GROWTH VARIATION OF CROTALARIA PALLIDA IN DIFFERENT SOIL SAMPLES

Dissertation Report

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MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

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CERTIFICATE FROM FACULTY

This is to certify that the dissertation submitted by **AFSAL N**, Enrolment No. **2101225003**, titled "**GROWTH VARIATION OF CROTALARIA PALLIDA IN DIFFERENT SOIL SAMPLES**" is a record of research work done by him during the academic year 2021-2023 under my supervision in partial fulfillment for the award of Master of Science in Environmental Science. This dissertation has not been submitted for the award of any degree, diploma, associateship, fellowship or other title. I hereby confirm the originality of the work and that there is no plagiarism in any part of the dissertation.

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DECLARATION

I **AFSAL N,2101225003** hereby declare that the dissertation entitled " **GROWTH VARIATION OF CROTALARIA PALLIDA IN DIFFERENT SOIL SAMPLES**" submitted by me in partial fulfilment of the requirements for the Degree of Master of Science in Environmental Science, Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, has not been submitted for the award of any other degree or diploma, and it represents original work done by me.

Date:

Place: IGNTU, Amarkantak

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ABSTRACT

This dissertation investigates the growth variation of *Crotalaria pallida*, a nitrogen-fixing leguminous plant with ecological significance, across five distinct soil samples: Agricultural Land, Barren Land, Dense Forest, Home Garden, and Shrub Land. The study assesses the influence of soil composition, specifically nutritional levels (N, P, K), soil pH, electrical conductivity (EC), and organic carbon content, on the growth of *Crotalaria pallida*.

The results show considerable growth differences between soil types, with Agricultural Land, Dense Forest, Shrub Land supporting the most vigorous development and Barren Land fostering the slowest. The study discovers links between particular soil factors and plant growth, such as the beneficial impacts of organic carbon content.

Keywords: Crotalaria Pallida, Soil Properties, Plant Growth Variation.

LIST OF ABBREVIATION

Abbreviation	Explanation
AL	Agricultural land
BL	Barren Land
DF	Dense Forest
HG	Home Garden
SL	Shrub Land
OC	Organic Carbon
EC	Electric Conductivity
C.Pallida	Crotalaria Pallida

CHAPTER-1

1. INTRODUCTION

Gaining insight into how plants interact with the soil around them holds significant importance in today's agricultural and ecological studies. The way plants grow and flourish is deeply influenced by the properties of the soil – things like how it feels, what's in it, and the living organisms it hosts. This makes soil a key player in deciding how healthy and productive plants become, and how stable the whole ecosystem remains. In this context, the exploration of how different types of soil impact the growth of various plant species emerges as a crucial pathway for untangling the intricacies of how plants and soil work together. This research delves into the behavior of the captivating *Crotalaria pallida* plant, as it interacts with different soil compositions. The aim is to uncover the subtle connections that steer its growth patterns. Picture it like reading a plant's journal to uncover its special relationship with the soil. By doing so, we're peeling back the layers of nature's narrative and discovering ways to enhance the smartness and health of our agriculture and environment.

Crotalaria pallida is a type of plant that's part of the Fabaceae family (F. M. Singha & Sharma, n.d.). It's pretty amazing because it can easily adjust to different situations and has a big impact on the environment. This makes it a perfect choice for studying how the ground and plants work together. People have noticed that this plant has a talent – it can take something called nitrogen from the air and use it to improve the soil. It's like giving the soil a healthy boost! This is important for farms because it could help them grow crops in a way that takes care of the environment. In this study, we're like investigators. We're going to carefully watch how *Crotalaria pallida* behaves in different kinds of soil. By doing this, we want to learn not just about how plants and soil cooperate but also to come up with smart ideas for helping crops grow better and keep nature balanced. Think of it like putting together pieces of a puzzle that helps farmers and the environment thrive.

