

**THE EFFECTS OF MAGNESIUM NANOPARTICLES ON THE GROWTH  
OF MAIZE (*Zea mays L.*) IN A FERRUGINOUS SOIL**

**By**

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**SR/2025/RPR/22/112**

**DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY**

**FACULTY OF LIFE SCIENCES**

**UNIVERSITY OF BENIN**

**BENIN CITY**

**SEPTEMBER, 2023**

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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF PLANT  
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THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE  
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## CERTIFICATION

This is to certify that this work was carried out by **Divine OKUIGBEDI** in the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Benin City, Nigeria.

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## **DEDICATION**

This work is dedicated to God Almighty, my lovely parents Pastor and Mrs Efe Okuigbedi, my siblings, my project supervisor Mrs F. N. Egbenoma for the motherly role she played and my deceased aunts Late Mrs Uche Oghene and Late Mrs Aboyowa Idiabana.

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## ABSTRACT

Many regions of the world have ferruginous soils, which lack magnesium. Magnesium is a crucial component for plant growth, and a lack of it can result in lower quality and yields. Numerous potential advantages of nanoparticles for plant growth have been demonstrated, including higher nutrient uptake, improved photosynthesis, and increased resistance to pests and diseases. Magnesium nanoparticles (MgNPs) have been shown to enhance plant growth in other types of soils, but their effects on maize growth in ferruginous soils have not been studied effectively. This study investigated the potential effects of magnesium nanoparticles on the growth of maize (*Zea mays L.*) in ferruginous soil. In this study, potted maize plants were grown in a controlled environment, with varying concentrations of magnesium nanoparticles applied to the ferruginous soil. The growth parameters assessed in this research study include: plant height, leaf length, leaf width, leaf area and stem girth. The results of this study demonstrate the potential of magnesium nanoparticles to reduce the negative effects of magnesium deficiency in ferruginous soils. The observed enhancements in maize growth were most likely caused by the nanoparticles' capacity to deliver a regulated release of magnesium ions into the soil environment. To identify the best application rates, potential long-term impacts, and interactions of magnesium nanoparticles with other soil components, additional research is required.

## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 BACKGROUND OF STUDY**

Ongoing research within the agricultural domain focuses on novel methods to increase crop yield and minimize ecological impact. Given the imperative of global food security amid a burgeoning population, the exploration of innovative avenues such as nanotechnology offers promising avenues for agricultural progress. By offering novel opportunities to augment plant growth and tackle nutrient insufficiencies, nanotechnology is poised to contribute significantly to the drive for agricultural improvement. Nanoparticles, due to their physical and chemical properties, have the potential to alter the redox state of plants and influence seed germination, growth, performance, and quality. (Adams *et al.*, 2006).

#### **1.2 MAGNESIUM**

Magnesium (Mg) is an essential secondary macronutrient that is required to enhance the growth and productivity of plants. It is the eighth major mineral on earth (Maguire *et al.*, 2002). Magnesium plays an important role in various physiological and biochemical processes including the activation of plant growth enzymes such as carboxylases, kinases, phosphates, ATPases and RNA polymerases (Mengel *et al.*, 2001; Cakmak *et al.*, 2008; Hawkesford *et al.*, 2012). Magnesium is also a key component of chlorophyll which is the pigment accountable for photosynthesis in plants. Magnesium is essential for the plant photosynthesis, since 15 to 35% of the total Mg in plants is bound to chloroplasts, mainly as a constituent of chlorophyll, where magnesium is a key component in the energy transfer process (Cakmak *et al.*, 2010). It is also

essential in generating energy, activating enzymes and facilitating the synthesis of proteins and nucleic acids. A considerable amount of magnesium (mg) is used as a binding element in plant cells for ribosome aggregation and thus play a key role in protein synthesis (Gout *et al.*, 2014). However insufficiency of magnesium levels in plants may inhibit their growth and also result in leaf discoloration (yellowing of leaves) and reduced crop productivity.

### **1.3 NANOPARTICLES**

The use of nanoparticles in research is a continuous, interdisciplinary trend (Ditta 2012). Nanoparticles can facilitate sophisticated uses in plants, including chemical reaction acceleration, pesticide use, feed additives, and effective micronutrient use (Srilatha 2011). In practice, they are applied gradually to plants as micronutrients, disinfectants, and antibacterial agents that help to produce higher-quality plants (De *et al.*, 2008).

Nanoparticles may not be as environmentally friendly as they are sometimes claimed or perceived to be (Monica *et al.*, 2009). However, the effects of nanoparticles on plants are poorly known and may vary positively or negatively, depending on factors such as plant species, via of incorporation (seed, root or leaf), chemical element and chemical composition and concentration of nanoparticles (Liu *et al.*, 2016). There is still controversy about whether nanoparticles may serve as a threat to or somehow disrupt a plant's biochemical processes (Song *et al.*, 2009).

The application of magnesium nanoparticles has attracted significant interest due to their possible benefits. These nanoparticles have the potential to boost nutrient absorption in plants, stimulate root development and enhance the overall well-being of the plant. The small size of these magnesium nanoparticles enable for better distribution in the soil to ensure the plants have easy and efficient access to magnesium.

## 1.4 THE MAIZE PLANT

Maize, which is also referred to as *Zea mays*, is an annual cereal plant which belongs to the tribe Maydae, family Poaceae. It is also known as corn. Maize is the world's leading cereal crop after wheat and rice which is widely cultivated and was domesticated in Mexico and Central America.

### 1.4.1 Scientific Classification of Maize

Kingdom:	Plantae
Phylum:	Magnoliophyta
Class:	Liliopsida
Order:	Cyperales
Family:	Poaceae
Genus:	<i>Zea</i>
Species:	<i>mays</i>
Botanical name:	<i>Zea mays L.</i>

### 1.4.2 Origin of Maize

Maize originated in the Americas and was initially domesticated by the indigenous people in Mesoamerica, which is present-day Mexico and Central America, about 9000 years ago (Staller *et al.*, 2001). *Teosinte*, a wild form of maize with small, hard kernels existed in this region and it gradually transformed into the maize varieties we know today through selective breeding by carefully choosing plants with desirable characteristics such as larger kernels and replanting their

seeds to further enhance maize plant over generations (Doebley *et al.*, 2006). The arrival of European explorers saw maize spread to other parts of the world through trade and exploration. Maize expanded to places like Europe, Africa and Asia where it has become a significant crop in numerous countries.

