

**THE EFFECT OF SELENIUM ON THE GERMINATION AND SEEDLING GROWTH
OF GROUNDNUT (*Arachis hypogaea* L).**

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BENIN CITY**

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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF SCIENCE
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THE AWARD OF BACHELOR OF SCIENCE DEGREE (B.SC) IN SCIENCE
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NOVEMBER, 2025.

DECLARATION

I Happy Ayekoren ROLAND (Miss), hereby declare that this research work was carried out by me in the department of Science Laboratory Technology, Faculty of Life Sciences, University of Benin, Benin City.

Signature: _____

Date: _____

CERTIFICATION

This is to certify that this project work was carried out by **Happy ROLAND (Miss)** with Matriculation Number **LSC2009941** of the department of Science Laboratory Technology, Faculty of Life Sciences, University of Benin, Benin City, Edo State.

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DEDICATION

This project work is dedicated to EL-ROI, the GOD that sees me who has been my source of strength and inspiration.

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ABSTRACT

This study investigated the effect of different concentrations of selenium (Se) on the germination and early growth of *Arachis hypogaea* (groundnut). Selenium, an essential micronutrient for humans and animals, is known to enhance antioxidant activity and stress tolerance in plants at optimal levels, but becomes toxic when applied excessively. This study was conducted in the Department of Plant Biology and Biotechnology, University of Benin, using five treatments: 0 g/L (control), 1.5 g/L, 2.5 g/L, 5 g/L, and 10 g/L sodium selenite solutions, with seed priming durations of 3, 6, and 9 hours. Parameters measured included germination rate, radicle length, stem girth, shoot length, and number of leaves. Results showed that moderate Se concentrations (1.5 g/L and 2.5 g/L) improved germination and growth relative to the control, while higher concentrations (5 g/L and 10 g/L) significantly reduced these parameters, indicating toxicity at elevated levels. The findings suggest that selenium at low concentrations can enhance seed germination and early seedling vigour in groundnut, but excessive application inhibits growth. This study underscores the importance of optimizing selenium use in groundnut cultivation to enhance yield.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Groundnut (*Arachis hypogaea L.*), is a native of South American legume (Ray *et al.*, 2016). Groundnut is one of the main oil crops, which is widely planted all over the world. It has been grown in more than 100 countries, mainly distributed in the tropical, subtropical and warm temperate zones of the earth, between latitudes 40° S to 40° N (Hammons *et al.*, 2016).

At present, the global groundnut cultivation area is 22.67 million ha and an annual output is 35 million tons (Fletcher and Shi, 2016). Groundnuts are produced and consumed in several African countries due to their nutritious and hardy nature. However, its production is constrained by *Aspergillus* species, which causes quantitative losses and produce highly toxic and carcinogenic chemical substances known as aflatoxins (Ephrem, 2015).

Recently, the groundnut research community has witnessed fast progress and achieved several key milestones in genomics research including genome sequence assemblies of wild diploid progenitors, wild tetraploid and both the subspecies of cultivated tetraploids, resequencing of diverse germplasm lines, genome wide transcriptome atlas and cost-effective high and low-density genotyping assays (Manish *et al.*, 2020).

Groundnut is popularly known as poor man's almonds for its high nutritional content with fat and protein making up 80% of seeds contents and is therefore a key contributor in the fight against malnutrition. More importantly, groundnut is an important ingredient in hundreds of delicious preparations and commercial products (Pandey and Varshney, 2018).

Climate change and food security are emerging issues around the Globe not just for human beings but also for the animals. Lack of climate resilient and nutritious germplasm is the biggest concern for the farmer's community. Selenium (Se) is an important trace element, which enhances anti-oxidation activity, improves immunity, health, and delays ageing (Zeng *et al.*, 2020).

Selenium (Se) is a nonmetal that is essential for humans and other animals, and is considered beneficial for plants. The bioavailability of Se strongly influences its content in the food chain. Soils are the main source of Se, and their Se content primarily influences its availability, along with other soil properties (Lucija *et al.*, 2023). Selenium has numerous functions in the human body such as in the antioxidant defense system and oxidative metabolism, thyroid hormone metabolism, the immune system, male fertility, the prevention of cancer and cardiovascular diseases (Wang *et al.*, 2023).

1.2 STATEMENT OF THE PROBLEM

The effect of selenium on groundnut is not yet fully understood, which presents multiple challenges in both groundnut cultivation and consumption. The absence of detailed knowledge regarding how selenium influences groundnut growth, development, and nutritional composition can hinder efforts to improve agricultural outcomes. Farmers may struggle to optimize yields without clear guidance on selenium's role, leading to reduced productivity and possible economic losses. Selenium's known functions in enhancing plant stress tolerance and antioxidant capacity suggest it could be beneficial in improving groundnut crop resilience, but this potential remains underutilized due to limited research. Moreover, groundnut is a significant dietary component in many regions, and understanding how selenium enrichment affects their nutritional

value is essential for addressing micronutrient deficiencies, especially in populations with low selenium intake.

However, the fine line between beneficial and harmful levels of selenium poses a risk of toxicity to both plants and humans if mismanaged. Hence, this study seeks to investigate the effect of selenium on groundnut by providing a detailed understanding of how different selenium concentrations affect groundnut growth. By addressing this issue the research aims to improve groundnut yield, enhance their nutritional value, and protect consumer health.

1.3 JUSTIFICATION OF THE STUDY

Groundnut (*Arachis hypogaea* L.) is a significant crop in Nigeria, contributing to food security, income for farmers, and nutritional needs of the population. Optimizing selenium application could lead to better yields and improved crop resilience against environmental stresses.

Enhancing selenium content in groundnut through optimized application could contribute to better dietary selenium intake, addressing potential deficiencies in populations reliant on groundnut-based diets. By examining the effects of selenium on groundnut, this study aims to provide insights into strategies that could enhance crop productivity and nutritional quality. This is particularly important in regions like Nigeria where access to a variety of healthy food is limited.

Findings from this study could inform farmers and agricultural extension services about optimal selenium application strategies for groundnut. This could lead to practical recommendations for improving groundnut cultivation, enhancing nutritional outcomes, and potentially increasing economic benefits for farmers.

1.4. AIM

The primary aim of this study is to investigate the effects of selenium on groundnut growth.

1.5. OBJECTIVES

- i. Assess the impact of different selenium concentrations on the germination of *Arachis hypogaea*.
- ii. Assess if priming groundnut seeds in selenium can enhance seed germination.
- iii. Estimate the difference in growth parameters of *Arachis hypogaea* grown in different selenium concentrations

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Arachis hypogaea, known as the groundnut or peanut, is an annual herbaceous legume grown in tropical and temperate areas of the world. Peanuts are a composite food consisting of a wide variety of nutrients, such as carbohydrates, proteins, lipids, vitamins, minerals, and a good dose of fiber.

