**Soil picture for the base:**

**A close-up of a pile of dirt

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**A close-up of a dirt field

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**LEARN**

The Science of Fertilizers

Defining Agriculture through time

The Triple Bottom Line of Sustainability: People, Planet, Profit

Climate Change & Agriculture

Agricultural Trends & Innovations

**>>>** The Science of Fertilizers

**What is Fertilizer?**

Fertilizers are basically plant food. They give plants the nutrients they need to grow big, strong, and healthy. When you add fertilizers to the soil, you're providing essential stuff like nitrogen, phosphorus, and potassium are key players in the plant's life process, like photosynthesis, energy production, and all the other things that help plants grow.

Now, imagine a plant trying to grow in soil that's run out of nutrients. It's like trying to run a marathon on an empty stomach. That's where fertilizers come in. While soil does naturally hold some nutrients, it's not a bottomless pit. Over time, through repeated planting, weather, and just the passage of time, nutrients can get washed away or depleted. Fertilizers top up the tank, giving plants what they need to produce food, oxygen, and all that good stuff. Without fertilizers, we'd be slowing down our crops, gardens, and even the ecosystems that keep the planet running. It's not just about feeding plants, but it's about feeding life itself.

**Plant Food: Staple versus Supplement**

**Fertilizers**

The *plant staples*: the foundational nutrients that plants need in large amounts to grow and thrive. They provide the critical building blocks that support everything from the plant’s vegetative growth, to its ability to reproduce, to the energy needed for harvest. Think of fertilizers as the plant’s *essential diet* which includes macronutrients such as nitrogen, phosphorus, and potassium that plants require in substantial quantities.

These nutrients are responsible for enabling the plant to grow strong roots, develop healthy stems, and produce the energy required for flowering and fruiting. Without fertilizers, plants don’t reach their full potential, since they lack the necessary nutrients to power these vital processes. Fertilizers are the heart of the plant nutrition, providing a broad, ongoing supply of what the plant needs to simply *survive* and grow.

**Fertilizing products**

The *boosters* or *supplements*: for targeted support. They’re formulated to target specific growth phases or enhance particular functions. For example, a targeted fertilizing product can be designed to promote flowering, giving the plant extra nudge to produce beautiful blooms. Others can help the plant ripen its fruits or accelerate photosynthesis, speeding up energy production for optimal growth. These products may be used in smaller amounts, but their role is just as crucial because they address specific, moment-to-moment needs in a plant’s development.

Where fertilizers provide the base nutrients required for overall growth, fertilizing products fine-tune the process, delivering exactly what the plant needs in support of a targeted process or metabolic activity. They step in when the plant has specific demands, whether it's for promoting the next phase of growth, helping the plant adapt to environmental conditions or enhancing its productivity.

**Fertilizer & fertilizing products**

The synergy between fertilizers and fertilizing products is where the magic happens. Fertilizers establish the strong foundation of nutrients for healthy growth, while fertilizing products provide that extra boost when the plant needs a little more focused attention. Together, they create a harmonious balance that ensures plants not only grow but thrive gracefully, producing rich and abundant harvests. It’s about giving the plant everything it needs, at every stage of its life cycle, for it to flourish to its fullest potential. Fertilizers keep the plant healthy, while fertilizing products help it shine at its best.

**Plant nutrients (make a table)**

Plants require essential nutrients to thrive and these can be classified into **macronutrients** (needed in large amounts) and **micronutrients** (needed in smaller amounts, but still vital).

**Macronutrients**

1. **Nitrogen (N)**  
   Nitrogen is a crucial nutrient for plant growth, as it is a key component of proteins, enzymes, and chlorophyll. It plays a significant role in photosynthesis, plant metabolism, and overall vegetative growth. It is typically required in large amounts by plants, especially during the early stages of growth when rapid leaf and stem development occur.

 Quantity Required: **1.5% - 5%** of the plant's dry weight.

 Forms: **Ammonium (NH₄⁺)** and **nitrate (NO₃⁻)** ions

1. **Phosphorus (P)**  
   Phosphorus is essential for energy transfer within the plant. It is a vital component of ATP (adenosine triphosphate), which drives many biochemical processes, including cell division, root development, and flowering. Phosphorus is also important for the development of healthy roots and the formation of seeds.

 Quantity Required: **0.1% - 1.0%** of the plant's dry weight.

 Forms: **Phosphate ions (PO₄³⁻)**.

1. **Potassium (K)**  
   Potassium helps regulate various plant processes, including water uptake, enzyme activation, and photosynthesis. It contributes to the overall health and disease resistance of plants. Potassium is required in large amounts, particularly by fruiting and flowering plants, as it influences fruit size, colour, and overall quality.

