

Organic and Inorganic Manures and Their Methods of Application in Horticultural Crops

OBJECTIVES

After studying this chapter, students will be able to:

- Gain basic knowledge about organic and inorganic manures and fertilizers.
- Understand the importance and principles of fertilizer application to horticultural crops
- Learn about different methods of fertilizer application.
- Decide on the most appropriate manures and fertilizers and their suitable method of application for a given situation.

INTRODUCTION

For optimum growth and production of horticultural crops, application of fertilizers is most important. Horticultural crops require nutrients for its growth and development which are absorbed through soil. In order to get maximum benefit from manures and fertilizers, they should not only be applied in proper time and in right manner but there are many other aspects, which should also be given due consideration. Different soils react differently on fertilizer application. Similarly, the N, P, K requirements of different crops are different and even for a single a crop, the nutrient requirements are not the same at different stages of growth. Now, certain questions may arise in your mind. What are the different methods of fertilizer application? Is there a choice to practice a particular method fertilizer application? Can any chemical fertilizer be sprayed on crops?

As we learnt about essential plant nutrients, their deficiency symptoms and various types of manures and fertilizers in chapter 5, let's revise it. There are 17 elements which are essential for plants namely, carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus(P), potassium(K), calcium(Ca), magnesium(Mg), sulphur(S), Iron(Fe), manganese(Mn), zinc(Zn), copper(Cu), molybdenum(Mo), chlorine (Cl), boron (B) and Nickel (Ni) . Manures and fertilizers are major nutrient supplying sources to plants. In this chapter we will learn about various methods of fertilizer application employed for optimum growth and yield of horticultural crops. A deficiency of any of these nutrient elements can limit plant growth and development and, ultimately, yield. Most soils contain sufficient amounts of the micronutrients needed to support

plant growth. However, soils may be lacking in some of the macronutrients, particularly nitrogen, phosphorus and potassium. Therefore, it becomes necessary to ensure the presence of all the essential elements supplied by the soil in the right quantities and the right chemical forms for plant use. This is done by supplying organic matter and by the judicious use of fertilizers and manures in order to supplement the nutrients required by the plants from soil to increase crop yield *vis-a-vis* to maintain/ improve the soil fertility. Continuous cropping and several other factors necessitate the use of manures and fertilizers. The dose, method and time of application depend on crop, soil, fertilizer/manure and climatic factors of the region.

Inorganic and organic manures

Inorganic manures: These are industrially manufactured chemicals containing higher nutrient content than organic manures, while fertilizer grade refers to the guaranteed minimum percentage of N, P_2O_5 and K_2O contained in the fertilizer material. Composition of different fertilizers commonly used in horticultural crop production is given in Table 1. Nutrient input is lost either through leaching, runoff, volatilization, fixation by soil or consumption by weeds, etc. Coated fertilizers namely, urea supergranules, tar-coated urea and sulphur-coated urea make nutrients available slowly and prevent wastage. Use of nitrification inhibitors can also be an approach for increasing the nitrogen-use efficiency.

In India, fertilizers consumed are of 5 types:

1. Nitrogenous fertilizers
2. Phosphatic fertilizers
3. Potassic fertilizers
4. Complex fertilizers
5. Fertilizer mixtures

Any natural or manufactured material, dry or liquid added to soil in order to supply one or more plant nutrients other than lime or gypsum is known as fertilizer.

1. Nitrogenous fertilizers

These fertilizers supply nitrogen. The common nitrogenous fertilizers are ammonium sulphate, calcium ammonium nitrate and urea etc. Ammonium sulphate and urea are by far the most important nitrogenous fertilizers used by Indian farmers.

2. Phosphatic fertilizers

These fertilizers are chemical substances that contain nutrient phosphorus in absorbable form. The primary material of phosphatic fertilizers is rock phosphate. The commonly used phosphatic fertilizers are Single super phosphate (16% P_2O_5 , 20% calcium and 12% sulphur), Dicalcium phosphate (32-36% P_2O_5) triple super phosphate (46-48% P_2O_5).