Bioactive compounds have also been isolated from peanuts that include flavonoids, phytosterols, amino acids, and stilbenes. Large scale clinical studies have shown that regular peanut consumption has a positive effect on cardiovascular diseases, type 2 diabetes, and Alzheimer's. These bioactive compounds also have anti-inflammatory, antioxidant, anticancer, and antitumor activities. Potential health concerns regarding peanuts include allergies and contamination with aflatoxins. Peanuts are widely used in the food industry for the production of flour, protein concentrates and isolates, confectionaries, oils, and beverages (Faiza *et al.*, 2020).

Cultivated groundnut is an allotetraploid and a predominantly self pollinating legume crop cultivated in most parts of the world. About 26.54 million hectares of groundnut is cultivated globally with an annual production of approximately 43.92 million tons of shelled grain (Hari *et al.*, 2012; FAOSTAT 2014). Africa accounts for about 31.6% of the global production. However, most African countries do not meet their domestic demand for groundnuts. The sub-Saharan Africa (SSA) region has one of the lowest groundnut productivity levels (< 1 t/ha) in the world. FAOSTAT (2020) estimated monetary value of US\$132 for importation of groundnut in Africa by 2020 to cover the shortfall due to low productivity in the region.

2.1 SELENIUM

Selenium was discovered in 1817 in Gripsholm, a Swedish city, by a Swedish chemist Jacob Berzelius, who was working in a chemical factory producing, among others, sulfuric acid and nitric acid. One of the raw materials that had been used in the production process was pyrite (iron sulfide), which was obtained from a mine in Falun. It was observed that, when ores from Falun were used in lead chambers of installations, reddish sediment was obtained. Initially, it was thought that arsenic compound was responsible for that characteristic sediment; hence, because of fear of its harmful effects, pyrite ores from Falun were avoided from being processed. The phenomenon was, however, regarded as curious and worth further assessment (Kieliszek and Blazejak, 2013). The results of sample analysis indicated a likely presence of tellurium; however, Berzelius questioned this result. At the beginning of 1818, Berzelius repeated the experiments in a laboratory in Stockholm and found that the sediment investigated contains a new, previously undiscovered element, with properties similar to sulfur. This substance was called selenium, from the Greek word “selene”, which means moon (Zhang, 2018).

Selenium is an important micronutrient and essential trace element for both humans and animals, which exist in the environment ubiquitously. Selenium deficiency is an important issue worldwide, with various reported cases of its deficiency. Low selenium contents in some specific terrestrial environments have resulted in its deficiency in humans. However, high levels of selenium in the geochemical environment may have harmful influences and can cause a severe toxicity to living things. Due to its extremely narrow deficiency and toxicity limits, selenium is becoming a serious matter of discussion for the scientists who deals with selenium related environmental and health issues (Habib *et al.*, 2019). Both selenium deficiency and excess are found in natural locations throughout the world, though Selenium excess can also be caused by

supplementation with Selenium. Both have been associated with adverse health effects that have often been characterized by a U-shaped relationship. Some health effects, such as increased mortality, are associated with both low and high selenium status. Certain people and populations are better able to tolerate low or high Selenium intake than others (Margaret, 2019).

According to (Rayman, 2012) adverse health conditions associated with Selenium deficiency are as follow:

1. Keshan disease
2. Kashin-Beck disease
3. Increased viral virulence
4. Increased mortality
5. Poorer immune function
6. Problematic fertility/reproduction
7. Thyroid autoimmune disease
8. Cognitive decline/dementia
9. Type 2 diabetes
10. Prostate cancer risk
11. Colorectal cancer risk in women

Non-experimental and experimental studies have generated insufficient evidence for a role of selenium deficiency in human disease, with the exception of Keshan disease, a cardiomyopathy. Conversely, recent randomized trials have indicated that selenium overexposure is positively associated with type 2 diabetes and high-grade prostate cancer. In addition, a natural experiment

has suggested an association between overexposure to inorganic hexavalent selenium and two neurodegenerative diseases, amyotrophic lateral sclerosis and Parkinson's disease (Vinceti, 2018).

2.2 OCCURRENCE OF SELENIUM IN THE ENVIRONMENT

Selenium is a commonly occurring element in nature. It can be found in the atmosphere, lithosphere, biosphere, and hydrosphere of the Earth (Reich and Hondal, 2016). Selenium is emitted into the atmosphere through volcanic gasses. Biomethylation of this element by microorganisms, decomposition of organic matter rich in this element, and so on contribute the most to the constant enrichment of the atmosphere with selenium (Mason *et al.*, 2018). Soils that have arisen from parent rocks rich in selenium such as sandstones and limestone have been reported to have selenium in large content (Kieliszek and Blazejak, 2016; Shahid *et al.*, 2018). For example, in the area of Olkiluoto Nuclear Power Plant (Japan) in the organic part of the soil (humus), selenium is present at a level of 34 mg/kg. In mineral soil, regardless of its depth, the content level of this element fluctuates 14 mg/kg (Soderlund *et al.*, 2016).

In water, selenium is present in trace quantities, and mainly in the form of selenates and selenites (Yangzhou *et al.*, 2018). The amount of selenium in groundwater is much higher than that in seawater (Natasha *et al.*, 2018). because of selenium elution from the parent rocks and excessive fertilization of soils with mixtures rich in selenium compounds (Paikaray, 2016). Selenium can be found in many minerals such as berzelianite (Cu_2Se), klaustalite (PbSe), and naumanite (Ag_2Se) (Etim, 2017). It penetrates the soil as a result of anthropogenic activity through the combustion of coal and lignite, crude oil, and the use of agrotechnical processes fertilization or liming (Soderlund, 2016).

There are two main forms of Selenium in nature: inorganic Selenium and organic Selenium. Inorganic Selenium mainly exists in the form of selenate and selenite. Inorganic Selenium must be combined with organic ligands in the intestine before it can be absorbed by the human cells. Various factors in the intestine will compete with Selenium for organic ligands, resulting in poor absorption rate and low bioavailability of inorganic Selenium. For example, sulphur, lead, arsenic, calcium and iron (Fe^{3+}) can impede the absorption of Selenium. Fe^{3+} can precipitate Selenium into a complex form that cannot be absorbed by the enterocytes; and sulphur reduces Selenium absorption by steric competitiveness (Jerry and William , 2008; Youcef *et al.*, 2013). Inorganic Selenium has serious toxicity to the human body (recommended 100 μg a day), and excessive intake can lead to poisoning, such as hair and fingernail loss (Sidnei *et al.*, 2022).

