Nitrogen Use Efficiency and Biofortification

For Prelims: Nitrogen, Nitrogen Use Efficiency (NUE), High Yielding Varieties, Nitrous Oxide (N_2O), Ammonia Pollution, Ozone Depletion, Climate Change, Dead Zones, Algal Bloom, Ground Level Ozone, Indian Council of Agricultural Research (ICAR), CR Dhan 416, Durum Wheat Variety, Biofortification, Nutrient Density, Biotechnology, Copenhagen Consensus

For Mains: Significance of Biofortified Foods in Meeting Nutritional Security in India and Associated Challenges.

Source: TH

Why in News?

Recently, **biotechnologists** have found significant variation in nitrogen-use efficiency among popular Indian rice varieties, enabling the development of **high-yielding**, low-nitrogen varieties to cut fertiliser costs and reduce pollution. The most efficient varieties had a **nitrogen use efficiency (NUE)** that was five times higher than the least efficient ones.

- In another development, the Prime Minister of India launched 109 high-yielding, climate-resilient, **biofortified** seed varieties developed by the **Indian Council of Agricultural Research (ICAR)** to boost farm productivity and farmers' incomes.

What is Nitrogen Use Efficiency (NUE)?

- **About:**
  - It is used to describe the efficiency of a plant in using **applied or fixed nitrogen** for biomass production.
  - It is further defined as the **ratio** between **crop yield** and the **amount of nitrogen absorbed** from the soil through roots or from the atmosphere through fixation by bacteria.
  - NUE in cereals, particularly rice, is a **critical factor** in agricultural sustainability.
- **Concerns:**
  - **Poor NUE** wastes Nitrogen fertilisers worth **Rs 1 lakh crore** a year in India and over **USD 170 billion per year** globally.
  - Nitrogen fertilisers are the main source of **nitrous oxide** and **ammonia pollution** of air and nitrate/ammonium pollution of water, affecting our health, biodiversity, and climate change.
  - **India** is the world's **second-largest** source of **nitrous oxide (N_2O)**, a greenhouse gas that heats up the atmosphere far more than carbon dioxide.
    - In 2020, nearly **11%** of such global man made emissions were from **India**, next only to China (16%). The major source of these emissions is **fertiliser usage**.

What is Nitrogen Pollution?

- **About:**
  - Nitrogen pollution is caused when some **nitrogen compounds** like ammonia and nitrous oxide become too abundant in the environment posing health risks.
  - In the past 150 years, human-driven flows of **reactive nitrogen** have increased **tenfold**, contributing to a dangerous **accumulation** of unused reactive nitrogen.
  - The uptake by crops of nitrogen as fertiliser is limited. Each year, 200 million tonnes of **reactive nitrogen (80%)** is lost to the environment, **leaching** into soil, rivers and lakes and emitted to the air.
    - As a result, ecosystems are **over-enriched**, biodiversity lost and human health affected. In some forms, it contributes to **ozone depletion** and **climate change**.
- **Effects:**
  - **Climate Change and the Ozone Layer:**
    - Nitrous oxide is **300 times** more **potent** than methane and carbon dioxide as a **greenhouse gas**.
    - It is also the biggest human-made threat to the **ozone layer**.
  - **Biodiversity and Ecosystems:**
    - Nitrogen pollution can **degrade soils**. Excessive application of synthetic fertilisers make soil acidic, damaging soil health and reducing the productivity of soils.
    - It can cause the inadvertent **fertilisation** of trees and grasslands or nitrogen tolerant species to outcompete more sensitive wild plants and **fungi**.
    - Nitrogen pollution can create **"dead zones"** in the ocean and cause toxic **algal blooms** to spread in **marine ecosystems**.
  - **Air:**
    - Nitrogen oxides generated from coal power plants, factory emissions and vehicle exhausts, can lead to **smog** and **ground-level ozone**.
    - Agricultural ammonia emissions combined with pollution from vehicle exhausts create extremely dangerous **particulates** in the air, which can exacerbate **respiratory diseases.**

What are the Biofortified Seed Varieties Developed by ICAR?