Bone meals have been used as manures for time immemorial. Bone meals are of two kinds (i) Raw bone meal and (ii) Steamed bone meal. Raw bone meal contains about 25% P_2O_5 and 4% N which is in the slow acting organic form. Steam bone meal contains 25-30% total phosphorus(P_2O_5) and about 1-2% N. It contains about 25% citrate soluble phosphorus (P_2O_5). Steam bone meal is applied to soil few days before sowing of crop.

Basic slag: It is a by product of the steel industry where the original iron ores contain appreciable amounts of phosphorus. It is a grayish black powder with a very high specific gravity. It contains 8-12% P_2O_5 .

3. Potassic fertilizers

These fertilizers are applied to soil to supply the plant with potassium (K) one of the essential elements for plant growth. Main potassic fertilizers used today are Muriate of Potash(60% K_2O), Sulphate of Potash(48 to 52% K_2O).

4. Complex fertilizers

Straight fertilizers versus Complex fertilizers:

Straight fertilizers supply only one of the primary fertilizer elements, either N or P or K for plant growth, e.g., urea. Complex fertilizers supply more than one fertilizer elements needed for crop growth. When they supply any of the two of the fertilizer elements needed for plant growth, they are called incomplete fertilizer, e.g. Mono-ammonium phosphate (11.0% N and 48.0% P_2O_5) and Diammonium phosphate (21% N and 52% P_2O_5). When they supply all the three fertilizer elements for crop growth, they are called complete complex fertilizer, e.g., Nitrophosphate (15% N, 15% P_2O_5 and 15% K_2O).

5. Mixed fertilizers:

A mixed fertilizer means a mixture of more straight fertilizers, e.g., ammonium sulphate and single super phosphate may be thoroughly mixed to get a mixed fertilizer.

Advantages of mixed fertilizer

- Two or more fertilizer elements are added together to make a mixed fertilizer to be applied in the field. Less labour is, therefore, required for application of a mixed fertilizer.
- Fertilizer elements can be more uniformly applied to the field especially when they are required in small quantities.
- Mixed fertilizer can easily be drilled because of good physical condition.

Disadvantages of mixed fertilizer:

- The use of mixed fertilizer does not permit the use of single nutrient which may be required by the crop at a certain stage.
- The illiterate farmers cannot effectively control the quantity of plant food nutrients present in the mixture.

Types of mixed fertilizers:

Mixed fertilizers are of two types (i) Open formula mixture and (ii) Close formula mixture

In open formula mixed fertilizer, manufacturer discloses the name and quantities of the straight fertilizers that are constituents of the mixed fertilizer whereas in close formula mixed fertilizer, firm does not disclose the constituents of the fertilizer.

Sulphur containing fertilizers

These are the chemical substances containing the nutrient 'S' in the nutrient form of absorbable sulphate anions SO_4^{2-} . The important 'S' containing water soluble fertilizers are Ammonium sulphate (24% S), Potassium sulphate (18% S), Ammonium sulphate Nitrate (15% S) and Super phosphate (12% S).

Micronutrient fertilizers:

Iron fertilizers: These are generally water soluble substances predominantly sprayed as foliar nutrients on the crops. Plants absorb iron in the form of Fe^{2+} . Commonly used iron fertilizers are Ferrous sulphate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) contains 20% Fe (water soluble).

Manganese fertilizers: Manganese sulphate ($\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$) is pink salt containing 24% Mn, suitable for foliar application.

Zinc fertilizers: Zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) is water soluble salt whitish in colour containing 23% Zn. It can be applied as foliar or in soil.

Boron fertilizers: Borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) is water soluble white salt which can be applied as soil dressing/foliar spray. It contains 11% boron.