This study is like a deep dive into the different aspects of soil. We're looking closely at how the soil feels, what's in it, and the living things inside it. And we're curious about how all of this affects the way *Crotalaria pallida*, the special plant we're studying, grows. We're checking out things like how the soil particles are, what nutrients are available, how acidic or not the soil is, the tiny creatures living in the soil, and how well the soil can hold onto water. All of these things together influence how *Crotalaria pallida* grows. It's like solving a mystery where we're trying to figure out how these different parts of the soil puzzle make the plant change. This close look helps us understand the secrets behind how *Crotalaria pallida* adapts and grows in different soil conditions, teaching us how it works its growth magic.

Considering the big problems our world faces like more people, making sure there's enough food, and taking care of our lands in a smart way, the discoveries from this research can be really helpful. It's like a treasure chest of knowledge that could guide farmers in growing crops better and help us take care of nature. By figuring out how *Crotalaria pallida* responds to different types of soil, we're not just learning cool stuff about plants, but we're also finding ways to make crops grow more, using land wisely, and being kind to the environment. It's like finding a bunch of keys that can unlock better farming practices. This study isn't just important for people who study plants or dirt – it's like a gift to the whole farming community, the people who care about the earth, and the ones who want to make sure we have enough food without harming the planet. It's like a big step forward in understanding how plants and different soil types work together, helping us figure out smart ways to make things better for everyone.

1.1 Crotalaria Pallida

Table 1

Plant Taxonomy

Kingdom	Plantae
Order	Fabales
Family	Fabaceae
Subfamily	Faboideae
Genus	Crotalaria
Species	C.pallida
Binomial Name	Crotalaria Pallida Aiton

(Zhou et al., 2021)

Crotalaria pallida is a leguminous plant of the Fabaceae family. It is native to the tropics and subtropics and is also known as the pale rattlebox. This plant is an important source of feed and green manure, and its potential to create symbiotic partnerships with beneficial bacteria like as mycorrhizal fungi and rhizobia has been intensively explored. These bacteria are essential for increasing plant development and soil fertility (F. M. Singha & Sharma, n.d.).

Crotalaria pallida, sometimes known as the showy rattlebox, is a Fabaceae family flowering plant. It is native to tropical and subtropical locations, most notably Africa, Asia, and Australia. This plant species is an annual or short-lived perennial herb that can reach a height of one meter. It is native to tropical and subtropical locations, most notably Africa, Asia, and Australia. *C pallida* is an annual or short-lived perennial herb that can reach a height of one meter. This species is not just any plant. It has been used for centuries for its medicinal properties and ability to improve soil fertility. But what makes it truly unique is its stunning yellow flowers that bloom in summer. These flowers add beauty to the landscape and attract pollinators like bees and butterflies (Boldrin et al., 2013).

Crotalaria L. is one of the world's largest genera, with over 700 species found primarily in tropical and subtropical climates, with the greatest concentration in Africa. It is also India's largest legume genus, with 93 species, two subspecies, 17 cultivars, and two formae. During a botanical investigation in Maharashtra's Western Ghats, a few Crotalaria specimens were collected from Gophan in Raigad District and later identified and confirmed as Crotalaria pallida Aiton var. obovata (G. Don) Polhill (*CrotalariapallidaAitonvar.ObovataG.DonPolhillFabaceae-AnextendeddistributionforGujaratMaharashtraGoaKarnataka*, n.d.).

Crotalaria pallida is a fast-growing plant that can grow up to 2 metres tall. It has a deep taproot system that allows it to acquire soil minerals and water. Crotalaria pallida's leaves are alternating, simple, and oval in shape. The yellow blooms are borne in racemes. The fruit is a cylindrical pod containing many seeds. Crotalaria pallida is a resilient plant that can grow in a variety of soil types and climates. It is drought-hardy and may thrive in locations with little rainfall. This plant is a key crop for farmers all over the world and has the potential to greatly contribute to sustainable agriculture (F. M. Singha & Sharma, n.d.).