- **About:** The biofortified seed varieties, launched recently by the PM, cover 61 crops, including 34 field crops and 27 horticultural varieties.
  - **Crop Varieties:** Cereals, millets, forage crops, oilseeds, pulses, sugarcane, cotton, and fibre crops.
  - **Horticulture:** Fruits, vegetables, plantation crops, tubers, spices, flowers, and medicinal plants.
  - **Some Examples:**
    - **CR Dhan 416:** It is a rice variety ideal for **coastal saline areas**. It is moderately resistant to **brown spot, neck blast, sheath rot, rice tungro disease, and glume discoloration**, besides offering full resistance to **brown plant hopper, grasshopper and stem borer**.
    - **Durum Wheat Variety:** It is adapted fo**r irrigated conditions** and suitable for Maharashtra, Karnataka, and the plains of Tamil Nadu. It is tolerant to **terminal heat, resistant to stem and leaf rusts, and biofortified** with higher levels of zinc (41.1 ppm) and iron (38.5 ppm). It also contains 12% protein.
- **About Biofortification:**
  - **Biofortification** is the process by which the **nutrient density** of food crops is increased through conventional plant breeding, improved **agronomic practices** and modern **biotechnology** without sacrificing any characteristic that is preferred by consumers.
  - It is recognized as a **nutrition-sensitive-agriculture intervention** that can reduce vitamin and mineral deficiency.
  - Examples of biofortification projects include:
    - **Iron-biofortification** of rice, beans, sweet potato, cassava and legumes;
    - **Zinc-biofortification** of wheat, rice, beans, sweet potato and maize;
    - **Provitamin A carotenoid-biofortification** of sweet potato, maize and cassava; and
    - **Amino acid and protein-biofortification** of sorghum and cassava.

- **Need of Biofortification:**
    - **Malnutrition:** India has very high levels of malnutrition among women and children. According to **NFHS-5 2019-21**, 57% of women in the age group 15-49 and 67% children between 6 and 59 months are anaemic. Iron, **Vitamin A**, and Iodine deficiencies are the most prevalent ones.
        - Biofortification can help reduce the occurrence of malnutrition and hidden hunger by providing deficient nutrients.
    - **Disease Resilient:** Biofortified crops are often more resilient to **pests, diseases, high temperatures**, and **drought**, while also offering high yields.
    - **Sustainable:** Once biofortified seeds are developed, they can be replicated and distributed without losing their **micronutrient concentration**, making them cost-effective and sustainable.
    - **No Behaviour Change Needed:** It seamlessly delivers nutrients without altering people's food habits or cultural practices, making it a socio-culturally acceptable approach.
    - **Cost Effective:** Biofortification is cost-effective using the existing technology and delivery platforms. The **Copenhagen Consensus** estimates that every 1 Rupee spent on fortification results in 9 Rupees in benefits to the economy.

Drishti Mains Question

Q. How biotechnology can help in achieving food and nutritional security?

Q. What challenges are associated with edible products created using biotechnology which hinder its widespread adoption in India?

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. Consider the following: (2019)

1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

Which of the above are released into the atmosphere due to the burning of crop/biomass residue?

(a) 1 and 2 only

(b) 2, 3 and 4 only

(c) 1 and 4 only

(d) 1, 2, 3 and 4

Ans: (d)

Q Consider the following statements: (2019)

1. Agricultural soils release nitrogen oxides into the environment.
2. Cattle release ammonia into the environment.
3. Poultry industry releases reactive nitrogen compounds into the environment.

Which of the statements given above is/are correct?

(a) 1 and 3 only

(b) 2 and 3 only

(c) 2 only

(d) 1, 2 and 3

Ans: (d)

Q. Consider the following statements: (2017)

1. The nation-wide ‘Soil Health Card Scheme’ aims at expanding the cultivable area under irrigation.
2. enabling the banks to assess the quantum of loans to be granted to farmers on the basis of soil quality.
3. checking the overuse of fertilisers in farmlands.

Which of the above statements is/are correct?

(a) 1 and 2 only

(b) 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

Ans: (b)

Q. Why does the Government of India promote the use of ‘Neem-coated Urea’ in agriculture? (2016)

(a) Release of Neem oil in the soil increases nitrogen fixation by the soil microorganisms.

(b) Neem coating slows down the rate of dissolution of urea in the soil.

(c) Nitrous oxide, which is a greenhouse gas, is not at all released into the atmosphere by crop fields.

(d) It is a combination of a weedicide and a fertiliser for particular crops.

Ans: (b)

Mains

Q. What are the research and developmental achievements in applied biotechnology? How will these achievements help to uplift the poorer sections of the society? **(2021)**

Q. How can biotechnology help to improve the living standards of farmers? **(2019)**

Q. Why is there so much activity in the field of biotechnology in our country? How has this activity benefitted the field of biopharma? **(2018)**