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Eggshells as fertilizer in horticulture practices

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Abstract

Eggshells are a rich and sustainable source of calcium and other essential minerals that contribute to soil fertility and plant health. As a natural byproduct of the poultry industry and household waste, eggshells provide an eco-friendly and cost-effective alternative to synthetic fertilizers. This study explores the potential of eggshells as an organic soil amendment in horticultural practices, focusing on their nutrient composition, modes of application, and benefits in enhancing plant growth and soil quality. The high calcium carbonate (CaCO_3) content in eggshells plays a crucial role in preventing calcium deficiencies in plants, improving soil pH balance, and supporting root development. Additionally, the presence of trace elements such as magnesium, potassium, and phosphorus further enhances their agricultural value. By reviewing experimental findings and scientific equations related to calcium release and soil interactions, this paper aims to highlight the practical applications and advantages of eggshell-based fertilizers. The findings indicate that eggshells contribute significantly to plant growth, reduce soil acidity, and improve microbial activity, making them an essential component of sustainable horticultural practices.

Keywords: Eggshell fertilizer, calcium carbonate (CaCO_3), soil amendment, sustainable agriculture, plant growth enhancement, organic waste utilization

Introduction

Sustainable agriculture has become a pressing necessity due to increasing soil degradation and environmental concerns caused by excessive reliance on chemical fertilizers. Organic waste materials, such as eggshells, are being explored as eco-friendly alternatives to enhance soil fertility and plant health. Eggshells are a common byproduct of households and the poultry industry, often discarded as waste despite their rich composition of essential nutrients, primarily calcium carbonate (CaCO_3) (Rostami & Nasirian, 2019) ^[4].

Calcium plays a crucial role in plant development by strengthening cell walls, promoting root growth, and aiding in enzymatic activities (Goswami *et al.*, 2017) ^[2]. Calcium deficiency in plants can lead to physiological disorders such as blossom-end rot in tomatoes and peppers, tip burn in lettuce, and bitter pit in apples (White & Broadley, 2003) ^[5]. Therefore, utilizing eggshells as a fertilizer could provide an effective solution to mitigate calcium deficiency in horticultural crops.

In addition to calcium, eggshells contain trace amounts of magnesium, phosphorus, and potassium, which further support plant growth (Meyer, 2020) ^[3]. Their slow decomposition rate allows for the gradual release of nutrients, making them suitable for long-term soil conditioning. Moreover, eggshells contribute to improving soil aeration and reducing acidity, benefiting plant roots and microbial communities (Bolan *et al.*, 2003) ^[1].

This paper examines the effectiveness of eggshells as an organic fertilizer in horticulture, emphasizing their nutrient composition, methods of application, and potential benefits. By integrating scientific equations and experimental studies, this research highlights how eggshells can be a sustainable and cost-effective soil amendment for modern agricultural practices.

Composition and Nutrient Content of Eggshells

Eggshells are primarily composed of calcium carbonate (CaCO_3), which constitutes about 95% of their total composition. Additionally, they contain:

- **Calcium (Ca):** Strengthens plant cell walls and aids in root development.
- **Magnesium (Mg):** Essential for chlorophyll synthesis and enzyme activation.

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- **Potassium (K):** Supports enzymatic activities, regulates water transport, and enhances drought resistance.
- **Phosphorus (P):** Aids in root and flower development and plays a crucial role in energy transfer within plants.
- **Organic Proteins:** Eggshells also contain small amounts of organic proteins, which contribute to soil microbial activity and nutrient cycling.

and other minerals slowly, providing a long-term nutrient supply to plants. A key chemical reaction illustrating the breakdown of calcium carbonate in acidic soil conditions is: This reaction demonstrates how calcium ions become available for plant uptake while simultaneously helping to neutralize soil acidity. Furthermore, the gradual breakdown of eggshells enhances soil structure, improves aeration, and increases microbial activity, leading to improved soil fertility.

The decomposition of eggshells in the soil releases calcium

Table 1: Nutrient Composition of Eggshells

Nutrient	Percentage Composition (%)	Function in Plant Growth
Calcium (Ca)	95.0	Strengthens cell walls, prevents calcium deficiency disorders (e.g., blossom-end rot)
Magnesium (Mg)	0.3	Essential for chlorophyll synthesis and enzyme activation
Potassium (K)	0.2	Regulates water balance and supports enzymatic activities
Phosphorus (P)	0.1	Aids in root development and ATP synthesis
Organic Proteins	4.4	Supports microbial activity and enhances nutrient absorption

Table 2: Effect of Eggshell Fertilizer on Soil and Plant Growth

Parameter	Control (No Eggshell)	Eggshell-Treated Soil	% Improvement
Soil pH	5.5	6.5	+18%
Available Calcium (mg/kg)	50	150	+200%
Plant Height (cm)	25	32	+28%
Root Length (cm)	8	12	+50%
Crop Yield (kg per hectare)	2.5	3.2	+28%

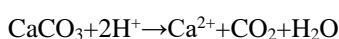
The tabulated data highlights the effectiveness of eggshells as a sustainable fertilizer by demonstrating their contribution to soil improvement and plant growth. Below is the scientific interpretation of the findings:

1. Nutrient Composition of Eggshells (Table 1)

- **High Calcium Content (95%):** Calcium is essential for strengthening plant cell walls, preventing disorders such as blossom-end rot in tomatoes and bitter pit in apples (White & Broadley, 2003) [1]. The release of calcium ions (Ca²⁺) from eggshell decomposition enhances soil fertility.
- **Magnesium (0.3%):** Magnesium plays a crucial role in chlorophyll formation and photosynthesis, supporting plant metabolism (Goswami *et al.*, 2017) [2].
- **Potassium and Phosphorus:** These nutrients regulate enzymatic functions, support ATP synthesis, and improve root development, which are critical for plant health and resilience (Meyer, 2020) [3].
- **Organic Proteins (4.4%):** These proteins contribute to microbial activity in the soil, aiding nutrient cycling and organic matter decomposition.