### 1.4.3 Botanical Description of Maize

Maize is a short day, monocot plant that varies in height from <1 to >4 meters producing large, narrow and opposing leaves that are arranged alternately along the stem which is herbaceous. The botanical features of various parts in maize plant are as follows:

**Root:** Maize has three different types of roots;

seminal roots, which develops from radical and persist for long period,

adventitious or fibrous roots, the active and effective roots of the plant

brace or prop roots, produced by lower two nodes.

**Stem:** The stem generally attains a thickness of three to four centimeters. It is herbaceous with the internodes being short and fairly thick at the base of the plant and become longer and thicker up the stem.

**Flower:** The apex of the stem ends up in the tassel, an inflorescence of male flowers and the female inflorescences, that are the cobs or ears, are borne at the apex of condensed, lateral branches known as shanks protruding from leaf axils. Both the male and female inflorescences are borne on the same plant (monoecious).

#### 1.4.4 Economic Importance of Maize

Maize has emerged as a crop of global importance due to its endless uses from human and livestock feed to raw material for industrial products. Globally, about 1.016 billion metric tonnes of maize are produced every year which makes it the highest among major cereals (FAOSTAT 2013). Maize serves a vital source of nutrition to billions of people in developing countries in Africa, Mesoamerica and Asia (Shiferaw *et al.*, 2011). Besides human consumption, maize is also used as animal feed which is known as fodder. Maize is also used to produce corn ethanol and other products such as corn flour, corn syrup, corn starch, etc. (Foley 2019).

#### 1.4.5 Types of Maize

There are numerous varieties of maize, sometimes known as corn, each with unique traits, applications, and adaptations. Here are some typical varieties of maize:

**Dent corn** (*Zea mays indentata*): It is sometimes referred to as field corn, is the most popular variety of maize. The unique "dent" or indentation that appears on the top of each kernel as it dries gives the food its name. Animal feed, industrial uses (such as the manufacturing of corn syrup and corn oil), and processed meals are the main uses for dent corn.

**Sweet corn** (*Zea mays saccharata*): Sweet corn has a higher sugar content than other varieties, it has a sweeter flavor. It is frequently eaten as a fresh vegetable because sweet corn's sugars do not turn into starch as quickly as other varieties of maize, it can be eaten when the kernels are still juicy and soft.

**Pop corn** (*Zea mays everta*): The kernels of popcorn have a hard exterior and a starchy interior. The moisture inside the kernel converts into steam when it is heated, which causes the kernel to explode and expand. This variety of maize is grown primarily to produce popcorn for snacks.

**Flour corn** (*Zea mays amylacea*): Flour corn has soft, starchy kernels that are easily ground into maize flour. It's commonly used in traditional dishes, tortillas, cornbread, and other baked goods.

**Flint corn** (*Zea mays indurata*): It is also referred as Indian corn. It has hard, glassy kernels that come in a variety of colours, including different tones of red, blue, yellow, and white. Native American cultures historically relied on it as a food source.

**Pod corn** (*Zea mays tunicata*): Each kernel of the unusual variety of corn known as "pod corn" is protected by a husk. It is not usually grown extensively for consumption; it is more of a botanical curiosity.

**Waxy maize** (*Zea mays ceratina*): The kernels of waxy maize have a greater concentration of the starch amylopectin, which gives them a waxy appearance. In the food business, this kind of maize is used to produce several specialized goods including starch and modified starches.

### 1.4.6 Uses of Maize

One of the most popular cereal crops in the world is maize, sometimes referred to as corn. It has several applications and is essential to many industries. Among the many uses of maize are:

**Food and Nutrition:** Around the world, maize is a staple diet for millions of people. In addition to fresh corn on the cob, it is also eaten as cornmeal, corn flour, syrup, oil, and popcorn. Carbohydrates, fiber, and important vitamins (A, B, and C) and minerals (iron, zinc) are all abundant in maize (McLellan 2023).

**Livestock Feed:** A sizable fraction of maize production is utilized as livestock feed, particularly for chickens, cattle, and pigs. For cattle, maize is a rich source of protein and energy that supports their growth and productivity (McLellan 2023).

**Industrial Uses:** Maize is employed in a number of industrial operations. Maize-derived cornstarch is used to make paper, textiles, adhesives, and a variety of food goods. Cooking with corn oil is also used to create biodiesel. A typical sweetener in the food and beverage sector is corn syrup (McLellan 2023).

**Ethanol Production:** Corn serves as the main source material for ethanol production, serving as a biofuel additive to gasoline. Through the fermentation of corn sugars, ethanol is generated, aiding in the reduction of greenhouse gas emissions and decreasing reliance on fossil fuels (McLellan 2023).

**Pharmaceuticals:** Corn finds applications in the pharmaceutical sector for producing medicines, vitamins, and supplements. Moreover, certain elements of corn, such as corn silk and corn oil, have a long history of use in traditional medicine due to their various health-promoting properties (McLellan 2023).

### **1.4.7 Health Benefits of Maize**

Maize, also known as corn, boasts an array of health benefits owing to its rich nutritional profile, encompassing a variety of essential vitamins, minerals, and fiber. This multifaceted grain offers a plethora of advantages that positively impact overall well-being and health (Reed *et al.*, 2021).

Among the notable health benefits of maize are:

**Reduced Risk of Heart Disease:** Maize stands out as an excellent source of dietary fiber, a crucial component known for its ability to promote heart health. The presence of fiber aids in lowering cholesterol levels, thereby mitigating the risk of heart disease and supporting cardiovascular well-being (Reed *et al.*, 2021).

**Reduced Risk of Stroke:** Notably, maize serves as a commendable source of potassium, an essential mineral that plays a pivotal role in regulating blood pressure. By incorporating maize into one's diet, individuals may potentially reduce their risk of stroke and other related cardiovascular events (Reed *et al.*, 2021).

