For example, certain soils have over abundance of sulphur, yet may require other nutrients like potassium, calcium and/or magnesium. However, acidic soils require potassium, calcium and magnesium and hence may restrict the use of acidifying fertilisers.

### ***Nitrogen Sources***

Nitrogen is the predominant element used in any kind of fertigation, including the ones used in greenhouses, as plants require it in large quantities besides being highly mobile across different phases of biogeochemical cycles. Nitrogen is used in fertigation from various sources and in different forms. Urea and urea ammonium nitrate solutions are considered the most predominant forms of nitrogen used as fertilisers. Nowadays soluble urea phosphate has also become available in the market. Fertigation through drip or sprinklers should avoid the use of free or anhydrous ammonia (compound containing no water).

Major sources of nitrogen, along with information on their use in fertigation are given below.

#### ***Ammonium Phosphate***

It may lead to lowering of pH and soil acidification. High calcium or magnesium in the water for irrigation causes precipitate formations and it can choke the drip emitters and drip lines.

#### ***Ammonium Sulphate***

It is a commonly used fertiliser. It is an inorganic soil supplement that benefits especially in alkaline soils. The active ingredients in it are nitrogen and sulphur. It dissolves readily in water, and is convenient to use for fertigation. It tends to be acid forming, which could be a disadvantage if greenhouse media is acidic.

#### ***Ammonium Thio-sulphate***

It is used both as a fertiliser and as an acidulating (which makes it slightly acidic) agent. When ammonium thio-sulphate is applied to the soil through fertigation, the

## NOTES

sulphur-oxidising bacteria, *Thiobacillus* spp., oxidises free sulphur to form sulphuric acid. The sulphuric acid dissolves lime in the soil and forms gypsum. The gypsum makes it easier and helps maintain good porosity and aeration.

### *Calcium Ammonium Nitrate*

It is high in fast acting nitrate-nitrogen, low in lasting ammonium nitrogen, and supplies calcium. Calcium ammonium nitrate may be combined with ammonium nitrate, magnesium nitrate, potassium nitrate and potassium chloride.

### *Calcium Nitrate*

It is soluble in water and causes only a slight shift in the soil or water pH. However, if the water is high in bicarbonate, the calcium content may lead to precipitation of calcium carbonate (lime).

### *Urea Ammonium Nitrate*

Nitrogen is available in three forms — nitrate nitrogen, urea nitrogen and ammonium nitrogen. The nitrate portion is immediately available as soon as it reaches the root zone. The urea portion moves freely with the soil water until it is hydrolysed by the urease enzyme responsible for the formation of ammonium nitrogen.

### *Urea Sulphuric Acid*

It is well suited for fertigation. Urea sulphuric acid is an acidic fertiliser, which combines urea and sulphuric acid. The nitrogen and sulphuric acid contents of these products vary depending on their specific formulation. The advantage of this combination eliminates disadvantages of their use singly. The sulphuric acid decreases losses of ammonia from soil due to volatilisation.

### **Phosphorus Sources**

Monoammonium phosphate, di-ammonium phosphate, monobasic potassium phosphate, ammonium polyphosphate, urea phosphate and phosphoric acid are some of the most common phosphate carrying water-soluble fertilisers. But if applied with high



calcium or magnesium concentrations, they can cause precipitation and choking of drip pipes or emitters. The precipitates so formed in drip pipes are fairly stubborn and do not dissolve easily. In order to clean such drip pipes and remove precipitates, the use of phosphoric acid injection is required, which also lowers the pH of the irrigation water. Its use may be advisable only when the pH of the fertiliser-irrigation water mixture remains low. But when the pH is high (due to dilution with the irrigation water) the phosphate may precipitate due to the presence of calcium and magnesium. One approach that is sometimes successful is to supplement the phosphoric acid injections with sulphuric or urea sulphuric acid to assure that the pH of the irrigation water remains low.

#### *Ammonium Nitrate*

It is a liquid fertiliser mainly used as a source of nitrogen in greenhouses. It is available in two forms of nitrogen — the nitrate-nitrogen form (mobile and instantly available) and ammonium-nitrogen (the longer lasting, as micro-organisms convert it to the nitrate form).

The major phosphorus sources along with information on their use in fertigation are as follows.