Other micronutrients like copper and molybdenum are supplied through copper sulphate and sodium molybdate, respectively.

Table 1. Composition of common inorganic manures.

Fertilizer	Composition (%)			
	N	P ₂ O ₅	K ₂ O	Miscellaneous
Anhydrous ammonia	82			
Ammonium sulphate	20.6			
Calcium ammonium nitrate	25			
Urea	46			
Single superphosphate	-	16		12 S
Diammonium phosphate	16 and 18	48 and 46		
Rock-phosphate		20-40		
Muriate of Potash			60	
Ferrous sulphate				19 Fe
Borax				11 B
Boric acid				17 B
Manganese sulphate				26 Mn
Basic zinc sulphate				55 Zn
Copper sulphate				21 Cu

Organic manures: These are plant and animal wastes that are used as nutrients after decomposition. Plants are directly or indirectly the source of recyclable materials. They provide various types of crop residues. When crushed, seeds of oil crops leave behind oil cakes. Biomass of several uncultivated plants is also recyclable. Human and animal wastes are largely the residues of plant products ingested either by humans or by domesticated animals. Organic manures and leguminous green manures are most valuable from crop nutrition point of view, whereas farmyard manure, crop residues and composts are most important from utilization and organic recycling point of view. Organic resources reduce the mining of soil nutrients and improve soil productivity, by improving soil tilth, aeration, water-holding capacity and activity of microorganisms. Organic manures are classified into bulky organic manures and concentrated organic manures depending on the nutrient content in them. Nutrient content of commonly used organic manures have been given in Table 2.

Bulky organic manures

Farmyard manure: The decomposed mixture of dung and urine of farm animals along with litter and left over materials from roughages or fodder fed to cattle is farmyard manure.

Quality of farmyard manure can be improved by concentrated feeds given to the cattle. Cotton seed, cotton seed cake, linseed meal, wheat bran, grain husk, ground nut cake etc. are rich in N, P, Mg, and S.

Compost: Composting is a process in which both aerobic and anaerobic micro-organisms decompose organic matter under medium to high temperature and low carbon-nitrogen ratio of refuse. Farm compost is mass of rotted organic matter made from farm waste like sugarcane trash, paddy straw, weeds and other plants, while town compost is mass of rotted organic matter made from town refuses like night soil, street sweepings and dustbin refuse.

Sewage and sludge: In modern system of sanitation adopted in cities, water is used for removal of human excreta and other wastes, called as sewage. Solid portion is sludge while the liquid portion is sewage water. Both sludge and sewage water are separated and given preliminary fermentation and oxidation treatments to reduce bacterial contamination and offensive smell and also to narrow down the C: N ratio.

Vermi-compost: It is the compost prepared with the help of earthworms. Earthworms consume large quantities of organic matter, excrete soil as casts which have several plant growth promoters, enzymes rich in plant nutrients, beneficial bacteria and mycorrhizae. Vermicompost is a rich mixture of major and minor plant nutrients. It increases total microbial population of nitrogen fixing bacteria, actinomycetes and symbiotic association of mycorrhiza on plant root system. Earthworm casts harbour a large number of vesicular arbuscular mycorrhizal (VAM) propagules which survive for about 11 months. Increased microbial activity improves soil phosphorus and nitrogen availability. It also improves by using residues as surface mulches.

Concentrated organic manures

Oil cakes: Oil cakes can be grouped into edible oil cakes which are suitable for cattle feeding and non-edible oil cakes which are unfit for cattle consumption.

Blood meal: An adult cattle gives about 13.6kg blood meal and goat or sheep about 1.36kg. It is effective for all horticultural crops and all types of soils.

Meat meal: The meat is converted into meat meal. It is quick acting and suitable for all types of horticultural crops and soils.

Fish meal: Non-edible fish carcasses and fish offal are used to prepare fish meal. These are crushed and powdered before use.