C. pallida is an indigenous legume species that was included in a field study in Zimbabwe to evaluate the establishment and nitrogen fixation patterns of fifteen indigenous legume species, according to the publication. *C. pallida* showed emergence rates of more than 15% and consistently fixed a large amount of nitrogen (Tauro et al., 2009).

Crotalaria pallida growth is affected by several factors, including soil type, climatic conditions, and the presence of helpful bacteria. Mycorrhizal fungi and rhizobia have been proven in studies to considerably increase the growth of Crotalaria pallida. Inoculation with these beneficial bacteria can boost the availability of minerals like phosphorus and nitrogen, both of which are required for plant growth (F. M. Singha & Sharma, n.d.).

Pests and diseases can also have an impact on the growth of *Crotalaria pallida*. Insect pests such as aphids and thrips can cause harm to the plant's leaves and blooms, resulting in reduced growth. *C. pallida* growth can also be hampered by diseases such as root rot and leaf spot. Crop rotation, the adoption of resistant types, and the application of fungicides can all assist in reducing the impact of pests and diseases on plant growth (F. M. Singha & Sharma, n.d.).

In addition to these parameters, *Crotalaria pallida* growth can be influenced by the plant's age. Young plants grow faster than older plants, and the pace of growth might moderate as the plant grows. Overall, Crotalaria pallida growth is a complex process influenced by a range of factors, and good management practices are required to ensure optimal development and output (F. M. Singha & Sharma, n.d.).

1.1.1 Uses of Crotalaria Pallida

An important application is its contribution to agriculture and horticulture. This plant possesses the ability to fix nitrogen, forming a mutually beneficial partnership with specific bacteria that convert atmospheric nitrogen into a form that plants can easily absorb(DAIMON et al., 1995a). This characteristic renders it valuable as a cover crop or green manure, especially in areas where the soil lacks essential nutrients. Many farmers and gardeners include Crotalaria pallida in their cultivation methods to enhance soil fertility and encourage environmentally conscious agricultural approaches.

An additional use of Crotalaria pallida revolves around its possible medical attributes. Diverse traditional herbal medicinal practices across various global regions have utilized different components of the plant due to their presumed healing advantages. Some research indicates that specific compounds present in Crotalaria species showcase properties like reducing inflammation, alleviating pain, and acting as antioxidants (Bulbul et al., 2018). Nevertheless, it's crucial to highlight that the plant harbours alkaloids which, when consumed excessively, can be hazardous. This underscores the necessity for cautious and well-informed utilization.

Moreover, Crotalaria pallida has the potential to function as a natural repellent against insects and as an element within comprehensive pest control approaches (F. Singha & G. Sharma, 2013). Specific types of Crotalaria are recognized for generating compounds that discourage particular insects and pests. Consequently, agriculturalists and garden enthusiasts might intentionally cultivate *Crotalaria pallida* to strategically diminish the presence of harmful insects. This approach can lead to a decreased reliance on chemical pesticides ("Crotalaria Pallida (Smooth Crotalaria)," 2022).

Within the realms of landscaping and reforestation initiatives, *Crotalaria pallida* holds the potential to be employed for the management of soil erosion. Its extensive network of deep roots plays a role in steadying the soil, thereby averting erosion in regions susceptible to surface water runoff and deterioration. This attribute can prove especially advantageous when applied to rehabilitation endeavours in areas that have undergone deforestation or experienced various types of land deterioration(Tauro et al., 2009).

While *Crotalaria pallida* has various possible applications, it is critical to approach its use with careful consideration of its environmental impact as well as any potential concerns related to its poisonous chemicals. When incorporating this plant into diverse uses, whether in agriculture, medicine, or ecological restoration, it is critical to employ a well-informed strategy that considers both its merits and limitations to achieve beneficial results.