 Quantity Required: **1.0% - 2.0%** of the plant's dry weight.

 Forms: **Potassium ions (K⁺)**.

1. **Calcium (Ca)**  
   Calcium is important for cell wall structure and stability, influencing plant strength and rigidity. It also helps with nutrient uptake and enzyme function. Calcium is particularly essential for the development of roots and young shoots.

 Quantity Required: **0.5% - 2.0%** of the plant's dry weight.

 Forms: **Calcium ions (Ca²⁺)**.

1. **Magnesium (Mg)**  
   Magnesium is the central atom in chlorophyll molecules, making it essential for photosynthesis. It also helps activate enzymes involved in energy transfer and various biochemical reactions.

 Quantity Required: **0.2% - 0.5%** of the plant's dry weight.

 Forms: **Magnesium ions (Mg²⁺)**

1. **Sulfur (S)**  
   Sulfur is involved in the synthesis of amino acids and proteins. It also plays a role in plant metabolism and is important for the formation of vitamins and certain enzymes.

 Quantity Required: **0.1% - 0.5%** of the plant's dry weight.

 Forms: **Sulfate ions (SO₄²⁻)**.

**Micronutrients**

Micronutrients are required in much smaller quantities but are no less critical for plant health. These include:

* Iron (Fe)

Role: Vital for chlorophyll synthesis and electron transport during photosynthesis.

Quantity Required: **0.01%** of the plant's dry weight.

Forms: **Ferrous (Fe²⁺)** and **ferric (Fe³⁺)** ions.

* Manganese (Mn)

Role: Involved in photosynthesis, enzyme activation, and stress tolerance.

Quantity Required: **0.01%** of the plant's dry weight.

Forms: **Manganese ions (Mn²⁺)**.

* Boron (B)

Role: Important for cell wall formation, membrane function, and reproductive growth.

Quantity Required: **0.0001%** of the plant's dry weight.

Forms: **Boron ions (B₄O₇²⁻)**.

* Zinc (Zn)

Role: Required for enzyme activation, protein synthesis, and growth regulation.

Quantity Required: **0.001% - 0.01%** of the plant's dry weight.

Forms: **Zinc ions (Zn²⁺)**

* Copper (Cu)

Role: Involved in electron transport during photosynthesis, enzyme activity, and respiration.

Quantity Required: **0.0005%** of the plant's dry weight.

Forms: **Copper ions (Cu²⁺)**.

* Molybdenum (Mo)

Role: Essential for nitrogen fixation in legumes and nitrate reduction.

Quantity Required: **0.00005%** of the plant's dry weight.

Forms: **Molybdate ions (MoO₄²⁻)**.

* Chlorine (Cl)

Role: Plays a role in osmoregulation, photosynthesis, and cell division.

Quantity Required: **0.001% - 0.05%** of the plant's dry weight.

Forms: **Chloride ions (Cl⁻)**.

**Nickel (Ni)**:

Role: Required for the proper function of certain enzymes, such as urease.

Quantity Required: **Extremely small quantities**, typically trace amounts.

Forms: **Nickel ions (Ni²⁺)**.

These micronutrients are involved in specific biochemical reactions and help plants with processes like enzyme activation, photosynthesis, and stress resistance.

 **Macronutrients (N, P, K, Ca, Mg, S)**: **>95%** of total nutrient requirement by weight.

 **Micronutrients (Fe, Mn, B, Zn, Cu, Mo, Cl, Ni)**: **<5%** of total nutrient requirement by weight.

**Sustainability in Agriculture**

**A group of white mushrooms growing on a tree

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### Food production at the expense of the environment

When we think about food production, it's easy to overlook one important thing: we’re really just borrowing from nature. The soil, the air, and the water; these are all the resources that help grow the food we eat every day. Nature has always provided for us, supporting our survival and helping us thrive. Just as nature supports us, we need to make sure we’re taking care of it in return.

Food production and environmental health should go hand in hand. It’s not just about feeding people today, it’s about making sure we can continue to grow food tomorrow. Unfortunately, a lot of modern farming practices are focused more on productivity than the long-term health of the environment. The result? Soil degradation, pollution, and deforestation which collectively harm our planet and ultimately, our food supply.

**Balancing food production with environmental protection**

The truth is, we need to find a balance between growing the food we need and protecting the environment around us. It’s not an “either-or” situation. We can’t keep pushing for higher yields if it means damaging the very systems that allow us to grow food in the first place.