Table 2. Nutrient content of organic manures

Organic manures	N (%)	P ₂ O ₅ (%)	K ₂ O (%)
Poultry manure	3.03	0.63	1.40
Farmyard manure	0.75	0.20	0.50
Vermi-compost	3.00	1.00	1.50
Neem cake	5.22	1.08	1.48

Bio-fertilizers

These are inputs containing micro-organisms capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. They are less expensive, eco-friendly and sustainable and do not require non-renewable source of energy during their production. They improve plant growth and fruit quality by producing plant hormones. They increase the sustainability of soil and make it more productive. They are also useful as bio-control agents since they control many plant pathogens and harmful microorganisms. Some of the beneficial microorganisms are capable of fixing atmospheric nitrogen, while some can increase the availability of N and P. Different bio-fertilizers available for use for horticultural crops are given in Table 3.

Table 3. Biofertilizers commonly used for horticultural crops

Biofertilizer	Organisms	Fixed nutrient
Saprophytes	Aspergillus, Trichoderma	Decomposes organic matter at a faster rate
Legume inoculants	Rhizobium species	Fixes atmospheric N in association with leguminous crops
In association with plants	Azospirillum	High N fixation capacity
Free-living organism	Azotobacter	Fixes N in neutral to alkaline soils
Phosphorus solubilizers	Pseudomonas striata, Bacillus polymixa, Aspergillus awamori and Pencillium digitatum	P
Endotrophic mycorrhizae (VAM)	Glomus, Gigaspora,	Higher N, P, K, Ca and Mg

Integrated nutrient management

It is the use of chemical fertilizers, organic manures, slow-releasing fertilizers, nitrification inhibitors, vesicular-arbuscular mycorrhizae and nutrient efficient rootstocks either singly or in combination, all at a time in a definite sequence during the growth developmental stages of plant for economic and efficient use of nutrients without having any adverse effects on soil health and environment.

Principles of fertilizer application

The basic principle of fertilizer application is to make the nutrients readily available to the plants as per their requirement without much wastage and harmful effects on soil. Usually larger quantities of fertilizers are added to clayey soils at longer intervals than to sandy soils because clayey soils are richer in humus than sandy soils and both clay and humus have a high capacity to retain nutrient ions by a phenomenon called Base Exchange. These adsorbed nutrient ions are not lost by leaching, can be gradually taken up by the plant roots. If a heavy dose of water soluble fertilizer is applied to sandy soils, most of it will be leached down by high rainfall in the humid regions.

Difference between manures and fertilizers

Sl. No.	Characteristics	Manures	Fertilizers
1.	Origin	Plant, animal, human residue	Chemically manufactured
2.	Type	Natural product	Artificial product
3.	Nutrient content	Low / less concentrated	High / more concentrated
4.	Availability of nutrient	Slow releasing	May or may not be readily available
5.	Effect on soil health	Improves physical property of soil	Do not improves physical property of soil

Quantities of fertilizers to be applied

Different crops require different quantities of nutrients. Fertilizer dose is calculated on the basis of requirement of plants for its various physiological activities. While applying fertilizers, nutritional status of soil is taken into account. After deducting contribution of soil, rest amount is replenished externally by the application of fertilizers.

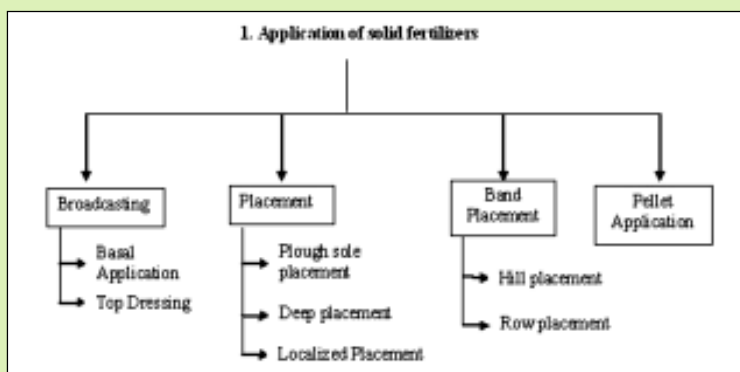
Time of application of fertilizers

Generally, the manures are applied in the field before the onset of monsoon. With the appearance of rain, the manures are decomposed well and their nutrients become readily available

