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Class 12
Chemistry

Chapter 22
Agriculture
Handwritten Notes

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AGRICULTURE

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Fertilizer

22.6 and 22.7
not included

Fertilizers are natural or artificial substances added to soil to improve plant growth and increase crop productivity. They either increase soil fertility or replace nutrients removed by previous crops. Soil fertility refers to the ability of soil to supply plants with essential nutrients. Plant growth also depends on factors such as light, temperature, humidity, and soil structure. Historically, fertilizers were obtained from natural sources such as compost, animal manure, crop rotation, mineral deposits, and industrial by-products (e.g. fish waste and blood meal). From the late 19th century, advances in plant nutrition led to the development of synthetic fertilizers, allowing large-scale farming and higher crop yields. Organic fertilizers release nutrients slowly as they decompose and are better for long-term soil health. Inorganic (chemical) fertilizers provide nutrients quickly, allowing rapid uptake by plants.

Composition of Fertilizers

Chemical fertilizers mainly contain Macronutrients: Nitrogen, Phosphorus, Potassium and Trace elements; Zinc, Magnesium, Copper, Iron, Calcium, Boron, Manganese, Molybdenum.

Types and Functions of Fertilizers

- **Nitrogen Fertilizers:** Nitrogen fertilizers promote leaf growth and are most important during the early and middle stages of plant growth. They must be applied at the start of the growing season. Examples: Urea, Ammonium Nitrate, Calcium Ammonium Nitrate.
- **Phosphorus Fertilizers:** Phosphorus fertilizers help in root and stem development and are essential at all stages of growth, especially for flowering, seed, and fruit formation. Examples: Superphosphate, Triple Superphosphate, Diammonium Phosphate, Ammonium dihydrogen phosphate.
- **Potassium Fertilizers:** Potassium fertilizers improve root development, support photosynthesis and increase disease resistance. Deficiency causes yellowing or browning of leaf edges. Example: Potassium Chloride (KCl), Potassium Sulphate (K_2SO_4), Potassium Nitrate (KNO_3).

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Impact of fertilizers on soil health

Balanced use of fertilizers improves crop yield. However, excessive or improper use can change soil pH, increase pest attacks, causes soil erosion, reduces beneficial soil organisms, increases greenhouse gas emissions and lower long-term soil fertility.

Pesticides

Pesticides are chemicals used to control or kill pests, weeds, fungi, rodents, and nematodes that damage crops.

Types of Pesticides

- **Insecticides:** Used to kill insects by affecting their nervous system.
 - **Organophosphates and Carbamates:** Inhibit acetylcholinesterase, causing nerve overstimulation and paralysis.
 - **Pyrethroids:** Disrupt sodium channels in insect neurons, producing repetitive nerve impulses.
 - **Neonicotinoids:** Affect nicotine acetylcholine receptors, disrupting the transmission of nerve signals and causing paralysis.
- **Herbicides:** Used to kill unwanted plants (weeds).
 - **Glyphosate:** Inhibits protein synthesis, ultimately kills the plant.
 - **2, 4-D and Dicamba:** Mimic plant hormone auxin, causing uncontrolled growth and eventual death.
 - **Paraquat:** Inhibits photosynthesis and causes death of a plant.
- **Fungicides:** Used to control fungal diseases.
 - **Triazoles:** Inhibit ergosterol synthesis in fungal membranes, causes cell death.
 - **Strobilurins:** Interrupt mitochondrial electron transport, causes cell death.
 - **Copper-based fungicides:** Disrupt fungal cellular processes.
- **Rodenticides:** Used to kill rodents.
 - **Vitamin K inhibitors:** Causes internal bleeding.

Class

- Zinc phosphate: Produces toxic phosphine gas in the stomach.
- Nematicides: Used to kill nematodes.
- Organophosphates: Disrupt the nervous system of nematodes.
- Biopesticides: Derived from natural sources such as plants, bacteria, or minerals. For example; canola oil, baking soda.

Benefits of Pesticides

Increases crop yields and food production, Control plant, animal and human diseases, Improves quality of fruits and vegetables, Cost-effective pest control.