The source of selenium in the environment can be divided into natural sources and man made sources (Long et al 2019). Natural sources mainly include soil and dust, bioaccumulation and volcanic eruptions (Tian *et al.*, 2010). Man-made sources mainly include coal combustion(Li and Fan, 2008), mineral mining, and metal and petroleum processing (Cordoba and Staicu, 2018), of which coal combustion accounts for more than 50% of man-made sources (Han *et al.*, 2021).

Selenium can play a positive and important role in organisms only in a narrow concentration range. The Food and Nutrition Board of the US National Research Council established an estimated safe and adequate daily dietary intake for humans is 11–280 $\mu\text{g}/\text{L}$ (Hadrup and Ravn-Haren, 2020). In drinking water, World Health Organization provisional guideline for Selenium was set at 40 $\mu\text{g}/\text{L}$ (Santos *et al.*, 2015). When the concentration is too high, it will cause harm to organisms and induce serious selenium-related diseases (Zhang *et al.*, 2020).

Selenium release and pollution is a worldwide phenomenon that results from a wide variety of anthropogenic activities, such as agriculture, mining, and other process industries. Selenium is a potentially toxic element, and mining-related selenium release was a major concern during the last decade as high concentrations were reported at some mine sites in the US (Sandy and Disante, 2010). Selenium contamination is vast, affecting both aquatic and terrestrial ecosystems, and has therefore attracted the attention of natural resource and water quality regulators around the world. Consequently, monitoring and pollution control efforts for selenium have been widely expanded (Aibyeq *et al.*, 2017).

2.3 SELENIUM IN PLANT NUTRITION

Selenium is an essential micronutrient that enhanced plant growth and development in trace amounts. It also protects plants against different abiotic stresses by acting as an antioxidant or stimulator in a dose dependent manner. Selenium can also enhance cellular functions like membrane stability, mineral nutrition homeostasis, antioxidant response, photosynthesis, and thus improve plant growth and development under metal or metalloids stress. Selenium uptake, translocation, and accumulation is crucial to achieving the inclusive benefits of selenium in plants. Plant growth is affected by various abiotic stresses, including water, temperature, light, salt, and heavy metals. Selenium is not an essential nutrient for plants but plays an important role in alleviating the abiotic stresses suffered by plants. Selenium promotes the uptake of beneficial substances, maintains the stability of plasma membranes, and enhances the activity of various antioxidant enzymes, thus alleviating adverse effects in plants under abiotic stresses (Abou *et al.*, 2025). Among higher plants selenium is not considered an essential nutrient. Yet many beneficial effects, such as increased resistance to stressors like drought and cold, are observed (Jonas, 2025).

Plants are the starting point of the food chain, and humans are at the end. By increasing the amount of selenium in plant foods like leafy greens, vegetables, and fruits without adding too much to cause harm can help both animals and people get more selenium in their diet. This could lead to lasting health. In Selenium enriched plants, most of the selenium is in an organic form. This form is easier for the human body to absorb and use than inorganic selenium. So, eating these plants is a good way to get selenium naturally.

Selenium in plants also acts as an antioxidant, which means it helps fight damage caused by harmful molecules. It also reduces the production of ethylene, a plant hormone that causes aging and ripening. Because of this, Selenium enriched vegetables and fruits may stay fresh longer and maintain their quality better over time (Martina, 2017).

2.4 EFFECTS OF SELENIUM ON GROUNDNUT YIELD AND QUALITY

Groundnut is an economic oilseed plant in the world, the seed provides 50–65% oil and 25–35% proteins, while the rest of the plant parts provide livestock fodder. The roots have nodules which provide nitrogen to soil, thus improves soil fertility (Ali *et al.*, 2016). However, the role of nano selenium (Nano- Se) in higher plants has not been illustrated distinctly. Earlier studies have evidenced that exogenously foliar application of nano-selenium enhanced the antioxidant potential in sweet basil (*Ocimum basilicum* L.) (Ardebili *et al.*, 2015), growth of tobacco (*Nicotiana tabacum* L.) (Chaoqiang *et al.*, 2015), groundnut (*Arachis hypogaea* L.) (Hebat-Allah *et al.*, 2019) and yield of mustard (*Brassica rapa* L.) (Lyons *et al.*, 2009).

Nanotechnology has a wide range of applications, one of them is nano-agriculture, which used to improve the productivity of plants and bio-controlling (Ibrahim et al 2018), fuel production (Osama *et al.*, 2019), food industry (Diaa *et al.*, 2019), environment protection (Mohamed *et al.*,

2018) and producing of antimicrobial agents (Reda *et al.*, 2019). The effects of nano-Se on different plant species can vary greatly with plant growth stages, method, and duration of exposure and depend on the nano-Se shape, size, chemical composition, concentration, surface structure, aggregation, and solubility (Hebat-Allah *et al.*, 2019).

Although the role of Selenium in plants remains elusive, research has revealed that Selenium at an appropriate concentration can promote plant growth, improve resistance to oxidative stress, and increase photosynthesis (Philip, 2018). Moreover, Selenium can effectively mitigate pests, diseases, plant senescence, and heavy metals, particularly in Cadmium stressed plants (Renwei *et al.*, 2013). This antagonistic effect is reflected in several crops, such as wheat, rice, and rape (Yanming *et al.*, 2021). Studies have indicated that proteins in plants can be combined with inorganic Selenium and converted into nontoxic organic Selenium for absorption by the human body (Lavender, 1987). Moreover, the protein content of groundnut kernels accounts for 25–36% of its dry weight, and is the main source of protein for human consumption (Liping, 2021). Thus, Se may be effective in inhibiting cadmium toxicity in groundnut and can supplement the Selenium required by the human body through peanuts.

Selenium application can be performed in four methods as follows: seed dressing, seed soaking, soil application, and foliar application (Kristen *et al.*, 2013). Selenium could stimulate plant growth by improving photosynthetic capability (Chaoqiang *et al.*, 2017).Applying appropriate Selenium could improve crops' yield and quality while improving the Selenium concentration of crops (Juan *et al.*, 2022). The increase in crop yield by Selenium was related to the increase in the concentration of chlorophyll and photosynthetic characteristics of crops, thus improving the dry matter accumulation and transport of crops (Mu *et al.*, 2014).

Groundnut have a strong Se enrichment capacity. Studies have shown that it can convert 70% of the inorganic Se absorbed from the culture medium into organic Se, making it one of the most effective foods for biofortification, thereby increasing interest in the growing market for Selenium enriched foods (Fangjian *et al.*, 2019). Spraying crops with Selenium rich fertilizers or soaking seeds with Selenium salts are effective ways to increase the Selenium content in cultivated crops, which can naturally accumulate and biotransform Selenium into plants to form organic Selenium compounds (Qi *et al.*, 2019).