to plants. The fertilizers are applied at the time of active growth of plants so that the nutrients may be absorbed by the roots. Generally, the plants remain active during February- March and July and new growth emerges on the plant. During these times, fertilizers must be applied. In case of bearing plants, the manures and fertilizers are applied to cope with nutritional requirement. Under such circumstances, the manures and fertilizers must be applied one month before the commencement of flowering in plants. Phosphatic fertilizers being less soluble should be applied about 20 days before the commencement of new growth. Nitrogenous fertilizers being highly soluble and hence prone to leaching losses should be applied in split doses. Half of the recommended dose of nitrogen should be given before commencement of flowering and rest half dose is given after fruit set. This holds true especially in case of fruits. In case of vegetables, the recommended doses of fertilizers are applied at the time of sowing, transplanting and also during growing. Nitrogenous fertilizers are given in splits to support production.

Methods of application

For maximized efficiency, fertilizer should be applied in root zones of the plants. The methods by which fertilizers can be applied are discussed as under:



1. Broadcasting: It refers to spreading fertilizers uniformly all over the field. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used. Broadcasting of fertilizers is of two types.

- (i) **Broadcasting at sowing or planting (Basal application):** The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

Advantages: Fast and economical.

Disadvantages: High nutrient losses, low uniformity. P efficiency is only 1/3 to 1/4 that of banding

- (ii) **Top dressing:** It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.



Disadvantages of broadcasting

The main disadvantages of application of fertilizers through broadcasting are:

- i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
- ii) The weed growth is stimulated all over the field.
- iii) Nutrients are fixed in the soil as they come in contact with a large mass of soil.

2. Placement: It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soil has a low level of fertility and to apply phosphatic and potassic fertilizers. The most common methods of placement are as follows:

- (i) **Plough sole placement:** In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing. Every band is covered as the next furrow is turned. This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.
- (ii) **Deep placement:** It is the placement of ammonical nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.
- (iii) **Localized placement:** It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:
 - (a) **Drilling:** In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes

germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

(b) Side dressing: It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are:

- (i) Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and
- (ii) Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

3. Band placement: It refers to the placement of fertilizer in bands. Band placement is of two types.

(i) Hill placement: It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

(ii) Row placement: When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.



Row placement

4. Pellet application: It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

Seed cum fertilizer drill is an implement used to sow the seed in rows as well as to apply the fertilizers at the same time

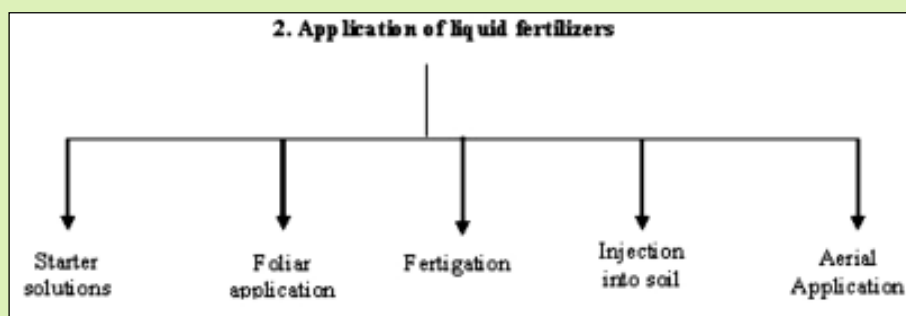
Advantages of placement of fertilizers

The main advantages are as follows:

- (i) When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced.
- (ii) The weeds all over the field can not make use of the fertilizers.
- (iii) Residual response of fertilizers is usually higher.