1.2 Soil Properties

Soil properties are an important part of agriculture and have an important impact on crop growth success. Soil's physical, chemical, and biological qualities are all linked and influence one another. These properties can be broadly classified into four categories: physical, chemical, biological, and mechanical.

1.2.1 Physical Properties

Texture, structure, bulk density, porosity, and water-holding capacity are all physical features of soil. The size of soil particles, which can range from sand to clay, is referred to as soil texture. The arrangement of soil particles into aggregates, which can alter water and air circulation in the soil, is referred to as soil structure. The weight of soil per unit volume is referred to as bulk density, and it has an impact on root growth and soil compaction. The amount of space between soil particles, which can affect water and air circulation in the soil, is referred to as porosity. The ability of soil to hold water, which can affect plant growth, is referred to as water-holding capacity (Chaudhari et al., 2021).

1.2.2 Chemical Properties

pH, nutrient content, and cation exchange capacity are all chemical features of soil. Soil pH is a measure of soil acidity or alkalinity, which can influence nutrient availability and plant growth. The amount of vital elements such as nitrogen, phosphorus, and potassium in the soil that are required for plant growth is referred to as nutrient content. The ability of soil to hold and exchange positively charged ions such as calcium, magnesium, and potassium, which can alter nutrient availability, is referred to as cation exchange capacity (Cahyono et al., 2019).

1.2.3 Biological Properties

Microorganisms such as bacteria, fungi, and protozoa, as well as bigger organisms such as earthworms and insects, are biological features of soil. These organisms are vital to nutrient cycling, soil structure building, and plant growth. Beneficial microbial populations aid in the breakdown of complex organic components into accessible nutrients, hence increasing plant nutrition availability. Symbiotic connections between mycorrhizal fungus and plant roots improve nutrient uptake and water absorption. Furthermore, soil organisms aid in soil aggregation, improving soil structure and water infiltration, both of which are essential for root penetration and good plant growth. In turn, plant roots exude exudates that feed soil bacteria, creating a dynamic feedback loop. Thus, cultivating a broad and balanced soil biota can considerably improve plant growth, resilience, and overall terrestrial ecosystem sustainability (AKAY & SERT, 2020).

1.2.4 Mechanical Properties

Soil strength, shear strength, and compressibility are examples of mechanical properties. The ability of soil to resist deformation or failure under load is referred to as soil strength. The ability of soil to resist sliding along a plane is referred to as shear strength. The ability of soil to be compressed under load is referred to as compressibility. Soil mechanical qualities have a significant impact on plant growth and development. The relative quantities of sand, silt, and clay particles in soil texture have a direct impact on the soil's water-holding capacity, drainage properties, and aeration. Sandy soils have bigger particles and drain quickly, which can cause plant water and nutritional deficits. Clay-rich soils, on the other hand, have smaller particles and can get compacted, restricting root penetration and water infiltration. The structure of the soil, dictated by particle aggregation and organization, influences root penetration as well as air and water circulation. Compacted soils restrict root growth and can cause poor water drainage, depriving plants of oxygen and nutrients. Soil compaction can also restrict soil pore space, reducing the soil's ability to store water for plants during dry periods. (Sung et al., 2017).

1.3 Objectives

The study hypothesizes that the availability of essential nutrients in different soil types will have a direct correlation with the growth performance of Crotalaria pallida, resulting in overall plant health and size. To test this hypothesis, the study was carried out with the following objectives,

1. To Assess Growth Parameters: Measure and compare parameters such as plant height and leaf count of *Crotalaria pallida* in various soil samples.
2. To Analyze Soil Composition: Determine the physicochemical properties of the different soil samples, including pH, nutrient content (nitrogen, phosphorus, potassium), and organic matter content.
3. To Examine Organic Carbon Impact: Determine the influence of Organic Carbon on plant growth in limited nutrients by analyzing the relationship between the concentration of organic carbon in different soil samples and *Crotalaria pallida* growth outcomes.