Harmful Effects of Pesticides

Toxic and carcinogenic effects on humans, harm to non-target organisms (birds, fish, beneficial insects), water and soil contamination, pesticide residues on food, development of pest resistance, reduction of pollinators such as bees.

Acid Rain

Normal rainwater has a pH of 5-6 due to dissolved carbon dioxide. Rain with a pH below 5-6 is called acid rain. Acid rain is caused by air pollution from Sulphur Oxides (SO_x) like Sulphuric acid (H_2SO_4) and Nitrogen Oxides (NO_x) like Nitric acid (HNO_3) dissolved in the rain water. Acid rain can have a pH as low as 2-1.

- **Impact of Acid rain on soil:** Acid rain has serious harmful effects on soil chemistry, fertility and crop productivity. When acids rain falls on soil, it causes several chemical reactions that disturb the natural balance of nutrients required for plant growth. Firstly, acid rain lowers the pH of the soil, making it more acidic. Most crops grow best in slightly acidic to neutral soils. When soil becomes too acidic, plant roots are unable to function properly, which reduces plant growth and yield. Secondly, increased soil acidity causes the leaching of essential nutrients such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), and sodium (Na^+). These nutrients are washed away by rainwater and replaced by hydrogen ions (H^+) from acids. As a result, the soil becomes nutrient-deficient and less fertile. For example, $\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2$. Thirdly, acid rain increases the solubility of aluminium compounds present in the soil. Aluminium ions (Al^{3+}) are released into the soil solution, which are toxic to plants. These ions damage root systems, restrict root growth, and reduce the ability of plants to absorb water and nutrients. Reaction involved: $\text{Al}_2\text{O}_3 + 3\text{H}_2\text{SO}_4 + 6\text{H}_2\text{O} \rightarrow 2\text{Al}(\text{OH})_3 + 3\text{SO}_4^{2-} + 6\text{H}^+$. Fourthly, acid rain damages soil microorganisms such as bacteria and fungi that play an important role in decomposing organic matter and recycling nutrients. The combined effects of nutrient loss, aluminium toxicity, reduced microbial activity and poor soil structure significantly reduce crop yield. Sensitive crop such as wheat, soybeans, and peanuts are particularly affected, leading to economic losses in agriculture.

SHORT QUESTIONS

Describe the chemical reactions involved in soil acidification due to acid rain.

Acid rain mainly contains sulphuric acid (H_2SO_4) and nitric acid (HNO_3) formed from SO_2 and NO_x in the atmosphere. When these acids enter the soil, they release H^+ ions, which lower soil pH. The H^+ ions displace essential base cations like Ca^{2+} , Mg^{2+} and K^+ from soil particles, causing nutrient leaching. This increased acidity can also dissolve toxic aluminium compounds, further degrading soil quality.

Explain the role of phosphorus in plant growth and development.

Phosphorus is essential for energy transfer in plants as it is a key component of ATP. It promotes strong root development, early plant growth, and flowering. Phosphorus also plays an important role in DNA, RNA and cell membrane formation. A deficiency of phosphorus results in weak roots, poor flowering, and stunted growth.

Discuss the potential environmental impacts of excessive nitrogen fertilizer use.

Excessive nitrogen fertilizers can leach into groundwater as nitrates, causing water pollution and health risks. Runoff into rivers and lakes leads to eutrophication, resulting in algal blooms and oxygen depletion. Nitrogen compounds can also increase soil acidity and reduce soil fertility over time. Additionally, nitrogen fertilizers contribute to the release of nitrous oxide, a greenhouse gas.

Describe the chemical composition of superphosphate fertilizer and its function in soil fertility.

Superphosphate fertilizer mainly contains calcium dihydrogen phosphate, $\text{Ca}(\text{H}_2\text{PO}_4)_2$, along with calcium sulphate. It is produced by treating phosphate rock with sulphuric acid. Superphosphate supplies phosphorus in a soluble form, making it readily available to plants. It improves root growth and enhances soil fertility.

How does acid rain affect nutrient uptake by plants?