- (iv) Utilization of fertilizers by the plants is higher.
- (v) Loss of nitrogen by leaching is reduced.
- (vi) Being immobile, phosphates are better utilized when placed.

The common methods of applying liquid fertilizers are as follows:



1. Starter solutions

It refers to the application of solution of N, P_2O_5 and K_2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables. Starter solution helps in rapid establishment and quick growth of seedlings. The disadvantages of starter solutions are:

- (i) Extra labour is required, and
- (ii) the fixation of phosphate is higher.

Can any chemical fertilizer be sprayed on crops?

- Only those fertilizers that do not scorch (burn) leaves are sprayed.
- Usually micronutrients, which are required in low rates, are foliar sprayed.
- Urea sprays are used for supplying nitrogen

2. Foliar application:

It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. The concentration of the spray solution has to be controlled; otherwise serious damage may result due to scorching of the leaves. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

3. Application through irrigation water (Fertigation): It refers to the application of water soluble fertilizers through irrigation water. The nutrients are thus carried into the soil in solution.



4. Injection into soil: Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types. Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

5. Aerial application: In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc.

Precautions in fertilizer use

- It is better to get the soil tested from soil-testing laboratory. The amount of fertilizer(s) should be calculated based on soil test for balanced use of nutrients.
- Secondary nutrients like sulphur should be used either alone or through sulphur bearing fertilizers. In acid soils, calcium and magnesium should be maintained at the optimum level.
- Micronutrient should be applied whenever necessary. In acidic soils boron and molybdenum, and in alkaline soils, iron, zinc and manganese should be made available. Phosphate rich calcareous soils may show zinc deficiency problems.
- Fertilizers should be selected on the basis of soil characteristic. Avoid acid fertilizers in acid soils and basic fertilizers in alkaline soils.
- Improve soil structure through the addition of organic manure and gypsum. Black and alluvial soils should be deep ploughed.
- Use of high yielding varieties, irrigation at an appropriate time and amounts, removal of weeds, spacing and plant population etc. should be given due consideration.

ACTIVITY/EXERCISE

1. Know the manures and fertilizers available and being used in your area by visiting co-operative society and prepare a list of the same mentioning contents of particular nutrient present in them.
2. Apply the available manure and fertilizers in your kitchen garden/farm/orchard by employing a particular suitable method of fertilizer application and record observations in respect of growth and fruiting of the crops being grown.

CHECK YOUR PROGRESS

- 1) What do you mean by organic and inorganic manures? List five inorganic manures along with their nutrient content.
- 2) Write the various types of concentrated organic manures.
- 3) What is vermi-compost? How does it differ from farm yard manure?
- 4) What is the principle of fertilizer application? Enlist the different methods of fertilizer application.
- 5) When is broadcasting of fertilizers practiced? What are the drawbacks with broadcast application?
- 6) What are the different methods of placing the fertilizers? When is placement of fertilizers practiced?
- 7) What are the advantages of band placement?
- 8) What is foliar application of fertilizers?

FILL IN THE BLANKS

1. Usually larger quantities of fertilizers are added to.....soils at longer intervals than to sandy soils.
2. Use ofinhibitors can also be an approach for increasing the nitrogen-use efficiency
3. Vermi-compost is prepared with the help of.....
4. The application of water soluble fertilizers through irrigation water is known as.....
5. The fertilizers are applied at the time of.....growth of plants
6. The manures and fertilizers must be applied one month before the commencement of in plants.
7. Nitrogen content present in Calcium ammonium nitrate is.....percent.
8. The application of water soluble fertilizers through irrigation water is referred to as
9. Foliar application is effective for the application ofnutrients.
10. The application of fertilizers in orchards is done through.....method.

SUGGESTED FURTHER READINGS

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