#### *Ammonium Polyphosphate*

It can be used as a fertiliser only by low injection rates. If the water being used has high buffering capacity (high carbonate/bicarbonate content generally with high pH, i.e., > 8.0) along with a high calcium and/or magnesium content, possibilities of precipitation in drips becomes very high.

#### *Diammonium Phosphate (DAP)*

It is one of the most popular fertilisers as a source of phosphorus and it is completely soluble in water. DAP is a boon under situations of high alkalinity and indeed many greenhouses face this problem.

#### *Mono-Ammonium Phosphate (MAP)*

It is also completely soluble in water and is a good source of phosphorus along with some nitrogen for the

## NOTES

plants. It provides nitrogen in ammonia forms that is taken up by the plants readily.

### *Monobasic Potassium Phosphate*

Also known as monopotassium phosphate, it provides good quantity of phosphorus along with potassium.

### *Phosphoric Acid*

It can be used in many formulations of nitrogen, phosphorus and potassium mixtures. But it cannot be mixed with any fertiliser with high calcium. Being a good source of phosphorus, it provides additional advantage of keeping the pH of input injections low and helps in avoiding precipitation.

### *Urea Phosphate*

It is a good source of both phosphorus as well as nitrogen. It provides nitrogen in the form of urea. It is basically acidic in nature and highly suitable for acidifying water and soil.

### **Potassium Sources**

Most potassium fertilisers are water soluble, and application of potassium through drip irrigation systems has been very successful. The most common constraint is that potassium injection leads to the formation of solid precipitants in the supply tank when potassium is mixed with other fertilisers. The potassium sources most often used in drip irrigation systems are potassium chloride (KCl) and potassium nitrate ( $\text{KNO}_3$ ). Potassium phosphates are avoided for injection into drip irrigation systems.

Major sources of potassium sources along with their uses in fertigation are given below.

### *Potassium Chloride*

Potassium is supplemented by using potassium chloride as it is highly soluble and inexpensive.

### *Potassium Nitrate*

It is costly, but provides both nitrogen and potassium simultaneously. Potassium nitrate is advisable to use with irrigation water where salinity problems exist as it has a low salt index.



### Potassium Sulphate

It can easily be used in place of potassium chloride in high-saline areas and simultaneously presents a source of sulphur, if that is required in fertility or soil management programme.

### Potassium Thio-sulphate (KTS)

Two grades of potassium thio-sulphate are available and are neutral to basic, chloride-free, clear liquid solution. It is blended with other fertilisers, but KTS mixed should not be acidified below pH 6.0. The correct order of mixing it is to first pour water, then pesticide (if any), and then KTS and/or other fertiliser.

**Table 4.2: Composition of major nutrients in different fertilisers commonly recommended for fertigation**

S. No.	Fertiliser	N-P-K
1.	Urea	46-0-0
2.	Ammonium Nitrate	34-0-0
3.	Ammonium Sulphate	21-0-0
4.	Calcium Nitrate	16-0-0
5.	Magnesium Nitrate	11-0-0
6.	Urea Ammonium Nitrate	32-0-0
7.	Potassium Nitrate	13-0-46
8.	Mono-Ammonium Phosphate (MAP)	12-61-0
9.	Potassium Chloride	0-0-60
10.	Potassium Nitrate	13-0-46
11.	Potassium Sulphate	0-0-50
12.	Potassium Thiosulphate	0-0-25
13.	Monobasic Potassium Phosphate (MKP)	0-52-0
14.	Phosphoric Acid	0-52-0
15.	NPK	19-19-19 20-20-20

**Table 4.3: Solubility of Nitrogenous Fertilisers**

S. No.	Types of fertiliser	Nitrogen content (%)	Solubility (gm/litre)
1.	Ammonium Sulphate	21	750
2.	Urea	46	1100



## NOTES

3.	Ammonium Nitrate	34	1920
4.	Calcium Nitrate	15.5	1290

**Table 4.4: Solubility of Potassic Fertilisers**

S. No.	Fertiliser	K content (%)	Solubility (gm/litre)
1.	Potassium Sulphate	50	110
2.	Potassium Chloride	60	340
3.	Potassium Nitrate	44	133

**Table 4.5: Solubility of Micronutrient Fertilisers**

S. No.	Fertilisers	Content (%)	Fertiliser Solubility (gm/litre)
1.	Solubor	20 B	220
2.	Copper Sulphate	25 Cu	320
3.	Iron Sulphate	20 Fe	160
4.	Magnesium Sulphate	10	710
5.	Ammonium Molybdate	54	430
6.	Zinc Sulphate	36	965
7.	Manganese Sulphate	27	1050

### Compatibility

Mixing the solutions of two or more water soluble fertilisers can sometimes result in the formation of a precipitate. Therefore, their solutions should be prepared independently in two separate tanks.