**Improved Digestion:** The abundance of dietary fiber in maize contributes to enhancing digestive health. Fiber aids in maintaining a healthy digestive system, facilitating smoother bowel movements, and preventing issues such as constipation (Reed *et al.*, 2021).

**Stabilized Blood Sugar Levels:** Maize's composition of complex carbohydrates contributes to its ability to stabilize blood sugar levels. By consuming maize, individuals may experience steadier blood sugar levels, offering potential benefits for those managing diabetes or seeking to regulate their glucose levels (Reed *et al.*, 2021).

**Weight Loss Support:** Embracing maize as part of a balanced diet can offer support to weight loss endeavors. Being a low-calorie food with high fiber content, maize can help individuals feel satiated while promoting weight management efforts (Reed *et al.*, 2021).

### 1.4.8 Planting of Maize

The propagation of maize relies on seeds, and the productivity of this essential crop is significantly influenced by various planting practices, including the timing, depth, and method employed for planting.

**Timing of Planting:** In the Forest zone, early season maize is conventionally planted between mid-March and the first week of April. However, with changing rainfall patterns, it is now advisable to sow maize as soon as soil conditions and temperatures become favorable, coupled with well-established rainfall. Delayed planting can lead to increased susceptibility to diseases and insect attacks. For late-season maize, such as popcorn, planting is timed to ensure proper drying of the maize, facilitating optimum popping expansion. It is important to note that in areas where irrigation farming is practiced, the timing of maize planting becomes less critical (Adu-Gyamfi *et al.*, 2023).

**Depth of Planting:** The depth at which maize seeds are sown typically ranges between 3 to 8 cm, depending on factors like soil moisture, air conditions, and temperature. In moist soil, a planting depth of 2 to 4 cm is generally adequate, while drier soils may require deeper sowing, ranging from 5 to 8 cm. Ensuring uniformity in planting depth for all maize seeds is essential to foster consistent and uniform plant growth (Adu-Gyamfi *et al.*, 2023).

**Method of Planting:** Maize planting can be carried out using manual labor or mechanized techniques and can be done in various configurations, such as hills or rows, on ridges, or on flat land. Seeds are typically planted at spacing of 75-85 cm between rows and 25-40 cm within rows. Wide spacing can result in increased weed growth and erosion. Achieving a uniform crop stand is crucial for maximizing yields. Hand planting is the traditional and widely used method, where

seeds are dropped into holes made with sticks or hoes and then covered with soil. This method facilitates simultaneous fertilizer application during planting. On the other hand, mechanical planting offers faster and more efficient planting on larger land areas within a specified planting period. With proper supervision, mechanical planting yields excellent results, but inadequate oversight can lead to suboptimal outcomes (Adu-Gyamfi *et al.*, 2023).

Successful maize planting practices are pivotal in achieving high yields and a thriving crop. The appropriate timing, depth, and method of planting must be considered and tailored to the specific environmental conditions and available resources. Embracing efficient planting techniques and adhering to uniformity in planting practices will contribute to the success of 0maize cultivation, ensuring an abundant and sustainable supply of this vital cereal crop.

#### **1.4.9 Climatic Requirements for the Growth of Maize**

The climatic conditions necessary for successful growth of maize vary on the type of maize and geographical region. However in general, maize has the following requirements for optimal growth:

**Temperature:** Maize thrives well in warm temperatures with an ideal range of 15°C (60°F) to 35°C (95°F). The germination process requires a minimum soil temperature requires a minimum soil temperature of about 10°C (50°F). Extreme heat or frost can be fatal on maize growth or development (EconStor 2018).

**Sunlight:** Maize is a crop that requires ample sunlight for photosynthesis and overall growth. It flourishes in areas with full sun exposure throughout the day (EconStor 2018).

**Rainfall:** Consistent and sufficient water supply is a necessity for optimal growth in maize. The exact water requirements vary at different growth stages but generally, maize needs around 50-75cm (20-30 inches) of water per growing season. Insufficient water can result in stunted growth and decreased yields (EconStor 2018).

However, maize is sensitive to insufficiency of nutrients which can have a huge impact on its growth and productivity. Maize often experiences frequent deficiencies in macronutrients such as nitrogen, phosphorus and potassium, as well as micronutrients like magnesium, zinc and iron. These deficiencies can be detrimental to the growth of the maize plants which may lead to stunted growth, reduced grain production and weakened plant health. Additionally, inadequate uptake of these vital nutrients can lead to lower grain yield, smaller cobs and underdeveloped kernels that compromise the nutritional value of the maize affecting its protein and mineral which are crucial for human and animal consumption (EconStor 2018).

## **1.5 FERRUGINOUS SOIL**

For growth of maize to be possible, one of the major factors is good soil. Soil consists of minerals, organic matter, microbes, water and air (Nnadi *et al.*, 2019). These components of soils greatly influence the fertility, structure and porosity of different soils and as well as affect the distribution of plants (Ikhajiagbe *et al.*, 2019). Furthermore, the richness and fertility of the soil significantly influence maize growth. Well-drained soils, boasting optimal aeration and water retention capabilities, are highly sought-after for successful maize cultivation. Additionally, the presence of essential nutrients such as nitrogen, phosphorus, and potassium plays a fundamental role in supporting the overall health and productivity of the maize crop.

Ferruginous soils are acidic red soils are found in warm, temperate, humid climates and in regions covered with deciduous or mixed forests (Yu *et al.*, 2016). These soils are distributed throughout the tropical and subtropical areas like Southeast Asia, Oceania, South America, southern North America and Africa (Zhao, 2014). However in Nigeria, it is found in some southern states such as Edo state occupying about seven zones including North and Central Benin (Dayou *et al.*, 2017). The availability and movement of nutrients may be hindered by the presence of ferruginous soil due to the high concentration of iron in the soil. The plants may experience nutrient deficiencies since the iron oxides in the soil can interact with the nutrients, making the plant roots to easily obtain the nutrients such as magnesium, potassium and phosphorus.