2.5 SELENIUM IN HUMAN ORGANISM.

Selenium is an essential bioelement that is necessary for the functioning of all organisms. The amount of this element present in nature and in the human organism is very diverse depending on the geographic region and diet. An optimal daily dose of this element is established at 55 µg (Immaculada *et al.*, 2014), and affects the normal course of biochemical and physiological processes (Regina *et al.*, 2016). Selenium is present in the human organism in trace quantities. Serum selenium levels may differ among populations, depending on a number of factors, including, but not limited to, concentration of selenium in food. The concentration of this element in adult human blood serum depends on a person's age (Michal *et al.*, 2018).

The total amount of selenium in a human organism is ~3–20 mg. Skeletal muscles of the body are main organs containing ~46.9% of the total content of this element in humans, whereas kidneys contain only 4% of selenium (Lyons *et al.*, 2007).

For a long time, selenium was considered a toxic element. Poisoning with this element led to the development of severe anemia, bone stiffness, hair loss, and blindness (Marek and Stanislaw, 2016). These symptoms have been observed in humans and animals in areas where the content of

this element in the soil was 1000 times greater in comparison with soils with an average amount of selenium in the other regions of the world (Lyons *et al.*, 2007). Selenium can also enter the body by inhalation; hence, its maximum concentration in the air should not exceed 0.2 mg/m³ (EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) *et al.*, 2018). It should be emphasized that either too high level of selenium or its deficiency is harmful to human health. The difference between a dose necessary for the proper functioning of the organism and a harmful dose is small (Anna and Kazimierz, 2013).

Selenium deficiency in the diet may have an adverse effect on health. Dietary selenium deficiency affects 0.5–1 billion people in the world, and currently, in many countries there is an inadequate intake of this element (David and Anne, 1999).

The trace element selenium (Se) was regarded as a dietary supplement for improving health as it possesses valuable antioxidant properties (Halyna *et al.*, 2018). Se is naturally found in water, soil, and food (Ning *et al.*, 2017). It should be noted that 25 selenoproteins have been discovered in humans (Ali *et al.*, 2021). Selenoproteins have been implicated in many metabolic and functional pathways, such as aging, cancer, or infection (Marco *et al.*, 2018).

According to the WHO recommendations, the daily intake of Se by adults should be at 40–70 µg/day depending on gender and body condition (weight, pregnancy status in women, etc.) (Norman *et al.* 2000). Nevertheless, the average content of Se in the daily diet quite often does not reach this level. The typical level of daily consumption varies in the range of 30–50 µg/day in different European countries (Marek and Stanislaw, 2016). It should be mentioned that Se in doses above 400 µg/day shows harmful actions. The uncontrolled intake of Se-enriched products may result in poisoning (Marek and Stanislaw, 2016).

2.6 EFFECT OF DEFICIENCY AND EXCESS OF SELENIUM IN HUMAN HEALTH

Prolonged selenium deficiency in human organism leads to serious diseases. Deficiency of this element adversely affects the functioning of the cardiovascular system and can be a direct cause of myocardial infarction (Muhammad *et al.*, 2018). It is associated with endemic diseases: Keshan and Kashin-Beck. These diseases were identified for the first time in women of childbearing age and children in the area of China where very low amount of selenium was found in soil and crops (Marianne *et al.*, 2015). As a result of epidemiological studies, it was concluded that moderate deficiency of selenium in daily diet affects the development of diseases resulting from reduced immunity (Marek *et al.*, 2017).

Selenium deficiency in daily diet can adversely affect the functioning of the nervous system (Holger and Helmut, 2013). Among individuals with selenium deficiency, development of depression, or intensification of anxiety is observed; Alzheimer's disease is also developed (Roshan *et al.*, 2014). Selenium deficiency in pregnant women negatively affects the development of the embryo (Muhammad *et al.*, 2018; Kehinde *et al.*, 2018).

Symptoms of selenium poisoning cause hair loss and skin and nail lesions (Barrak *et al.*, 2012). A characteristic symptom of selenium poisoning is the odor of garlic in the exhaled breath because of the presence of a volatile metabolite dimethyl selenide (Marek and Stanislaw, 2013). Early symptoms of acute poisoning include the occurrence of hypotension and tachycardia. Neurological symptoms include tremor and muscle contractions (Mihae *et al.*, 2018). Recent studies suggest that increased consumption of selenium may increase the risk of type 2 diabetes (Hai-bo *et al.*, 2013). The intake of a large amount of substances, for example, selenic acid, can damage the mucus membrane of the digestive tract, nausea, and diarrhea (Tortelly *et al.*, 2018).

Other symptoms of selenium poisoning are anemia, dry cough, fever, and hypersalivation. Poisoning leads to increased permeability of the capillaries and nephrosis (Barrak *et al.*, 2012).

Selenium affects the functioning of the thyroid gland (Mara *et al.*, 2017). Changes in thyroid function resulting from insufficient coverage of demand for this element may result in mood worsening, as well as impairment of behavior and cognitive functions (Jinyuan *et al.*, 2016). The effects of these conditions can be alleviated by selenium supplementation (Mara *et al.*, 2017).

2.7 THE ROLE OF SELENIUM IN THE PREVENTION AND TREATMENT OF HEALTH DISORDERS

2.7.1 Oxidative Stress, Inflammation, and Immunity

In the inevitable aging process provided by nature, there is an imbalance between antioxidative defense and reactive oxygen species, irreversible changes in mitochondrial renewal, and stem cell exhaustion (Urban *et al.*, 2021). According to Alehagen *et al.*, these disorders are closely associated with chronic inflammation, which accompanies age related diseases. Simonoff *et al.*, claimed that the antioxidant status of older people could be evaluated by measuring blood Selenium and vitamin (A and E) levels (Simonoff *et al.*, 1992). Serum and plasma Selenium levels, glutathione peroxidase activity, and selenoprotein concentrations are commonly used measures of a Selenium status in humans (Joseph and Peter, 2018).

Selenium possesses antioxidant, immunostimulating, and anti-inflammatory effects (Tanuj *et al.*, 2022) Many selenoproteins are involved in the regulation of antioxidant activities (Zhonglin *et al.*, 2019).