**Table 4.6: Combined nutrients**

S. No.	Fertilisers	Urea	Ammonium Nitrate	Ammonium Sulphate	Calcium Nitrate	Mono Ammonium Phosphate	Mono Potassium Phosphate	Potassium Nitrate
1.	Urea		C	C	C	C	C	C
2.	Ammonium Nitrate	C		C	C	C	C	C
3.	Ammonium Sulphate	C	C		LC	C	C	LC



4.	Calcium Nitrate	C	C	LC		NC	NC	C
5.	Mono Ammonium Phosphate	C	C	C	NC		C	C
6.	Mono Phosphate Phosphate	C	C	C	NC	C		C
7.	Potassium Nitrate	C	C	L	C	C	C	

*C = Compatible, NC = Not Compatible, LC = Limited Compatible*

### **Other Macronutrients**

Sulphur (S), when needed, can also be provided as ammonium thio-sulphate, ammonium sulphate or flowable S. It is amenable to use with urea ammonium nitrate and other soluble fertiliser grades for drip fertigation. Magnesium sulphate is often used to supply magnesium and sulphur.

### **Micronutrients**

They can be applied readily through the drip system. Sulphates of copper, iron, manganese and zinc are highly water soluble, and move well through the drip system. They are oxidised or precipitated readily in soil, and hence their utilisation can be wasteful. Therefore, it is advisable to use chelated fertilisers which improve micronutrient utilisation efficiency. Chelate forms of fertilisers are generally highly water-soluble and do not choke drips by precipitation.

### **Fertigation Equipment**

Different types of fertiliser application systems through drip irrigation are commercially available. They are venturi, fertiliser tank and piston pump. Selection of a particular fertigation system depends on the area, flow, investing capacity and precision needed. Generally, small cultivators (up to 1008



*Fig. 4.8: Fertigation unit*

sq m) use venturi due to lower cost, the mid size cultivators (from 1008–4000 sq m) use fertiliser tanks or piston pumps and the big cultivators (more than 5 acre) go for electrical or automation as the initial investment is very high. Further, manual mistakes can be avoided in electrical or automation, besides providing ease of operation. In general, nutrient management is essential during each irrigation.

### **Calculation of Crop Water Requirement (CWR)**

Water is the most critical input under drip irrigation system. Knowledge about calculation of water requirement during crop growth period helps to increase water use efficiency both under open field and protected condition.

Important terminology related to drip irrigation system is as follows.



*Fig. 4.9: Pan evaporation*

#### **Pan Evaporation**

It is evaporation of water from open surface and is recorded at meteorological station on a daily basis and expressed in mm/day. Under protected cultivation, open field pan evaporation is multiplied by a conversion factor of 0.45 to know the actual evaporation inside protected structures.

#### **Pan Factor**

It is the factor (0.8) taken to compensate the actual measurement of pan evaporimeter.

#### **Evapotranspiration (ET)**

It is water loss through transpiration from plants canopy and evaporation from soil surface. It is expressed in mm/day.

## Crop Factor

It is the ratio between the actual and potential evapo-transpiration. It varies as per the crop growth stages.

Crop water requirement for open field and protected cultivation can be calculated by using the following formula. Here ET is in mm/day.