Cultivating maize in a ferruginous soil may pose challenges due to the fact of the inherent limitations regarding nutrient availability. The restricted presence of nutrients, particularly magnesium, may impede the growth and progress of maize plants. Moreover, the elevated iron content in ferruginous soil can impact other soil characteristics like pH and the cycling of nutrients, thereby further influencing the nutrition of maize plants.

## **1.6 LITERATURE REVIEW**

Magnesium is a crucial nutrient for plant development, and its deficiency can lead to stunted growth, chlorosis, and decreased yield. Ferruginous soils are typically low in magnesium, making the application of magnesium fertilizers beneficial for maize growth in such soil conditions.

Magnesium nanoparticles (MgONPs) represent a promising form of magnesium fertilizer due to their high surface area, enhancing their bioavailability to plants compared to conventional

magnesium fertilizers. Additionally, MgONPs have demonstrated various positive effects on plant growth, including increased photosynthesis, improved drought tolerance, and enhanced resistance to pests and diseases.

Many studies have devoted special attention to improve techniques for the soil macronutrient availability. This availability is one of the major strategies to increase grain yield. In particular, magnesium availability processes for maize plants have adopted procedures that employ the direct application of magnesium precursor to the soil.

For instance, Adhikari et al. (2019) discovered that applying 10 ppm MgONPs to maize plants cultivated in ferruginous soil led to significant improvements in plant height, leaf area, and grain yield. The researchers also observed that MgONPs enhanced root length and volume, indicating potential benefits in increasing maize's drought tolerance.

Kaur *et al.* (2022) did a comparative study of chemo-bio synthesized magnesium oxide (MgO) nanoparticles on maize seed germination. The study reported the synthesis of MgO nanoparticles by using magnesium acetate and *Cissus quadrangularis* (Veld grape) plant extracted solution in biological method. For the comparative study, a chemical method was used to synthesize the MgO nanoparticles by using sodium hydroxide (NaOH) as a reducing agent while *Cissus quadrangularis* plant extract was used as the reducing agent in the biological method for production of MgO nanoparticles (Kaur *et al.*, 2022).

The result of the study revealed that the germination process of the maize seed was influenced by biological method synthesized MgO nanoparticles by increasing the root growth of the maize seed compared to the chemical method synthesized MgO nanoparticles and control. The MgO also had faster ability to be transported through the plant within the metabolic processes as the

MgO nanoparticles were helpful for the absorption of minerals and water at the same time support the photosynthesis of the plant (Kaur *et al.*, 2022).

Ahmed *et al.* (2020) carried out a research on growth, chlorophyll content and productivity responses of maize to magnesium sulphate application in calcareous soil. A calcareous soil is a soil that has an abundance of calcium carbonate (CaCO<sub>3</sub>). They hypothesized that the addition of magnesium will mitigate Mg deficiency under calcareous soil conditions and optimize maize crop yield traits. The study was conducted with the objective to examine the influence of soil application of Mg on maize growth and productivity in calcareous soil (Ahmed *et al.*, 2020).

The result of the research showed that Mg concentration in grains, leaves and shoots was observed to be low when maize was cultivated in calcareous soils without Mg application. A higher concentration of calcium (Ca) and potassium (K) in soil decreases the bioavailability of Mg to the plants thereby showing an antagonistic relationship with the mobility of Mg. The plants with the highest concentration of Mg was observed to significantly have the highest height growth, productivity in terms of number of grains and grain weight. It was also observed that the chlorophyll content in leaves were affected by the application of Mg application in soil as increasing the level of Mg significantly increased chlorophyll a, chlorophyll b and total chlorophyll (Ahmed *et al.*, 2020).

Jayarambabu *et al.* (2016) made a research on the enhancement of growth in maize by biogenic-synthesized MgO nanoparticles. They prepared the MgO nanoparticles using *Piper betle* (betel plant) leaf extract as reducing and stabilizing agent (Jayarambabu *et al.*, 2016).

The result of this research showed that the application of MgO stimulated the seed germination of maize. However, the response was dependent on the concentration of the applied MgO on the

maize seed as the maize seed with the highest concentration of MgO showed the highest seed germination. The chlorophyll content in maize was observed to be increased by low concentration but it was found to be inhibited by higher concentration of MgO nanoparticle (Jayarambabu *et al.*, 2016).

Furthermore, Rajitha *et al.* (2020) found that applying 50 ppm MgONPs to maize plants in ferruginous soil resulted in a substantial increase in the chlorophyll content of the leaves, which could be attributed to the nanoparticles' capacity to enhance photosynthesis.

Magnesium nanoparticles have been observed to enhance the availability and uptake of magnesium by maize plants which result in improved growth and development of the plants. Maize plants show positive effects in response to magnesium nanoparticles by increase in plant growth, productivity and enhanced root absorption and subsequent translocation of macro- and micronutrient to the shoot of the maize plant.

In conclusion, the current body of research suggests that MgONPs have the potential to serve as a beneficial fertilizer for maize cultivated in ferruginous soils. Nonetheless, more comprehensive investigations are necessary to fully comprehend the effects of MgONPs on maize growth and yield under various environmental conditions.

## **1.7 JUSTIFICATION**

The purpose of this study is to examine the potential effects of using magnesium nanoparticles as a nutrient supplement to promote maize (*Zea mays L.*) growth and development in soils that are known as ferruginous soils because they have high iron content and low magnesium availability. The purpose of the study is to determine whether adding magnesium nanoparticles to the soil can effectively solve soil magnesium deficiency and, as a result, boost maize yield and growth.

## 1.8 AIMS AND OBJECTIVES

The aim of this study is to find out the potential effects of magnesium nanoparticles on the growth of maize in a ferruginous soil.

The following are the objectives for carrying out this research:

1. To provide valuable insights for the agricultural application of magnesium nanoparticles to enhance the production of maize in a ferruginous soil.
2. To explore the potential mechanisms underlying the observed effects of magnesium nanoparticles on maize growth in a ferruginous soil.
3. To determine the optimal concentration of magnesium nanoparticles to enhance growth of maize in a ferruginous soil.
4. To examine the impact of magnesium nanoparticles on nutrient availability and soil characteristics in a ferruginous soil.
5. To investigate how the growth parameters of maize plants in a ferruginous soil are influenced by the application of magnesium nanoparticles.
6. To evaluate the physiological response of maize plants when exposed to magnesium nanoparticles.

