**RESEARCH ARTICLE**

# EFFECT OF INORGANIC NON-METALS ON SOIL FERTILITY AND PLANT GROWTH WITH SPECIAL REFERENCE TO COARSE GRAINS (MOTA ANAJ)

**Divya Jyoti Mishra[1] and Naveen Awasthi*[2]**

[1]Department of Agriculture Chemistry,

[2]Department of Chemistry,

Janta College, Bakewar, 206 124, Etawah, U.P., India

*Corresponding author E-mail: nvn_awsthi@rediffmail.com

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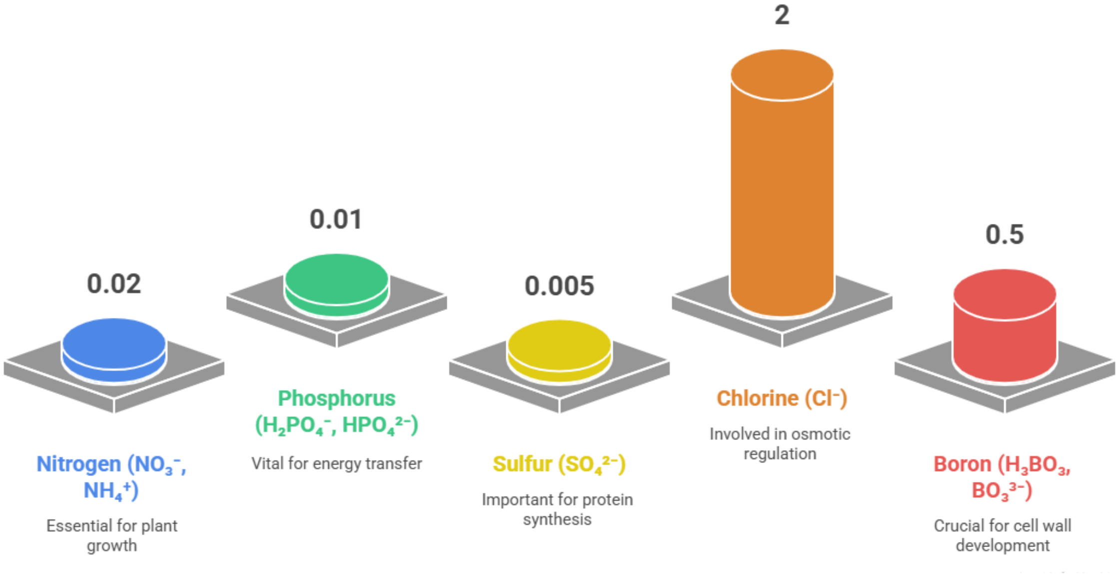
**Abstract:**

Soil fertility and plant productivity are strongly governed by the availability of essential nutrients, among which inorganic non-metals occupy a central position. Non–metals like nitrogen (N), phosphorus (P), sulphur (S), chlorine (Cl), and boron (B) influence critical biochemical and physiological processes, thereby determining crop growth and yield. Nitrogen is indispensable for chlorophyll, amino acid, and protein synthesis, directly enhancing vegetative development. Phosphorus functions in energy transfer through ATP and promotes root expansion, flowering, and seed production. Sulphur plays a key role in the formation of sulphur-containing amino acids and vitamins, while also improving the quality and oil content of crops. Although required in smaller amounts, chlorine contributes to osmoregulation, stomatal conductance, and the photosynthetic water-splitting reaction. Boron, often categorized as a non-metallic micronutrient, is essential for cell wall integrity, sugar transport, and reproductive development. Deficiencies of these nutrients manifest as visible disorders such as chlorosis, purpling of leaves, reduced flowering, and poor seed set, whereas imbalances or excessive application may lead to nutrient toxicity and soil degradation. This review highlights the typical concentration ranges of these non-metals in fertile soils, their functional roles in plants, and their collective impact on sustainable agricultural productivity. Understanding the interactions and availability of inorganic non-metals is fundamental for designing effective nutrient management strategies that enhance soil health, minimize environmental losses, and secure long-term food production. The study emphasizes that balanced nutrient application is essential not only for maximizing yield but also for maintaining ecological sustainability in modern agriculture.