Acid rain lowers soil pH, which reduces the availability of essential nutrients such as calcium, magnesium, and potassium. These nutrients are leached away by acidic water before plants can absorb them. Acidic conditions also increase aluminium toxicity, which damages root systems. As a result, plants absorb fewer nutrients, leading to poor growth.

Explain the impact of acid rain on soil microbial activity.

Soil microorganisms function best in near neutral pH conditions. Acid rain lowers soil pH, which reduces microbial activity and slows down decomposition of organic matter. This decreases nutrient recycling in the soil. Reduced microbial activity ultimately lowers soil fertility and plant productivity.

Discuss the effects of acid rain on crop yield.

Acid rain damages crops by lowering soil fertility and increasing toxic metal concentration. Poor nutrient availability and root damage reduce plant growth. Leaves may also be directly injured by acidic rain. Over time, crop yields decrease due to weakened plant health.

Explain how pesticides contribute to increased crop yields.

Pesticides control pests such as insects, weeds, and fungi that damage crops. By reducing crop loss, they allow plants to grow efficiently. Healthy crops absorb nutrients better and produce higher yields. Pesticides therefore help ensure food security when used properly.

What is meant by the term "pesticide resistance", and why is it a concern?

Pesticide resistance occurs when pests develop the ability to survive pesticide applications. This happens due to repeated and excessive use of the same pesticide. Resistant pests multiply and become harder to control. As a result, stronger chemicals or higher doses are required, increasing environmental and health risks.

Discuss one human health concern associated with pesticide exposure.

Exposure to pesticides can cause serious health problems such as skin irritation, respiratory issues, and neurological disorders. Long-term exposure may increase the risk of cancer.

Pesticides can enter the human body through contaminated food, water, or air. Proper handling and regulation are essential to reduce health risks.

Class

How would you determine the appropriate fertilizer to use for a crop with phosphorus deficiency? Soil testing is used to identify phosphorus deficiency. If phosphorus levels are low, phosphate fertilizers such as superphosphate are recommended. The fertilizer choice depends on soil pH and crop type. Proper application restores soil fertility and improves plant growth.

How does the mode of action of insecticides differ from that of herbicides?

Insecticides target insects by affecting their nervous system, respiration, or growth. Herbicides control weeds by disrupting photosynthesis or plant hormone balance. Insecticides act on animals, while herbicides specially target plant processes. This difference allows selective pest control.

What are the potential environmental risks of excessive pesticide use?

Excessive pesticide use can contaminate soil and water bodies. It may harm non-target organisms such as beneficial insects, birds, and aquatic life. Pesticides can persist in the environment and enter the food chain. This leads to ecological imbalance and biodiversity loss.

Design a plan to minimize the negative impacts of fertilizer runoff into nearby water bodies.

To reduce fertilizer runoff, fertilizers should be applied in correct amounts and at appropriate times. Buffer zones of vegetation near water bodies can absorb excess nutrients. Slow-release fertilizers help reduce leaching. Proper irrigation practices also prevent nutrient loss.

How does acid rain affect nutrient availability in the soil?

Acid rain reduces nutrient availability by leaching essential minerals from the soil. Calcium, magnesium, and potassium are washed away by acidic water. Increased acidity also releases toxic aluminum ions. This imbalance negatively affects plant nutrition.

What are the potential consequences of long-term soil acidification on crop yield?

Long-term soil acidification reduces soil fertility and damages root systems. Nutrient deficiencies become more common due to leaching. Toxic metal levels increase, further stressing plants. Over time, crop yields decline significantly.

How do different types of pesticides target pests differently?

Insecticides kill insects, herbicides eliminate weeds, and fungicides control fungal disease.

Each type targets specific biological processes. Selective pesticides affect only certain pests, while non-selective ones affect many organisms. This targeting helps protect crops efficiently.

What are the long-term impacts of pesticide use on soil health?

Long-term pesticides use can reduce soil microbial diversity. Beneficial organisms that maintain soil structure and fertility may be harmed. Persistent chemicals can accumulate in soil and disrupt nutrient cycles. This leads to reduced soil productivity over time.