## **CHAPTER TWO**

### **MATERIALS AND METHODS**

#### **2.1 STUDY AREA**

The location used for the study was the botanical garden of the Department of Plant Biology and Biotechnology, the faculty of Life Sciences, University of Benin, Benin City, Edo State. Nigeria.

#### **2.2 SOURCE OF MATERIALS USED**

##### **2.2.1 Maize Seeds**

The *Zea mays* seeds used in this study was Sammaz-52, a hybrid variety of maize seeds which was gotten Ring Road market, Benin City, Edo State.

##### **2.2.2 Soil**

The soil used for this study was gotten from a field at the back of Faculty of Agriculture farm close to Keystone Hostel, University of Benin, Benin City by using a spade to dig the ground.

##### **2.2.3 Heavy Metal and Magnesium**

The iron (ii) sulphate ( $\text{FeSO}_4$ ) and magnesium sulphate ( $\text{MgSO}_4$ ) were gotten from the University of Benin Teaching Hospital, Benin City.

##### **2.2.4 Distilled Water**

The distilled water used was gotten from the Department of Chemistry, Faculty of Physical Sciences, University of Benin, Benin City.

### **2.2.5 Polythene Bags**

The polythene bags were gotten from Ring Road market, Benin City.

### **2.2.6 Ruler**

A 30cm Avanti (Made in Nigeria) ruler was used to take measurements of plant parts in the study.

### **2.2.7 Weighing Balance**

CAMRY EMPEROR (44lbs×20oz = 20kg50g). Made in China was used to measure the weight of the soil used. It was gotten from the Mushroom Research Centre, Department of Plant Biology and Biotechnology, University of Benin, Benin City.

### **2.2.8 Plant Extract**

Dried *Hibiscus sabdariffa* (sorreal leaves) which is locally known as zobo leaves was used as the plant extract for the nanoparticles synthesis and it was gotten from a confectionery shop at Newton Street, Ekosodin, Benin City.

## **2.3 EXPERIMENTAL METHOD**

### **2.3.1 Preparation of Soil Sample**

The soil obtained was carefully sieved to remove debris, measured as 7.5kg for each polythene bag and then poured into 60 polythene bags. Each bag was also perforated to avoid water logging of the soil.

### **2.3.2 Site Preparation**

The proposed site for the study, which was the botanical garden of the Department of Plant Biology and Biotechnology, was cleared to get rid of weeds and a black polythene tarp was laid on the ground before the 60 polythene bags containing the soil were placed on it.

### **2.3.3 Pollution of Soil**

The 60 bags of soil were to be polluted with iron (ii) sulphate ( $\text{FeSO}_4$ ) and as such were divided into 3 different sections; 1 ESV, 3 ESV and 5 ESV with each section containing 20 bags where ESV stands for Ecological Screening Value. For the 1 ESV section, 0.3g of iron (ii) sulphate ( $\text{FeSO}_4$ ) was weighed and mixed in 1 liter of water which was then poured on each bag; the same process was done for all 20 bags of soil in the 1 ESV section. For 3 ESV, 0.9g of iron (ii) sulphate ( $\text{FeSO}_4$ ) was weighed, mixed in 1 liter of water and then poured on each bag of soil; the same process was also done for all 20 bags of soil in the 3 ESV section. For 5 ESV section, 1.5g of iron (ii) sulphate ( $\text{FeSO}_4$ ) was weighed, mixed in 1 liter of water and thereafter poured in each bag; the same process was also done for all 20 bags in the 5 ESV section. The polluted soil was left for 2 days before planting.

### **2.3.4 Randomization of the Polythene Bags**

The polythene bags were later randomized after the pollution of the soil into 5 different blocks with each block or sector consisting of 4 bags from the 1 ESV section, 4 bags from 3 ESV section and 4 bags from 5 ESV section making 12 bags under 1 block or sector.

### **2.3.5 Viability Test**

The *Zea mays* seeds to be used were soaked in water for 30 minutes using floatation techniques to test if seeds are viable.

### **2.3.6 Sowing of Seed**

A hole 3cm deep was dug in each bag containing the soil; 4 holes per bag. 1 maize seed was planted in each hole across the 60 polythene bags to carry out germination studies and watering was done regularly early in the morning or late in the evening. This was done to enable the plants have enough water before transpiration occurs due to the high radiation during the day. Germination started 5 days after planting and the various readings of the plant (*Zea mays*) height, leaf area, stem girth were taken before and after the application of magnesium nanoparticles.

### **2.3.7 Preparation of Leaves Extract of Plant Used for the Study**

10g of the dried *Hibiscus sabdariffa* leaves was weighed and put in a beaker. Distilled water was added to the beaker up to the 100 ml mark. The beaker containing the *Hibiscus sabdariffa* leaves and distilled water was heated in a pressure cooker for about 30 minutes and then it was allowed to cool down. The solution was then filtered and the filtrate was used for the nanoparticles synthesis.

### **2.3.8 Synthesis of Magnesium Nanoparticles**

5ml of the *Hibiscus sabdariffa* leaf extract was added to 50ml of the aqueous solution of 0.2 M of Magnesium sulphate ( $\text{MgSO}_4$ ) while heating and stirring at 70°C and pH 7 for 30 minutes.

### **2.3.9 Application of the Magnesium Nanoparticles**

15% of the magnesium nanoparticles (15ml of magnesium nanoparticles and 85ml of distilled water) was applied to one of bags containing the *Zea mays* plant in the 1 ESV section, 3 ESV section and 5 ESV section for the five replicates. 30% of the magnesium nanoparticles (30ml of magnesium nanoparticles and 70ml of distilled water) was applied to one of bags containing the *Zea mays* plant in the 1 ESV section, 3 ESV section and 5 ESV section for the five replicates. 75% of the magnesium nanoparticles (75ml of magnesium nanoparticles and 25ml of distilled water) was applied to one of bags containing the *Zea mays* plant in the 1 ESV section, 3 ESV section and 5 ESV section for the five replicates.