**Keywords:** Soil Fertility; Inorganic Non-Metals; Nitrogen; Phosphorus; Sulphur; Chlorine; Boron; Nutrient Management.

**Introduction:**

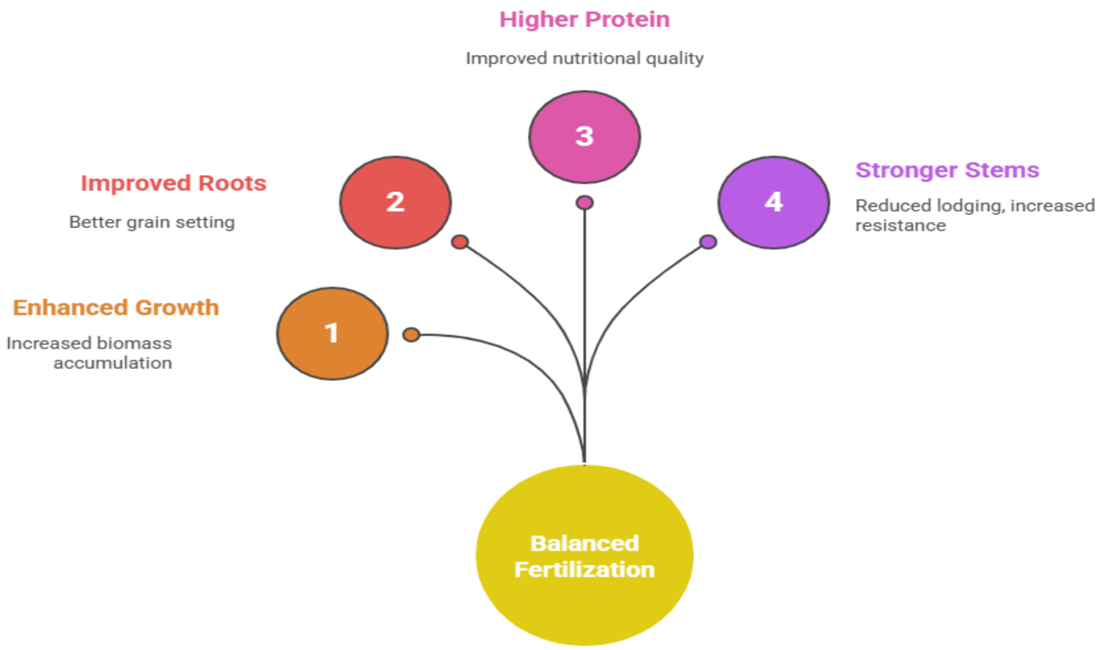
Soil fertility represents the foundation of agricultural productivity and is directly influenced by the presence and availability of essential plant nutrients. Among them, inorganic non-metals such as nitrogen (N), phosphorus (P), sulfur (S), chlorine (Cl), and boron (B) play a vital role in regulating plant metabolism and sustaining crop yields. These elements function as structural components of bimolecular, cofactors in enzymatic reactions, and regulators of physiological processes essential for plant growth[1].The availability of non-metals in soil is highly dependent on soil texture, organic matter content, pH, and redox conditions. For example, nitrogen is readily leached from sandy soils due to high mobility, while phosphorus availability decreases in acidic and alkaline soils due to fixation by iron/aluminum oxides or calcium carbonate, respectively[2]. Sulfur is often deficient in intensively cultivated soils where organic matter is low, whereas boron availability is reduced in coarse-textured soils with high leaching potential[3]. Thus, soil nature governs nutrient cycling and bioavailability, ultimately affecting plant growth. To address nutrient deficiencies, modern agriculture increasingly relies on inorganic fertilizers. Nitrogen fertilizers such as urea, ammonium sulfate, and calcium ammonium nitrate are widely used, while triple superphosphate and diammonium phosphate serve as major phosphorus sources. Gypsum and ammonium sulfate act as sulfur fertilizers, whereas borax and boric acid are common boron supplements. Micronutrient-enriched fertilizers are also gaining importance for balanced nutrient management[4]. The aim of this study is to evaluate the effect of inorganic non-metals on soil fertility and plant growth, emphasizing their roles, soil interactions, and crop responses. The scope extends to assessing nutrient functions, deficiency impacts, and management strategies with an emphasis on sustainable agricultural practices. By integrating soil chemistry with plant physiology, this work highlights the necessity of balanced non-metal application for enhancing productivity while maintaining soil health.




**Scheme 1: Nutrient content in fertile soil**

**Result and Discussion:**

Soils treated with nitrogen showed a marked increase in total nitrogen content, which enhanced microbial activity and improved the mineralization process. Similarly, phosphorus supplementation increased available phosphorus levels in the soil, which is crucial for energy transfer and root development. Sulfur application improved sulfate availability, promoting protein synthesis in plants. Silicon, although not an essential element, contributed to structural stability of soil aggregates and increased water retention capacity, enhancing overall soil health. A comparative analysis of treated soils indicated that nutrient availability was closely associated with soil pH, organic matter content, and texture as shown in table1. Acidic soils exhibited reduced phosphorus availability, whereas sandy soils showed lower retention of nitrogen, suggesting that soil type plays a critical role in nutrient management. These findings align with prior studies demonstrating the interdependence of inorganic non-metals and soil characteristics in regulating fertility [5-7]. Plants grown in soils enriched with inorganic non-metals showed significant improvements in vegetative growth, biomass accumulation, and yield. Nitrogen-treated plants exhibited enhanced leaf area, chlorophyll content, and stem elongation due to its direct involvement in amino acid and chlorophyll synthesis. Phosphorus application[8-10] resulted in stronger root systems, better flowering, and increased seed production, confirming its role in energy metabolism and reproductive development. Sulfur supplementation improved protein content in plant tissues, contributing to better growth and