Crop water requirement ( $\text{m}^3/\text{day}/\text{ha}$ ) =  $\text{ET} * 10 * 0.5$   
for open field cultivation

Water requirement ( $\text{m}^3/\text{day}/1000 \text{ m}^2$ ) =  $\text{ET} * 1 * 0.5$   
for protected cultivation

Where, ET (mm/day) = Pan evaporation \* Kc (where Kc = crop coefficient)

AVSM (Available soil moisture) or MAD (Management allowable deficit) =  $50\% = 0.5$

## Calculation of Fertiliser Solution Concentration

The concentration of fertiliser solutions is usually expressed in parts-per million (ppm) of nitrogen. To determine how much fertiliser material is required to produce a solution of a desired concentration, the following formula is used.

$$\begin{aligned} &\text{Quantity of fertiliser required (grams)} \\ &= \frac{\text{Solution concentration (ppm)} \times \text{solution volume (litres)}}{10 \times (\%N \text{ of fertiliser material})} \end{aligned}$$

For example, to make a 100 ppm solution of 20-10-20 fertiliser in a 500 litre tank, the amount of fertiliser required is

$$\text{Quantity of fertiliser required (grams)} = \frac{(100 \times 500)}{(10 \times 20)}$$

Therefore, the quantity of fertiliser required is 250 grams.



**Table 4.7: Fertigation scheduling in flowers under protected cultivation**

Crop	Spacing		Plants No./ 1000m <sup>2</sup>	Fertigation schedule	Dose			Total			Yield
	Plant to plant (m)	Row to row (m)			N	P	K	N Kg/ 1000m <sup>2</sup>	P Kg/ 1000m <sup>2</sup>	K Kg/ 1000m <sup>2</sup>	
Rose	0.2	0.4	12000	Vegetative Stage: September–October	80	50	60	28	17	25	270000
				Flowering and harvesting flush: November–March	100	60	80				
				Flowering and harvesting normal: April–August	80	50	80				
Gerbera	0.2	0.3	16000	Vegetative Stage: September–October	70	50	60	17	12	17	650000
				Flowering and harvesting flush: November–April	80	60	80				
				Maintenance dose: May–August	40	24	40				
Chrysanthemum	0.1	0.15	65000	Vegetative Stage: September–October	80	50	60	21	13	19	90000
				Flowering and harvesting flush: November–April	90	60	80				
				Maintenance Dose: May–August	50	30	50				
Lilium	0.15	0.2	32000	Vegetative Stage: September–October	60	36	60	17	11	17	130000
				Flowering and harvesting flush: November–March	80	50	80				
				Maintenance Dose: April–August	50	30	50				



Carnation	0.15	0.2	32000	Vegetative Stage: September–October		50	30	40	14	08	13	300000
				Flowering and harvesting flush: November–March		60	40	60				
				Maintenance Dose: April–August		40	20	40				

Source: Hasan et al (2010), *Fertigation Scheduling for Horticultural Crops. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi.* p. 44

**Table 4.8: Month-wise fertigation scheduling in flowers under protected cultivation (1000m<sup>2</sup>)**

Crops	Particulars	Month-wise application of water soluble fertilisers (kg/1000m <sup>2</sup> ) and Irrigation (No)												
		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Rose														
	Irrigation	4	6	7	8	8	8	6	6	8	8	6	4	79
	Urea phosphate	1.5	2.1	3.7	4.5	5.1	5.3	3.4	2.9	2.9	2.9	2.7	1.7	38.8
	Urea	1.9	2.6	4.5	5.2	6.0	6.2	4.0	3.3	3.4	3.4	3.2	2.1	45.8
	Sulphate of potash (SOP)	1.8	2.5	4.3	6.4	7.2	7.5	4.8	4.1	3.1	3.1	3.1	2.0	49.8
Gerbera														
	Irrigation	4	6	7	8	8	8	8	8	8	8	6	4	79
	Urea phosphate	1.5	2.1	3.2	4.6	2.1	2.1	1.4	1.4	2.5	2.6	2.7	1.7	27.6
	Urea	1.4	1.9	2.9	4.2	2.5	2.6	1.7	1.5	2.4	2.5	2.4	1.5	27.5
	SOP	1.8	2.5	3.7	5.4	3.0	3.1	2.0	1.7	2.6	2.7	3.1	2.0	33.8
Chrysanthemum														
	Irrigation	4	6	8	8	8	8	6	6	8	8	6	4	80
	Urea phosphate	1.	2.1	3.7	4.6	2.6	2.7	1.7	1.5	2.5	2.9	3.0	1.9	30.7
	Urea	1.6	2.2	3.9	4.9	3.1	3.3	2.1	1.8	2.9	3.4	3.2	2.0	34.5
	SOP	1.8	2.5	4.3	5.4	3.8	3.9	2.5	2.2	2.6	3.1	3.5	2.2	37.8