## **2.4 DETERMINATION OF GROWTH PARAMETERS**

### **2.4.1 Measurement of Plant Height**

The height of the plant was measured with a 30cm ruler from ground level to terminal bud which was done on weekly interval.

### **2.4.2 Measurement of Stem Girth**

The stem girth was measured 3cm from the point of emergence with a 30cm ruler and thread which was done on weekly interval.

### **2.4.3 Measurement of Leaf Area**

Leaf area was determined by the measuring the length and breadth of the third leaf and then multiplying it by 0.75 [L x B x 0.75]

## **2.5 STATISTICAL ANALYSIS**

The data collected from the measurements of the plant height, leaf length, leaf breadth, leaf area and stem girth were analyzed using Microsoft Excel to derive the mean and standard error.

## CHAPTER THREE

### RESULTS

Table 1 shows the plant height of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $10.8 \pm 0.5$ ,  $11.3 \pm 0.5$ ,  $10.2 \pm 1.3$  and  $11.3 \pm 1.1$  respectively. There were no significant differences in plant height between all concentrations and the control. At 4 WAP, the 75% MgNP concentration exhibited the highest plant height growth with the value  $17.4 \pm 1.6$ , while the control, 15% and 30% MgNPs had  $17.4 \pm 1.6$ ,  $15.7 \pm 0.5$  and  $15.4 \pm 1.0$  respectively. At 8 WAP, the plant height for the control, 15%, 30% and 75% MgNPs were recorded as  $27.3 \pm 0.6$ ,  $21.7 \pm 0.6$ ,  $22.1 \pm 1.2$  and  $24.5 \pm 1.4$  respectively with the control showing the highest growth for plant height.

**Table 1:** Plant height of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>	<b>7WAP</b>
Control	10.8±0.5	11.9±1.3	14.7±0.6	17.4±1.6	19.2±0.5	21.7±0.6	23.5±0.6
15% MgNP	11.3±0.5	12.0±0.5	14.4±0.5	15.7±0.5	17.2±0.5	18.8±0.7	20.5±0.7
30% MgNP	10.2±1.3	13.9±0.3	13.6±1.1	15.4±1.0	17.0±1.0	18.6±1.2	20.3±1.2
75% MgNP	11.3±1.1	12.9±1.3	15.3±1.3	17.4±1.6	19.4±1.5	21.0±1.5	22.7±1.5

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 2 shows the plant height of *Zea mays* polluted with 0.9g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $9.9\pm 1.6$ ,  $9.6\pm 0.3$ ,  $11.9\pm 0.5$  and  $10.0\pm 1.0$  respectively. There were no obvious significant differences in plant height between all concentrations and the control. At 4 WAP, the 30% MgNP concentration exhibited the highest plant height growth with the value  $17.1\pm 0.5$ , while the control, 15% and 75% MgNPs had  $15.5\pm 1.4$ ,  $15.2\pm 0.5$  and  $15.9\pm 0.8$  respectively. At 8 WAP, the plant height for the control, 15%, 30% and 75% MgNPs were recorded as  $23.2\pm 1.1$ ,  $22.1\pm 0.7$ ,  $23.8\pm 0.4$  and  $24.5\pm 0.9$  respectively with the 75% MgNP showing the highest growth for plant height.

**Table 2:** Plant height of *Zea mays* polluted with 0.9g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

Concentration	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP
Control	9.9±1.6	11.3±1.1	13.5±1.4	15.5±1.4	17.7±1.4	19.5±1.3
15% MgNP	9.6±0.3	13.1±0.8	13.5±0.3	15.2±0.5	16.9±0.5	18.8±0.6
30% MgNP	11.9±0.5	12.2±0.8	15.2±0.5	17.1±0.5	18.9±0.5	20.7±0.4
75% MgNP	10.0±1.0	12.1±0.6	13.7±0.5	15.9±0.8	18.1±0.8	20.3±0.9

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 3 shows the plant height of *Zea mays* polluted with 1.5g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $9.3 \pm 0.9$ ,  $11.3 \pm 0.8$ ,  $10.4 \pm 0.7$  and  $10.8 \pm 0.8$  respectively. There were no obvious significant differences in plant height between all concentrations and the control. At 4 WAP, the 75% MgNP concentration exhibited the highest plant height growth with the value  $17.1 \pm 0.5$ , while the control, 15% and 30% MgNPs had  $14.8 \pm 0.8$ ,  $16.6 \pm 0.6$  and  $15.8 \pm 0.7$  respectively. At 8 WAP, the plant height for the control, 15%, 30% and 75% were recorded as  $20.8 \pm 0.8$ ,  $22.6 \pm 0.6$ ,  $23.4 \pm 0.9$  and  $25.4 \pm 0.9$  respectively with the 75% MgNP showing the highest growth for plant height.

**Table 3:** Plant height of *Zea mays* polluted with 1.5g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>
Control	9.3±0.9	12.6±0.4	13.2±0.8	14.8±0.8	16.2±0.9	17.7±0.8
15% MgNP	11.3±0.8	12.0±1.1	15.0±0.6	16.6±0.6	18.1±0.6	19.6±0.6
30% MgNP	10.4±0.7	12.9±1.3	13.8±0.8	15.8±0.7	17.8±0.8	19.8±0.8
75% MgNP	10.8±0.8	12.6±0.9	14.4±0.8	17.3±0.9	20.0±0.9	21.4±0.8

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 4 shows the leaf area of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $5.6\pm 0.6$ ,  $5.0\pm 0.4$ ,  $4.1\pm 0.3$  and  $6.5\pm 0.5$  respectively. There were no obvious significant differences in the leaf area between all concentrations and the control. At 4 WAP, the control and 75% MgNP concentration had the largest leaf area with the values  $22.6\pm 2.2$  and  $22.6\pm 1.3$  respectively, while the 15% and 30% MgNPs had  $20.5\pm 0.7$  and  $20.8\pm 1.9$  respectively. At 8 WAP, the leaf area for the control, 15%, 30% and 75% MgNPs were recorded as  $37.6\pm 2.4$ ,  $44.0\pm 1.5$ ,  $43.0\pm 2.0$  and  $51.3\pm 5.0$  respectively with the 75% MgNP having the largest leaf area.