**Scheme 2: Balanced fertilization boosts coarse Grain yield**

Stress tolerance. Silicon-treated plants demonstrated increased stem strength and resistance to biotic and biotic stress, which indirectly enhanced growth performance. The interactions between different non-metals were also evident. Combined application of N, P, and S led to synergistic effects, improving nutrient uptake efficiency and growth parameters more than individual treatments. Conversely, excessive application of a single element sometimes caused nutrient imbalance, highlighting the need for optimized fertilizer management. The results emphasize that proper management of inorganic non-metals can enhance both soil fertility and plant productivity. Integrating inorganic non-metals with organic amendments, such as compost or green manure, may further improve nutrient availability and soil microbial diversity. This approach not only boosts crop yield but also reduces environmental risks associated with chemical fertilizers, such as leaching, eutrophication, and soil acidification. The application of inorganic non-metals significantly influenced the growth and yield of coarse grains, including sorghum, pearl millet, and maize. Nitrogen supplementation enhanced vegetative growth, increased leaf area, and promoted chlorophyll synthesis, resulting in higher biomass accumulation. Phosphorus improved root development and early flowering, which is critical for grain setting and overall yield in coarse cereals. Sulfur contributed to higher protein content in the grains, improving their nutritional quality. Silicon application strengthened stem structure, reduced lodging, and increased resistance to drought and pest stress. Combined application of N, P, and S showed a synergistic effect, producing better growth and higher grain yield compared to individual nutrient applications. However,

**Table 1: % compositions of various non-metals and their forms present in Soil**

| Element | Form in Soil | Typical Amount in Fertile Soil |
|---|---|---|
| N (Nitrogen) | $NO_3^-$, $NH_4^+$ | 0.02–0.5% |
| P (Phosphorus) | $H_2PO_4^-$, $HPO_4^{2-}$ | 0.01–0.2% (10–60 mg/kg available) |
| S (Sulfur) | $SO_4^{2-}$ | 0.005–0.05% (10–40 mg/kg available) |
| Cl (Chlorine) | $Cl^-$ | 2–20 mg/kg |
| B (Boron) | $H_3BO_3$, $BO_3^{3-}$ | 0.5–5 mg/kg |

**Table 2: Effect of Inorganic Non-Metals on Soil Fertility and Coarse Grains (Mota Anaj)**

| Nutrient (Non-Metal) | Effect on Soil Fertility | Effect on Plant Growth | Specific Effect on Coarse Grains (Mota Anaj) |
|---|---|---|---|
| **Nitrogen (N)** | Increases total N content; stimulates microbial activity; improves mineralization | Enhances vegetative growth, leaf area, and chlorophyll synthesis | In sorghum and maize, improves biomass and grain yield; excessive N may delay flowering |
| **Phosphorus (P)** | Improves available P in soil; critical for energy transfer; reduces P fixation in neutral soils | Enhances root growth, early flowering, and seed setting | In millet and barley, strengthens root systems and accelerates grain setting |
| **Sulfur (S)** | Increases sulfate availability; supports enzymatic activity | Boosts protein synthesis and chloroplast development | Enhances protein content in barley and improves grain quality in coarse cereals |
| **Silicon (Si)** | Strengthens soil aggregates; improves water retention capacity | Enhances stem strength and resistance to stress (biotic and abiotic) | In all coarse grains, increases drought resistance, reduces lodging, and improves stress tolerance |

Excessive nitrogen without balanced phosphorus and sulfur led to poor nutrient uptake efficiency and, in some cases, delayed flowering. These findings highlight that balanced fertilization of inorganic non-metals is essential for optimizing coarse grain productivity, particularly under variable soil conditions. Overall, the study demonstrates that inorganic non-metals are vital for maintaining soil health and promoting sustainable crop production. The selection of appropriate nutrient types, doses, and combinations should be tailored according to soil characteristics to maximize plant growth and ensure ecological balance.

**Conclusion:**

This study highlights the essential role of inorganic non-metals, such as nitrogen, phosphorus, sulfur, and silicon, in improving soil fertility and supporting healthy plant growth. Their application positively influenced soil properties, including nutrient availability, microbial activity, and moisture retention, which collectively enhanced plant development and productivity. Nitrogen primarily stimulated vegetative growth and chlorophyll synthesis, phosphorus facilitated root expansion and energy transfer, sulfur promoted protein formation, and silicon contributed to structural stability and stress resilience in plants. The findings indicate that a balanced and combined application of these elements is more effective than the use of individual nutrients, while overuse of a single non-metal may disrupt nutrient equilibrium and reduce efficiency. Soil characteristics, including texture, pH, and organic matter content, were found to modulate the effectiveness of nutrient supplementation, emphasizing the importance of site-specific management strategies.

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