For food production to be sustainable, we need to start thinking in terms of *win-win* solutions. This means farming in ways that don’t deplete the soil, pollute our water or harm local ecosystems. It’s about adopting smarter practices that ensure we can keep producing food over a long run while keeping our planet healthy.

### The essence of sustainable agriculture

Sustainable agriculture is about farming in a way that’s kind to the planet, good for people, and still makes sense financially. Farming with a conscience. It’s a promise to the Earth: “Hey, we’ll grow our food on you, but we’ll do it responsibly”. Sustainable agriculture focuses on methods that reduce environmental harm, so no more leaving the planet high and dry (literally) or turning soil into a wasteland. We’re talking about conserving water, keeping soil healthy, and cutting down on harmful chemicals that could make Mother Nature frown. And don’t forget about biodiversity because we want to protect those cute little critters and the not-so-cute ones, too that help keep our ecosystems running smoothly.

Sustainable farming also supports fair labour practices, because let’s face it, farmers and workers should be treated well, not just paid in tomatoes. It’s about balancing three big Ps: people, planet, and profit. By focusing on all three, sustainable agriculture helps ensure that we’re not just solving today’s food challenges but leaving resources for future generations. In a nutshell, sustainable agriculture is all about doing the right thing for the planet, for people, and for the pocketbook.

### International Network

International treaties and organizations play an integral role in creating frameworks, guidelines, and funding mechanisms that support sustainable agriculture

### 1. ****United Nations Sustainable Development Goals (SDGs)****

* Focus on **Goal 2: Zero Hunger**, which promotes sustainable agriculture and food security while balancing environmental, social, and economic concerns.

### 2. ****Food and Agriculture Organization (FAO)****

* The FAO sets global standards, policies, and technical guidelines for sustainable agricultural practices.

### 3. ****The Paris Agreement (UNFCCC)****

* Focuses on climate change and encourages countries to include sustainable agricultural practices in their climate action plans.

### 4. ****Convention on Biological Diversity (CBD)****

* Supports sustainable agricultural practices to conserve biodiversity and prevent land degradation.

### 5. ****International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)****

* Ensures sustainable use and conservation of plant genetic resources for food security and agricultural biodiversity.

### 6. ****International Fund for Agricultural Development (IFAD)****

* Provides funding for sustainable agriculture projects that improve rural livelihoods and reduce poverty.

### 7. ****Global Environment Facility (GEF)****

* Supports projects that integrate sustainable agriculture with environmental conservation and climate adaptation.

### 8. ****The World Bank****

* Invests in sustainable agricultural development, rural livelihoods, and food security projects across the globe.

### 9. ****World Trade Organization (WTO)****

* Regulates international agricultural trade to ensure sustainable practices while addressing global food security issues.

### 10. ****International Finance Corporation (IFC)****

* Focuses on financing sustainable agricultural projects and green technologies for smallholder farmers.

### 11. ****Global Agriculture and Food Security Program (GAFSP)****

* A multi-partner initiative that supports agriculture and food security projects with a focus on sustainability.

### 12. ****International Commission on Irrigation and Drainage (ICID)****

* Promotes sustainable irrigation systems and water management in agriculture, focusing on improving productivity while conserving water.

### 13. ****World Resources Institute (WRI)****

* An international NGO that works on sustainable food systems, including the promotion of sustainable agriculture and climate-smart practices.

### 14. ****International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)****

* Conducts research and development on sustainable farming practices, particularly in semi-arid areas, to enhance food security and resilience to climate change.

### 15. ****The Alliance for a Green Revolution in Africa (AGRA)****

* Focuses on sustainable agricultural development in Africa, aiming to improve food security through climate-smart agriculture, innovations, and equitable growth.

### 16. ****International Food Policy Research Institute (IFPRI)****

* Conducts research on agricultural policy, food security, and sustainable farming practices to inform global policies and strategies.

### 17. ****United Nations Environment Programme (UNEP)****

* Works on sustainable agriculture initiatives that link environmental protection and food security, particularly through the promotion of agroecology.

### 18. ****The World Wildlife Fund (WWF)****

* Promotes sustainable agricultural practices and responsible food production systems that reduce environmental impact and preserve biodiversity.

### 19. ****Sustainable Agriculture Initiative Platform (SAI Platform)****

* An industry-driven initiative focused on promoting sustainable agricultural practices across global supply chains.

### 20. ****The Global Alliance for Climate-Smart Agriculture (GACSA)****

* A multi-stakeholder platform that promotes the scaling of climate-smart agriculture practices to address food security and climate change.