**Table 4:** Leaf area of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

Concentration	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP
Control	5.6±0.6	10.3±1.0	15.3±1.9	22.6±2.2	25.3±2.0	30.7±3.1
15% MgNP	5.0±0.4	9.5±0.4	13.8±0.5	20.5±0.7	25.6±0.7	30.1±1.0
30% MgNP	4.1±0.3	10.6±0.8	15.6±1.1	20.8±1.9	28.2±2.2	33.3±3.2
75% MgNP	6.5±0.5	12.6±0.8	16.4±0.8	22.6±1.3	28.6±2.0	36.6±2.3

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 5 shows the leaf area of *Zea mays* polluted with 0.9g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $5.3\pm 0.6$ ,  $5.4\pm 0.4$ ,  $5.9\pm 0.2$  and  $6.2\pm 0.6$  respectively. There were no obvious significant differences in the leaf area between all concentrations and the control. At 4 WAP, the 15% MgNP concentration had the largest leaf area with the value  $22.2\pm 1.1$ , while the control, 30% and 75% MgNPs had  $17.7\pm 2.1$ ,  $19.8\pm 0.9$  and  $21.1\pm 0.4$  respectively. At 8 WAP, the leaf area for the control, 15%, 30% and 75% MgNPs were recorded as  $33.9\pm 3.3$ ,  $44.3\pm 1.9$ ,  $45.9\pm 1.2$  and  $43.5\pm 1.1$  respectively with the 75% MgNP having the largest leaf area.

**Table 5:** Leaf area of *Zea mays* polluted with 0.9g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

Concentration	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP
Control	5.3±0.6	10.2±1.1	13.3±1.1	17.7±2.1	22.8±1.9	26.9±2.2
15% MgNP	5.4±0.4	11.4±0.6	15.3±1.1	22.2±1.1	27.1±1.5	31.5±1.8
30% MgNP	5.9±0.2	11.1±0.5	14.2±0.9	19.8±0.9	25.6±0.9	32.5±1.7
75% MgNP	6.2±0.6	12.2±0.9	15.3±1.0	21.1±0.4	26.2±0.4	34.1±0.5

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 6 shows the leaf area of *Zea mays* polluted with 1.5g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $4.8\pm 0.5$ ,  $5.7\pm 0.6$ ,  $4.6\pm 0.2$  and  $5.4\pm 0.6$  respectively. There were no obvious significant differences in the leaf area between all concentrations and the control. At 4 WAP, the 75% MgNP concentration had the largest leaf area with the value  $20.9\pm 1.6$ , while the control, 15% and 30% MgNPs had  $17.0\pm 1.8$ ,  $20.6\pm 1.9$  and  $20.2\pm 1.1$  respectively. At 8 WAP, the leaf area for the control, 15%, 30% and 75% MgNPs were recorded as  $32.4\pm 1.4$ ,  $41.8\pm 2.6$ ,  $44.8\pm 1.4$  and  $49.5\pm 5.6$  respectively with the 75% MgNP having the largest leaf area.

**Table 6:** Leaf area of *Zea mays* polluted with 1.5g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>
Control	4.8±0.5	10.1±0.5	14.4±0.9	17.0±1.8	22.7±1.7	26.8±1.7
15% MgNP	5.7±0.6	11.5±0.6	14.2±1.1	20.6±1.9	26.7±2.4	31.0±2.5
30% MgNP	4.6±0.2	9.6±0.4	14.5±0.6	20.2±1.1	25.2±1.6	31.1±1.6
75% MgNP	5.4±0.6	11.0±1.0	14.9±1.2	20.9±1.6	28.0±2.3	34.9±2.6

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 7 shows the stem girth of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $1.5\pm 0.1$ ,  $1.3\pm 0.0$ ,  $1.3\pm 0.1$  and  $1.4\pm 0.1$  respectively. There were no obvious significant differences in the stem girth between all concentrations and the control. At 4 WAP, the 75% MgNP concentration had the largest stem girth with the value  $2.3\pm 0.1$ , while the control, 15% and 30% MgNPs had  $2.1\pm 0.1$ ,  $2.1\pm 0.1$  and  $2.0\pm 0.1$  respectively. At 8 WAP, the stem girth for the control, 15%, 30% and 75% MgNPs were recorded as  $2.9\pm 0.1$ ,  $2.9\pm 0.1$ ,  $2.9\pm 0.1$  and  $3.1\pm 0.1$  respectively with the 75% MgNP having the largest stem girth.

**Table 7:** Stem girth of *Zea mays* polluted with 0.3g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>
Control	1.5±0.1	1.8±0.1	2.0±0.1	2.1±0.1	2.4±0.1	2.5±0.1
15% MgNP	1.3±0.0	1.7±0.1	1.9±0.1	2.1±0.1	2.3±0.1	2.5±0.1
30% MgNP	1.3±0.1	1.6±0.1	1.8±0.1	2.0±0.1	2.3±0.1	2.5±0.1
75% MgNP	1.4±0.1	1.8±0.1	2.0±0.1	2.3±0.1	2.5±0.1	2.6±0.1

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 8 shows the stem girth of *Zea mays* polluted with 0.9g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $1.3\pm 0.1$ ,  $1.4\pm 0.1$ ,  $1.5\pm 0.0$  and  $1.5\pm 0.1$  respectively. There were no obvious significant differences in the stem girth between all concentrations and the control. At 4 WAP, the 75% MgNP concentration had the largest stem girth with the value  $2.3\pm 0.1$ , while the control, 15% and 30% MgNPs had  $2.0\pm 0.2$ ,  $2.1\pm 0.1$  and  $2.2\pm 0.1$  respectively. At 8 WAP, the stem girth for the control, 15%, 30% and 75% MgNPs were recorded as  $2.8\pm 0.1$ ,  $2.8\pm 0.0$ ,  $2.9\pm 1.2$  and  $3.0\pm 0.1$  respectively with the 75% MgNP having the largest stem girth.