Source: Hasan et al (2010), *Fertigation Scheduling for Horticultural Crops. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi.* p. 44

## NOTES

**Table 4.9: Month-wise fertigation scheduling in flowers under protected cultivation (1000m<sup>2</sup>)**

Crops	Particulars	Month-wise application of water soluble fertilisers (kg/1000m <sup>2</sup> ) and Irrigation (No)												
		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Lilium														
	Irrigation	4	6	8	6	8	8	6	6	6	8	6	4	76
	Urea phosphate	1.3	1.7	2.7	2.3	2.6	2.7	1.7	1.5	1.8	2.1	2.2	1.4	24.0
	Urea	1.5	1.7	2.7	2.3	2.6	2.7	1.7	1.5	1.8	2.1	2.2	1.4	24.0
	SOP	1.8	2.5	3.7	3.4	3.8	3.9	2.5	2.2	2.6	3.1	3.1	2.0	34.6
Carnation														
	Irrigation	4	6	8	6	8	8	6	6	6	8	6	4	76
	Urea phosphate	1.0	1.4	2.1	1.5	1.7	1.8	1.1	1.0	1.5	1.8	1.8	1.1	17.9
	Urea	1.1	1.5	2.3	2.4	2.6	2.7	1.8	1.5	1.8	2.2	1.9	1.2	23.0
	SOP	1.3	1.8	2.8	2.7	3.0	3.1	2.0	1.7	1.8	2.1	2.3	1.5	26.3

Source: Hasan et al (2010). Fertigation Scheduling for Horticultural Crops. Tech Bull. TB-ICN: 80/2010, I.A.R.I., New Delhi, p. 44

## Practical Exercises

## NOTES

### Activity 1: Visit a greenhouse and observe the operation of irrigation and fertigation system

*Material required:* notebook, pen, etc.

#### *Procedure*

- Visit a nearby greenhouse.
- Note down the components of irrigation/fertigation system.
- Note down the sequences of different types of drippers.
- Apply irrigation and fertiliser and observe the process.
- Observe difficulties faced during the operation.
- Discuss with the owner/farmers.

### Activity 2: Identification of common fertilisers

*Material required:* notebook, pen, fertilisers and practical file.

#### *Procedure*

- Visit a nearby greenhouse/market.
- Identify fertilisers on the basis of appearance.
- Note down the content of each fertiliser.
- Note down the commonly used water soluble fertiliser.
- Discuss with the owner/farmers.

## Check Your Progress

### A. Fill in the blanks

1. Application of soluble fertilisers through their irrigation systems is known as \_\_\_\_\_.
2. The most fertigated element in greenhouses due to high plant nutritional needs is \_\_\_\_\_.
3. A liquid fertiliser widely used as a source of nitrogen in greenhouses is \_\_\_\_\_.
4. Diammonium phosphate (DAP) is one of the major sources of \_\_\_\_\_.

### B. Mark the correct answers

1. Which of the following fertilisers may choke the drip due to precipitation, if water is in high carbonate?
  - (a) Calcium Nitrate
  - (b) Ammonium Sulphate
  - (c) Ammonium Nitrate
  - (d) Ammonium Thio Sulphate

## NOTES

2. Urea sulfuric acid is an \_\_\_\_\_ fertiliser.  
(a) alkaline  
(b) acidic  
(b) saline  
(d) neutral
3. To avoiding clogging of drippers \_\_\_\_\_ pH is helpful.  
(c) higher  
(b) very high  
(c) medium  
(d) lower
4. Water loss through transpiration from plants canopy and evaporation from soil surface is called \_\_\_\_\_.  
(a) transpiration  
(b) evaporation  
(c) evapo-transpiration  
(d) respiration

### C. Descriptive questions

1. Describe major nitrogen sources and their use in fertigation.

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2. Write in brief  
(a) Micronutrients  
(b) Fertigation equipment  
(c) Crop water requirement

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### D. Match the columns

#### A

1. Source of N and P
2. Good source of Calcium
3. Lower pH
4. Supplies K

#### B

- (a) Ammonium Thio Sulphate
- (b) Calcium Ammonium Nitrate
- (c) Potassium Nitrate
- (d) Urea Phosphate