As a cofactor of enzymes involved in antioxidant protection, Selenium plays a significant role in regulating different inflammatory processes in the organism (Marek, 2021). Insufficient Selenium level in the organism is associated with such inflammatory skin diseases as psoriasis and atopic dermatitis (Ping *et al.*, 2020). Generally, Selenium stimulates increasing antibody production in the immune system (Marek and Stanislaw, 2016; Chi and Peter, 2021). The optimal Selenium status (60–175 ng Se/mL plasma) can mitigate an inflammatory process and reduce complications in the lungs, intestines, etc. (Joseph and Peter, 2018).

It could be concluded that Selenium supplementations can boost immunity against cancer or other diseases, creating an opportunity for healthy longevity.

2.7.2 Infections

As it is known, ROS are frequently produced in the human body during viral infections, and their excess can induce oxidative stress being one of the hallmarks of clinical symptoms for many diseases (Olivia *et al.*, 2019). Among the essential micronutrients implicated in the progression of viral infection, Selenium plays an important role in redox homeostasis and antioxidant defense due to its incorporation, as already mentioned, in the vitally important selenoproteins (Jinsong *et al.*, 2020; Wesam *et al.*, 2021). For example, Selenium supplementation strongly affected viral suppression and T-cell recovery in HIV infected patients in Rwanda (Julius *et al.*, 2015). Patients infected with tuberculosis and HIV had lower Selenium statuses when compared to healthy humans (Joseph and Peter, 2018). Recent studies revealed that COVID-19 patients have lower circulating levels of iron (Fe), zinc (Zn), and Selenium (Yunhui *et al.*, 2022).

Selenium supplementation was beneficial during murine infection with a Brazil strain of *Trypanosoma cruzi*, resulting in decreased parasitemias and increased longevity. After 64 days of infection, groups receiving 4 ppm and 8 ppm Selenium as sodium selenate in drinking water exhibited 60% survival, and the group without Selenium demonstrated 0% survival (Davis *et al.*, 1998).

2.7.3 Endocrine System Disorders

As it is known, the proper functioning of the thyroid gland requires several elements, including Selenium, Zinc, and copper (Cu), in addition to iodine (Michal *et al.*, 2017). Selenium is one of the important regulators of metabolic processes, and optimal intake is necessary to homeostasis (Catherine, 2011).

As reported recently, 35 selenoproteins have been identified (Aparna *et al.*, 2023). As it was noted by Schomburg (Lutz, 2012), a significant number of selenoproteins are involved in the functioning of the thyroid gland. Se deficiency is crucial for developing Hashimoto's thyroiditis and Graves' disease (Francesca *et al.*, 2021). A severe deficiency of Selenium in diet during pregnancy can cause the development of autoimmune thyroid disease (Ursula *et al.*, 2017).

Three of them are iodothyronine deiodinases, which play a key role in thyroid hormone metabolism. One of the critical roles of Selenium enzymes is the involvement in the thyroid hormone synthesis and, therefore, in regulating basic metabolism in all body cells and tissues (Waldemar, 2022).

Persistent Selenium deficiency may also cause infertility (Marek, 2021). Many clinical studies implicate Selenium deficiency in several reproductive complications, such as male and female infertility, miscarriage, preterm labor, etc. (Hiten *et al.*, 2012; Albaraa *et al.*, 2021).

2.7.4 Cancer

During the 5-year epidemiologic studies and clinical trials conducted by Japanese scientists, the significant effects of sufficient Selenium status were established in patients with different cancer types (Shigeki and Hiroai, 2002). Razaghi *et al.* reported that nutritional doses of Selenium can stimulate the immune system against cancer (Ali *et al.*, 2021). According to Varlamova *et al.*, various mechanisms are involved in the anticarcinogenic effect of Selenium. Besides the prominent antioxidant effects, Selenium containing compounds can maintain DNA stability, regulate inflammatory and immune responses, and inhibit the toxicity of heavy metals (Elena *et al.*, 2021). Thus, Selenium possesses anticarcinogenic properties, especially if administered in a preventive manner before the onset of a disease or at the early stage of its development (Marek and Stanislaw, 2016; Wesam *et al.*, 2021; Dominika *et al.*, 2021). However, its overdosing can act as pro-oxidant inducing cell death. As it is commonly known, the anticancer mechanism of Selenium is related to its significant antioxidant capacity (Marek and Stanislaw, 2016).

Considering that cancer cells are quite vulnerable to exposure to ROS, targeting the antioxidant capacity of tumor cells has been considered a promising strategy for anticancer therapy (Rob *et al.*, 2011). At increased but non-lethal doses, Se acts as a pro-oxidant and inhibits the growth of cancer cells without side effects on normal cells (Zhi *et al.*, 2012; Claire and Hugh, 2013).

The anti-cancer effects of Selenium compounds are related to their ability to induce oxidative stress and subsequent DNA damage in cancer cells that lead to obligate apoptosis (Joseph and Peter, 2018). On the contrary, the Selenium intake at an optimal level could prevent damage to the DNA in healthy cells and, consequently, the occurrence of mutations.

During the clinical study, 325 cases of Chinese patients with oral cancer were analyzed by Chen *et al.* (Qing *et al.*, 2019). The multiple interactions between Selenium intake, drinking/smoking status, and fish and fresh fruit intake frequencies were studied. The high level of serum Selenium was regarded as a protective factor for the risk of oral cancer. Appropriate diet and immunity are considered important modifiable factors in oral cancer (Mathew *et al.*, 2021).

2.7.5 Intoxication

Selenium is an effective protective agent for the human body against various environmental pollutants and drug-related side effects (Kielczykowska *et al.*, 2018). Limaye A. *et al.* found that Selenium and polyphenol curcumin were quite effective against aflatoxicosis due to their prominent antioxidant properties (Aniket *et al.*, 2018). Geir (Geir, 2015) found that numerous studies have shown that many Selenium containing foods protect the human body against mercury (Hg) exposure. It is due to the high affinity between Selenium and Mercury. The appropriate intake of Selenium and Zinc and some vitamins have been suggested to reduce As induced toxicity (Geir *et al.*, 2022).