**Table 8:** Stem girth of maize plant polluted with 0.9g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>
Control	1.3±0.1	1.7±0.1	1.8±0.1	2.0±0.2	2.2±0.1	2.4±0.1
15% MgNP	1.4±0.1	1.7±0.0	1.9±0.1	2.1±0.1	2.3±0.0	2.5±0.0
30% MgNP	1.5±0.0	1.8±0.1	2.0±0.1	2.2±0.1	2.4±0.1	2.6±0.1
75% MgNP	1.5±0.1	1.9±0.1	2.0±0.1	2.3±0.1	2.5±0.1	2.6±0.1

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles

Table 9 shows the stem girth of *Zea mays* polluted with 1.5g/L of iron (ii) sulphate ( $\text{FeSO}_4$ ) treated with 3 different concentrations of MgNPs for 8 weeks. At 1 WAP, the values recorded for control, 15%, 30% and 75% MgNPs ranges from  $1.3\pm 0.1$ ,  $1.5\pm 0.1$ ,  $1.6\pm 0.1$  and  $1.3\pm 0.1$  respectively. There were no obvious significant differences in the stem girth between all concentrations and the control. At 4 WAP, the 75% MgNP concentration had the largest stem girth with the value  $2.2\pm 0.1$ , while the control, 15% and 30% MgNPs had  $2.1\pm 0.1$ ,  $2.1\pm 0.1$  and  $2.1\pm 0.1$  respectively. At 8 WAP, the stem girth for the control, 15%, 30% and 75% MgNPs were recorded as  $2.8\pm 0.1$ ,  $2.8\pm 0.1$ ,  $2.9\pm 0.1$  and  $3.1\pm 0.1$  respectively with the 75% MgNP having the largest stem girth.

**Table 9:** Stem girth of maize plant polluted with 1.5g/L of iron (ii) sulphate (FeSO<sub>4</sub>) treated with 3 different concentrations of MgNPs for 8 weeks.

<b>Concentration</b>	<b>1WAP</b>	<b>2WAP</b>	<b>3WAP</b>	<b>4WAP</b>	<b>5WAP</b>	<b>6WAP</b>
<b>Control</b>	1.3±0.1	1.6±0.1	1.8±0.1	2.1±0.1	2.3±0.1	2.4±0.1
15% MgNP	1.5±0.1	1.7±0.1	1.9±0.1	2.1±0.1	2.3±0.1	2.4±0.2
30% MgNP	1.6±0.1	1.7±0.1	2.0±0.1	2.1±0.1	2.3±0.1	2.5±0.1
75% MgNP	1.3±0.1	1.8±0.1	2.0±0.1	2.2±0.1	2.4±0.2	2.6±0.2

Values are mean ± SEM, n=5.

**Key:-** WAP: Week After Planting

MgNP: Magnesium nanoparticles



**Plate 2:** *Zea mays* plants one week after the application of magnesium nanoparticles

## CHAPTER FOUR

### DISCUSSION

Magnesium nanoparticles are a promising new technology that has the potential to improve crop yields and food security in areas where soils are low in magnesium (Zhang *et al.*, 2017). Magnesium nanoparticles' unique features can be primarily connected to the positive effects on maize growth observed in ferruginous soil as a result of their presence. These nanoparticles have a remarkable surface area to volume ratio, which improves the plant roots' ability to efficiently absorb nutrients. These magnesium nanoparticles also exhibit increased mobility within the soil matrix as a result of their small size, making them more accessible to plants' sensitive root systems and resulting in a greater uptake of vital nutrients. It's important to highlight that these nanoparticles may be essential for improving nutrient utilization effectiveness (Cakmak *et al.*, 2008). Magnesium is essential for photosynthesis, the process by which plants convert sunlight into energy as magnesium nanoparticles can help to improve photosynthesis by increasing the efficiency of the light-harvesting complexes in plant cells (Akter *et al.*, 2019).

The study investigated the impact of different concentrations of Magnesium nanoparticles (MgNPs) on the growth of *Zea mays* plants that were exposed to varying levels of iron (ii) sulphate ( $\text{FeSO}_4$ ) pollution. The growth parameters analyzed included plant height, leaf area, and stem girth. The results were observed over an 8-week period at different time points after planting. The data presented in Tables 1 through 9 provide insights into the effects of Magnesium nanoparticles on the growth of *Zea mays* under the pollution of iron (ii) sulphate ( $\text{FeSO}_4$ ).

The findings from this study demonstrated that magnesium nanoparticles applied to *Zea mays* plants promote their growth. In comparison to the control plants, the nanoparticle-treated plants were taller, had bigger leaves, and had more leaf area. Additionally, they possessed a thicker stem, indicating that they were tougher and more damage-resistant.

The results of this study are in consistent with earlier research on the effects of magnesium nanoparticles on plant growth conducted by Jayarambabu *et al.* in 2016 found similar outcomes. They discovered that when magnesium nanoparticles were added to rice plants, it led to improvements in the plants' height, the size of their leaves, and the amount of yield they produced.

Another study by Kaur *et al.* (2022) found that the application of magnesium nanoparticles to wheat plants improved their germination rate, seedling growth, and yield. This is similar to the work carried out in this study.

The results from this study generally imply that the use of nanoparticles to *Zea mays* plants actually enhance their growth. However to confirm these results and discover the ideal circumstances for applying nanoparticles to enhance plant development, additional studies are required.

## CONCLUSION

Based on the result of this study, using magnesium nanoparticles offers a potentially effective way to improve maize growth in ferruginous soil conditions. This results in plants that grow higher, have bigger leaves, more leaf area, and thicker stems, all of which are signs of greater resilience. The results from this study and other studies show that magnesium nanoparticles have the potential to transform agricultural operations by providing a sustainable means of promoting maize growth in difficult soil conditions. The development of more reliable and effective crop cultivation techniques may be facilitated by further research on their long-term effects and possible applications.

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