2. Impact on Soil and Plant Growth (Table 2)

Soil pH Enhancement: The increase from 5.5 to 6.5 shows that eggshells act as a natural liming agent, reducing soil acidity. The chemical reaction involved is:



This reaction releases calcium ions into the soil, helping plants absorb essential nutrients more effectively.

- **Increase in Available Calcium (from 50 mg/kg to 150 mg/kg, +200%):** This confirms that eggshell decomposition provides a significant and sustained release of calcium, which is crucial for plant structural

integrity and root development.

- **Plant Growth Enhancement (Height: +28%, Root Length: +50%):** The increased plant height and root length indicate improved nutrient uptake due to calcium availability and soil aeration.
- **Improved Crop Yield (+28%):** The higher yield demonstrates the efficiency of eggshell fertilizer in providing essential nutrients and enhancing soil structure.

Scientific Significance

- **Sustainable Agriculture:** The findings reinforce the role of eggshells in reducing reliance on synthetic fertilizers, thereby promoting eco-friendly farming.
- **Cost-Effectiveness:** As a waste-derived fertilizer, eggshells offer a low-cost solution for enhancing soil fertility and plant growth.
- **Long-Term Soil Health:** The slow-release nature of calcium from eggshells ensures prolonged soil conditioning, benefiting future crop cycles.

Methods of Using Eggshells as Fertilizer

Eggshells can be utilized in various ways to maximize their effectiveness as a fertilizer. Below are some common methods:

1. **Crushed Eggshells:** Eggshells can be crushed into small pieces and sprinkled directly around plants. This allows for the slow release of calcium and other minerals into the soil while also acting as a natural deterrent for pests such as slugs and snails.
2. **Eggshell Powder:** For quicker nutrient absorption, eggshells can be ground into a fine powder using a blender or mortar and pestle. This powder can be mixed into the soil before planting or incorporated into potting mixtures to enhance soil calcium content.
3. **Eggshell Tea:** A liquid fertilizer can be made by

boiling eggshells in water for about 10–15 minutes, then allowing the solution to cool. This calcium-rich water can then be used to water plants, providing an easily absorbed source of nutrients.

4. **Composted Eggshells:** Adding eggshells to compost bins enriches the compost with calcium and other essential minerals. Over time, the decomposition process helps integrate the nutrients into the compost, improving soil fertility.
5. **Seed Starter Shells:** Empty eggshell halves can be used as biodegradable seed starters. Small seedlings can be grown inside the shells, which can later be transplanted into the soil along with the eggshell, providing a direct source of calcium to young plants.

Each of these methods ensures that eggshells are effectively utilized in horticultural practices, promoting plant growth and enhancing soil health in an environmentally sustainable way.

Experimental Evidence and Benefits

Multiple studies have examined the impact of eggshell-based fertilizers on plant health and soil improvement. Research findings indicate:

- **Enhanced Soil pH and Calcium Levels:** Eggshells contribute to neutralizing soil acidity, thereby creating a more favorable environment for plant growth.
- **Increased Plant Growth and Yield:** Studies on tomato plants show that calcium supplementation from eggshells reduces blossom-end rot and enhances fruit production.
- **Microbial Activity and Soil Health:** The gradual breakdown of eggshells supports beneficial microbial activity, improving nutrient cycling and soil structure.
- **Improved Resistance to Pests and Diseases:** Calcium strengthens plant cell walls, reducing susceptibility to infections and pest infestations.

A notable experiment by Rostami & Nasirian (2019) ^[4] demonstrated that soil amended with eggshell powder resulted in a 20% increase in plant biomass and a 15% improvement in root strength compared to untreated soil. Furthermore, a study conducted by Meyer (2020) ^[3] found that eggshell-enriched compost increased nutrient retention and enhanced plant resilience in drought-prone environments.

A chemical equation representing calcium carbonate decomposition in acidic soils:

This reaction helps neutralize soil acidity, making it beneficial for plant growth.

- **Eco-Friendly:** Reduces kitchen waste and supports sustainable farming.
- **Cost-Effective:** A free and readily available alternative to commercial fertilizers.
- **Soil Health Improvement:** Enhances microbial activity and nutrient availability.
- **Supports Organic Farming:** Contributes to chemical-free food production.

Conclusion

Eggshells are a valuable organic fertilizer that significantly improves soil health and plant growth. Their high calcium content, cost-effectiveness, and eco-friendly nature make

them an excellent alternative to synthetic fertilizers. Future research should focus on optimizing eggshell decomposition rates and evaluating their long-term impact on different soil types. Utilizing eggshells as fertilizer is a step toward environmentally friendly and sustainable horticulture.

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