2.8 SOURCES OF SELEMIUM IN THE HUMAN DIET

Organic Selenium from food is considered a safe and efficient source of supporting human health (Mei *et al.*, 2022). Among the sources of organic Selenium for humans, we find foods of animal, vegetable, and mushroom origin (Halyna *et al.*, 2018; Xin *et al.*, 2022). The main animal sources

of Selenium are red meats, poultry, beef or sheep liver, seafood, eggs, and dairy products (Wenli *et al.*, 2021; Marek, 2021; John, 2005). The main kinds of food containing Selenium in comparatively high amounts are shown below

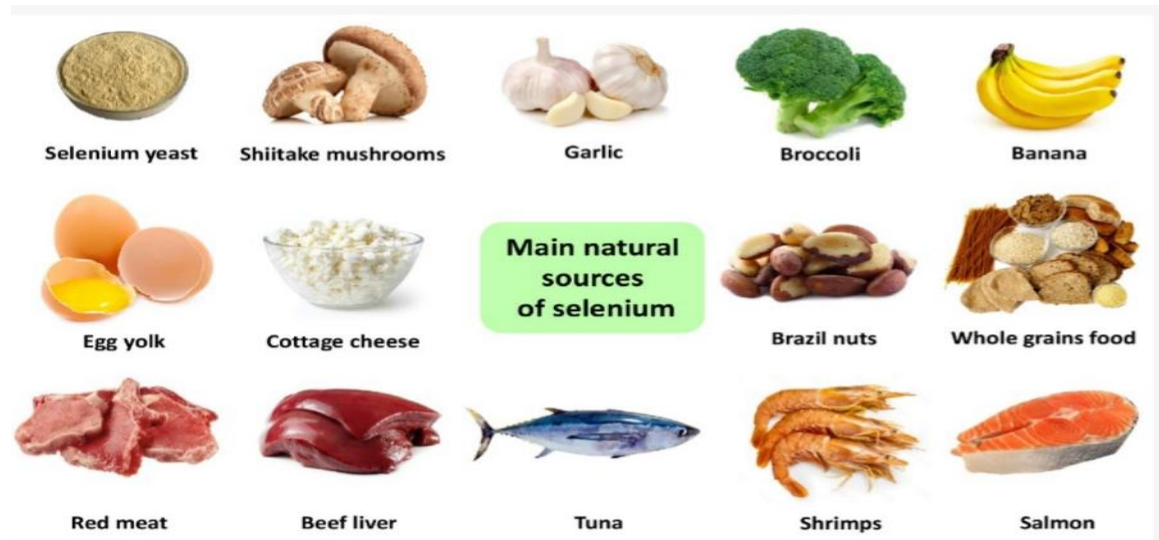


Plate 2.1: Foods containing selenium

Plants can absorb inorganic Selenium from soil and transform it into an organic form such as selenomethionine or selenocysteine, which are much more accessible for animals and humans than inorganic ones (Malgorzata *et al.*, 2016; Miguel and Carmel, 2008). Consumed by humans, organic Selenium changes by joining amino acids and proteins (Malgorzata *et al.*, 2016).

The extremely high Selenium content, mainly in the form of selenomethionine, is a characteristic feature of Brazilian nuts (Marek and Stanislaw, 2016). Broccoli, which can accumulate Selenium many fold higher than other plants, is associated with a reduced risk of some cancer types (John, 2003). Consumption of Selenium enriched broccoli led to activation of human leukocytes and increased cytokine production during immune response (Kerry *et al.*, 2014). It should be noted

that consumed vegetables (garlic, broccoli, etc.) should contain methylated forms of organic Se to be effective in the prevention of cancer (Malgorzata *et al.*, 2016; John, 2005). Methylseleninic acid can cause stress in the functioning endoplasmic reticulum through modulation of the membrane selenoproteins and activating the apoptosis of cancer (Elena, 2018; Valentina *et al.*, 2022; Goltyaev *et al.*, 2020).

2.9 DETERMINATION OF SELENIUM IN FOODS

Selenium appears in the environment in a trace amount. Thus, determining the Selenium amount in food samples demands appropriate measurement methods, including sample preparation, separation technique, and detection (Malgorzata *et al.*, 2016). Selenium speciation in food is not an easy goal because of its very low concentrations and availability of many different forms, as well as the lack of appropriate reference materials for its speciation that generates problems with validation. That is why speciation of Selenium has been conducted only for a few foods (Dil *et al.*, 2007).

Bodnar *et al.*, summarized that among different sample preparation techniques for Selenium determination, cryogenic trapping, wet/dry mineralization, and extraction methods (solid phase, liquid liquid, liquid solid, and enzymatic) are the most used (Malgorzata *et al.*, 2016). A UV oxidation procedure was developed to completely digest food samples for the evaluation of trace levels of Selenium (Manjusha *et al.*, 2007).

The chromatographic methods (liquid and gas chromatography) are more frequently used than capillary electrophoresis or isotachophoresis in the field of separation techniques. Gilbert López *et al.* reported that more than 100 Selenium metabolites were identified in the Selenium enriched yeast using the liquid chromatography mass spectrometry method (Bienvenida *et al.*, 2017).

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY LOCATION

This study was carried out at the undergraduate project plot of the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin

3.2 PURCHASE OF SEEDS

The seeds of *Arachis hypogaea* (Auchi groundnut) used in this experiment were bought from New Benin Market, Benin City, Edo state.

3.3 MATERIALS

- Sensitive Weighing balance
- Petri dish
- Distilled water
- Masking tape
- Tissue paper
- Syringe

3.4 CHEMICALS

Sodium Selinite was purchased from pyrex chemical, opposite UBTH, Benin City.

3.5 EXPERIMENTAL SETUP

The setup was termed "germination studies" and was carried out in a petri dishes using control SE.0 (A1) and four treatments 1.5g/L (A2), 2.5g/L (A3), 5g/L (A4), 10g/L (A5) in three

replicates. The groundnut (45 seeds per concentration) was primed in the different concentration of Sodium Selenite for three (3), six (6), and nine (9) hours respectively. Little wraps of tissue paper was placed in each petri dish to absorb water. Five seeds each from different priming duration and concentration were added to the labeled petri dish each, and was watered with distilled water once a day for seven days. Germination was observed 48 hours after the setup and data were taken for number of seeds that germinated per day, girth, radicle length, shoot length and number of leaves.

3.6 GERMINATION STUDY

3.6.1 DETERMINATION OF NUMBER OF LEAVES

The number of leaves were counted seven days after planting (7 DAP).

3.6.2 MEASUREMENT OF GIRTH

The thickness of the stem of plant was measured by wrapping a thread around it and then measuring the length using a ruler. This was done on the seventh day.

3.6.3 MEASUREMENT OF RADICLE LENGTH

Radicle length was measured using a ruler and was done four days after planting (4 DAP), and seven days after planting (7 DAP).

3.6.4 MEASUREMENT OF SHOOT LENGTH

The shoot length was measured using a meter rule from where it sprouted to the terminal bud and this was seven days after planting (7 DAP).

3.7 STATISTICAL ANALYSIS

The values obtained that were presented in the tables are those of mean and standard error of each treatment.

CHAPTER FOUR

RESULTS

This section presents the data analysis and interpretations of findings in line with the objectives and hypotheses stated for the study.