CHAPTER-2

2. REVIEW OF LITERATURE

The literature review will be divided into many important parts, each covering a distinct feature of C. pallida development in different soil samples. It will present an overview of the current level of knowledge on this topic, highlight major research findings, and provide the groundwork for the subsequent empirical investigation. Finally, the goal of this research is to improve our understanding of plant-soil interactions, increase our understanding of C. pallida's adaptability, and provide practical insights for sustainable land use and agricultural practices.

The study, "Effects of Mycorrhizal Fungi and Rhizobia Inoculation on the Growth of Crotalaria Pallida- An Approach to Tripartite Symbiosis," was published in the journal Global Research Analysis in June 2013. F. Malina Singha and G. D. Sharma, the paper's authors (F. M. Singha & Sharma, n.d.), conducted a study to investigate the impact of these beneficial bacteria on the growth of the leguminous plant. The research finishes by emphasizing the potential of mycorrhizal fungi and rhizobia as biofertilizers for Crotalaria pallida cultivation. According to scientists, the utilization of these beneficial bacteria can considerably contribute to sustainable agriculture and improve soil fertility. The research sheds light on the significance of mycorrhizal fungi and rhizobia in increasing plant growth and improving soil fertility, as well as the potential of these beneficial bacteria in leguminous plant cultivation.

In the study of "Germination, field establishment patterns and nitrogen fixation of indigenous legumes on nutrient-depleted soils" conducted by Tauro and his colleagues stated that C. pallida is an indigenous legume species that was included in a field study in Zimbabwe to evaluate the establishment and nitrogen fixation patterns of fifteen indigenous legume species, according to the publication. According to the article, C. pallida showed emergence rates of more than 15% and consistently fixed a large amount of nitrogen (Tauro et al., 2009).

The study conducted in the year 1995 by Daimon and colleagues looked at the interspecific variations in growth and nitrogen uptake among three Crotalaria species, to determine if they may be used as green manure legumes. C. juncea had a high dry weight and nitrogen content in the early growth stage, but underwent defoliation and a high C-N ratio in the late growing stage, according to the data. C. pallida developed slowly at first, but later it had a high nitrogen content and an acceptable C-N ratio for breakdown. C. spectabilis exhibited intermediate dry matter production and nitrogen absorption characteristics. The root system and root nodule distribution patterns differed amongst the three species. When selecting green manures for diverse cropping systems, these characteristics should be taken into account (DAIMON et al., 1995).

Uratani, Daimon, and others conducted a study on the topic "Ecophysiological Traits of Field-Grown Crotalaria incana and C. pallida as Green Manure" in the year 2004 has discovered that both Crotalaria species demonstrated rapid vegetative development, with leaf area enhanced in C. pallida and branching promoted in C. incana. C. pallida had twice the top dry weight. The paper also discovered that the subterranean sections of legumes were quantitatively assessed concerning nitrogen supply via microbial biomass. The study indicated that both Crotalaria species could be utilized as green manure, however, C. pallida was more successful in terms of nitrogen supply than C. incana (Uratani et al., 2004).

The article on the topic "Exploration of Fatty Acid from the Seed Oil of Crotalaria pallida Aiton for Its Healthcare and Antibacterial Efficacy" in the year 2019 indicates that the seed oil of Crotalaria pallida has potential therapeutic and antibacterial efficacy due to its high amount of saturated fatty acids and effectiveness against both Gram-positive and Gram-negative bacteria. The work is the first attempt to investigate the seed oil of C. pallida and gives useful information for future research on its possible applications (Ukil et al., 2019).

The study conducted on the topic "Pharmacological activity investigation of Crotalaria pallida" has looked into the pharmacological activities of a plant extract called *Crotalaria pallida*. The extract was created with methanol and tested for biological activity against a variety of bacteria. As a result, the research indicates that Crotalaria pallida plant extract possesses high pharmacological activity and has the potential to be employed as a traditional medicine (Mahmud et al., 2019).