Figure 1 shows the effect of selenium on the germination of *Arachis hypogaea* L. The data and graph for 2 DAP show that selenium (Se) concentration significantly influenced plant growth from Day 2 to Day 7. Growth increased with time across all treatments, but the extent varied with Se levels. The A2 treatment produced the highest and most consistent growth (73.33%), showing that a low Se dose stimulated growth beyond the control (66.67%). Moderate concentrations (A3 –A4) resulted in growth similar to or slightly below the control, indicating a reduced stimulatory or mildly inhibitory effect. The highest concentration (A5) caused strong growth inhibition (48.89%), confirming toxicity at excessive Se levels. Overall, the graph illustrates a dose-dependent hermetic response, where low Se enhances growth while higher doses suppress it.

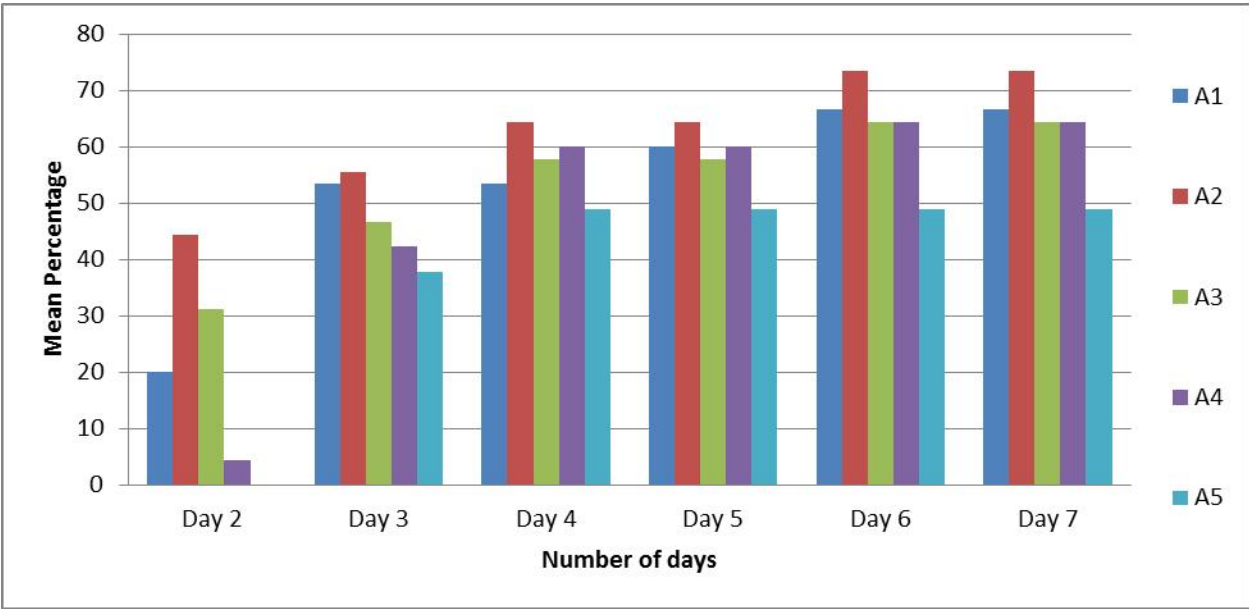


Figure 4.1: Effect of selenium on the germination % of *Arachis hypogaea*

Table 2 shows that selenium (Se) concentration significantly influenced the vegetative growth of *Arachis hypogaea*.

Stem Girth:

The control plant A1 had a mean girth of 2.15 ± 0.15 cm, while A2 produced similar values, indicating that low selenium levels did not impair stem development. However, higher concentrations A3, A4, and A5 caused a progressive decline, with A5 recording severe suppression (0.00 ± 0.00 cm), suggesting toxicity and inhibited cell growth.

Shoot Length:

Control plants (2.55 ± 0.05 cm) and those treated with A2 (up to 3.20 ± 0.40 cm) showed the greatest shoot elongation, indicating a stimulatory effect of low Selenium. Beyond A3, shoot length decreased markedly, showing that excessive Selenium impaired photosynthesis and metabolism through oxidative stress.

Table 3 shows the effect of selenium on number of leaves. Leaf production peaked at A1 (15.50 ± 0.50 leaves) but declined with increasing Selenium concentration. A5, leaf formation was completely inhibited (0.00 ± 0.00), reflecting toxicity effects on leaf initiation and chlorophyll function.

Table 4.1: Effect of Selenium on the girth (cm) and shoot length (cm) of *Arachis hypogaea* at 7 DAP

<u>Treatment</u>	<u>Stem Girth</u>			<u>Shoot Length</u>		
	-	<u>3</u>	<u>6</u>	<u>9</u>	<u>3</u>	<u>6</u>
A1		2.15±0.15			2.55±0.05	
A2	2.15±0.25	2.05±0.05	1.80±0.10	3.00±0.40	2.45±0.55	2.40±0.20
A3	2.05±0.25	2.00±0.10	1.65±0.15	2.05±0.15	1.95±0.15	1.75±0.25
A4	1.80±0.30	1.75±0.25	1.60±0.10	1.95±0.05	1.75±0.25	1.60±0.40
A5	1.50±0.50	1.25±0.25	0.00±0.00	1.75±0.25	1.05±0.05	0.0±0.00

Table 4.2: Effect of selenium on number of leaves of *Arachis hypogaea* at 7DAP

Treatment	Priming Duration		
	3	6	9
A1		11.00±1.00	
A2	15.00±0.50	13.50±0.50	13.50±0.50
A3	12.00±0.00	11.50±0.50	11.00±1.00
A4	9.00±1.00	8.50±0.50	8.00±1.00
A5	8.50±1.50	7.50±0.50	0.00±0.00

Values are expressed as mean ± standard error.

Table 3 shows that selenium (Se) concentration affected the radicle length of *Arachis hypogaea* seedlings at 4 and 7 days after planting (DAP). In the control A1, radicle length increased slightly from 1.50 ± 0.50 cm at 4 DAP to 1.83 ± 0.60 cm at 7 DAP. The A2 treatment produced the longest roots (up to 3.50 ± 0.50 cm at 7 DAP), indicating that a low selenium dose stimulated early root growth.

At A3, radicle elongation was moderate, while higher concentrations (A4 and A5) caused a marked reduction, with lengths remaining around 1.0–1.3 cm. This shows that selenium's effect on root development is concentration dependent, beneficial at low levels but inhibitory at higher ones.

The promotion of radicle growth at A2 may be linked to selenium's role in enhancing antioxidant enzyme activity and protecting cells from oxidative damage. However, excessive selenium likely induces toxicity and growth suppression.

Selenium enhances root elongation in *Arachis hypogaea* at low concentrations (A2) but becomes inhibitory above A3, confirming its dual physiological role as both an essential micronutrient and a potential toxin.

Table 4.3: Effect of Selenium on the radicle length (cm) of *Arachis hypogaea*

TREATMENT	Priming Duration					
	4 DAP			7 DAP		
	3	6	9	3	6	9
A1		1.50±0.50			1.83±0.60	
A2	1.83±0.33	2.00±0.29	2.50±0.00	2.67±0.33	3.00±0.50	3.50±0.50
A3	1.00±0.00	1.50±0.00	1.67±0.44	1.33±0.33	2.00±0.58	3.00±0.58
A4	1.17±0.33	1.07±0.30	0.83±0.17	1.33±0.17	1.27±0.54	1.17±0.44
A5	1.10±0.31	1.00±0.29	0.80±0.15	1.30±0.15	1.23±0.15	1.17±0.17

Values are expressed as mean ± standard error.



Plate 4.2: Arachis hypogaea with 0 selenium concentration



Plate 4.3: Arachis hypogaea with 1.5g selenium concentration



Plate 4.4: Arachis hypogaea with 2.5g selenium concentration



Plate 4.5: Arachis hypogaea with 5g selenium concentration



Plate 4.6: Arachis hypogaea with 10g selenium concentration

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 DISCUSSION

The study investigated the impact of varying concentrations of Selenium on the germination and subsequent seedling growth of *Arachis hypogaea* (groundnut). The experiment involved exposing seeds to four different concentration of Selenium, ranging from control (A1) no Selenium to increasing levels of Selenium (A2, A3, A4, A5). Germination was observed across seven days, with careful measurements taken from day 2 to monitor the temporal dynamics of seedling emergence and vigour. The data obtained provided valuable insights into the relationship between priming *Arachis hypogaea* in Selenium and seedling development.

The data (Table 1) indicate that selenium (Se) application influenced germination percentage of *Arachis hypogaea* across the seven-day period. Germination generally increased with time in all treatments, but the magnitude of increase varied with selenium concentration.

At Day 2, germination was highest in plants treated with A2 (44.44%), followed by A3 (31.11%), while higher concentrations (A4 and A5) caused a drastic reduction in germination (4.44% and 0%, respectively). This trend shows that low Se concentration enhanced early germination, whereas higher concentrations were inhibitory. Similar results were observed by Hawrylak-Nowak (2013), who reported that low selenium doses improved seed germination in lettuce, but excessive selenium reduced germination due to oxidative stress.

By Day 3 to Day 5, germination continued to rise across treatments, with A2 maintaining the highest germination rate (55.56–64.44%), slightly higher than the control (53.33–60%). Treatments with A3 and A4 showed moderate responses, while A5 consistently exhibited the

lowest values. This pattern supports the idea that selenium acts as a beneficial element at trace levels but becomes toxic at higher concentrations (Terry *et al.*, 2000; Hasanuzzaman *et al.*, 2010).

By Day 6 and 7, germination appeared to stabilize, with A2 still recording the highest percentage (73.33%) compared to the control (66.67%) and the other treatments. The A5 treatment remained lowest (48.89%), confirming that selenium toxicity suppresses physiological processes necessary for germination such as enzyme activity and seed metabolism (Filek *et al.*, 2008).

These findings are consistent with the reports of Kaur *et al.* (2014) and Trippe *et al.* (2021), who found that selenium at low doses enhances antioxidant defense mechanisms, whereas excessive Se induces toxicity through reactive oxygen species (ROS) accumulation.

The control (A1) and A2 treatments produced the highest stem girth (2.15 ± 0.25 cm) and shoot length (3.00 ± 0.40 cm), suggesting that moderate Se exposure promotes cell elongation and division. However, higher concentrations (A3–A5) led to progressive declines, with A5 (10 g/L) showing complete growth inhibition (0.00 ± 0.00 cm). These findings are consistent with Jiang *et al.*, (2017), who reported that appropriate selenium concentrations enhance photosynthetic activity and improve dry matter accumulation. In contrast, high selenium levels interfere with chloroplast function, reduce chlorophyll content, and inhibit photosynthesis (Nawaz *et al.*, 2016). The reduction in shoot and girth growth observed at high selenium levels could therefore be attributed to oxidative damage and nutrient imbalance, as also described by Li *et al.*, (2025), who found that excessive selenium disrupts metabolic and enzymatic balance in plant cells.

Leaf production followed a similar pattern to other growth parameters. The control (A1 = 15.50 ± 0.50) and low Se treatment (A2 = 15.00 ± 0.50) produced the highest leaf numbers, indicating that moderate selenium does not inhibit chlorophyll synthesis or leaf development. However, as

Se concentration increased, leaf production declined sharply, and at A5 (10 g/L), leaf initiation was completely inhibited (0.00 ± 0.00). This reduction could be due to selenium toxicity, which damages the photosynthetic apparatus and impairs chlorophyll biosynthesis (Zhu *et al.*, 2017). At optimal concentrations, selenium enhances photosynthetic pigments and antioxidative defense, improving plant growth and stress tolerance (Khan *et al.*, 2025), but excessive exposure induces chlorosis and stunted leaf development (Verstegen, 2025).

Table 3 showed that radicle elongation increased with low selenium concentration but declined at higher doses. The A2 treatment produced the longest roots (3.50 ± 0.50 cm at 7 DAP), while A4 and A5 showed stunted root growth, indicating selenium's dual role as a nutrient and toxin. The promotion of root elongation at A2 suggests that low selenium doses activate antioxidant enzymes and improve cellular respiration (Estariaga-Navarro *et al.*, 2025). Conversely, high selenium levels may disrupt cell division and cause oxidative stress in root tissues (Terry *et al.*, 2000). These findings corroborate the report of Li *et al.*, (2025), who stated that selenium at optimal doses enhances physiological processes but becomes toxic when applied in excess.

CONCLUSION

The results clearly demonstrate that selenium has a dose-dependent effect on the germination and early growth of *Arachis hypogaea* (groundnut). Low selenium concentrations (A2–A3) significantly enhanced germination percentage compared to the control, suggesting a stimulatory role of Selenium at trace levels. In contrast, higher concentrations (A4 – A5) inhibited germination, indicating selenium toxicity at elevated doses.

This pattern supports the concept that selenium, though not essential for all plants, functions as a beneficial micronutrient when applied in small amounts, improving physiological and metabolic activities that promote germination and early seedling vigor. However, excessive Selenium disrupts these processes, likely through oxidative stress and enzyme inhibition.

Therefore, optimal selenium supplementation can be used to enhance seed germination and early establishment of groundnut, but careful attention must be paid to concentration levels to avoid phytotoxic effects.

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