According to the study conducted by S. Bhuyan and his colleagues in the year 2019 has concluded the study that root nodules of Crotalaria pallida cultivated in Assam include a variety of plant growth-promoting rhizobia strains. These isolates were identified and characterized using morphological and physiological characteristics. The physiological characteristics of the isolates varied greatly, including phosphate solubilization efficiency, IAA generation, pH, and salt tolerance ability. The presence of the nifH gene was discovered in six isolates by nifH gene analysis. The isolates were classified into three kinds of 16S rDNA. Overall, the findings indicate that Crotalaria pallida could be a source of plant growth-promoting rhizobia (S. Bhuyan et al., 2019).

The study conducted in the year 2013 by Singha and G. Sharma looked at the impact of mycorrhizal fungi and rhizobia inoculation on Crotalaria pallida growth. The researchers discovered that plants treated with VAM spores and rhizobia grew faster than those that were not. According to the authors, using helpful microorganisms can considerably boost crop development. However, the paper does not make any additional conclusions (Singha & G. Sharma, 2013).

The paper established by Bulbul and his co-researchers in the year 2018 has concluded that an ethanolic extract of Crotalaria pallida leaves has considerable anti-nociceptive and anti-inflammatory properties, confirming the plant's traditional use in the treatment of different disorders linked with pain and inflammation. According to the findings, C. pallida could be a natural and safe treatment for analgesia and inflammation. The authors also believe that isolating pure secondary metabolites from the plant will aid in understanding the mechanism of these activities and in identifying primary chemicals with clinical usefulness (Bulbul et al., 2018).

According to the article published by Chaudhari and his co-researchers has found that continued agricultural usage necessitates improved soil management practices to improve soil's physical, chemical, and biological quality. Organic soil additions can help increase soil quality, plant development, and soil microbiology. Biofertilizer, green manure, compost, charcoal, biogas slurry, wasted mushroom compost, and kelp weed have all been examined for their effects on soil characteristics, microflora, and plant growth. The report gives particular examples of how these supplements affect soil parameters like nitrogen content, bulk density, humus content, and enzyme activity, as well as plant development and soil pathogens. Mulching is sometimes mentioned as a way to keep soil moisture in check (Chaudhari et al., 2021).

The article on the topic Influence of soil microorganisms and physicochemical properties on plant diversity in an arid desert of Western China suggests that soil microorganisms and physicochemical qualities are the two most critical elements in maintaining plant variety in arid desert tree patches. The study discovered that soil physicochemical parameters are the most important factor influencing plant diversity in these patches. Soil fungi were shown to limit plant diversity, whereas bacteria boosted it in tree patches. Plant and soil microbial diversity increased as one moved away from large trees, while soil physicochemical properties (such as soil water, soil organic matter (SOM), salinity, total phosphorus, and nitrogen, pH, soil bulk density, and fine root biomass) decreased(Yang et al., 2021).

Rai and Chatrath had conducted a study on the topic "Effects of soil viscosity, soil temperature, and specific gravity on plant growth sown in soil prepared from laboratory chemical waste" in the year 2019 and they found that plant growth is affected by changes in soil viscosity, temperature, and density. All plants cannot possibly grow at the same temperature, viscosity, or density. To reduce pollution, the use of chemical wastes rather than fertilizers is being considered. The study helped to learn that every plant has different nutrient, dietary, and physical requirements for growth. The study also helped to realize that, while the soil is initially the same, the viscosity and density of the soil alter as a result of the plants grown in it (Rai & Chatrath, 2019).

The paper published by Luo and his co-researchers stated that in the controlled field trial, concrete grinding residue (CGR) applications up to 8.96 kg m2 had no significant effect on soil physical parameters or plant development. CGR had no significant effects on soil physical parameters such as bulk density, saturated hydraulic conductivity, or water infiltrability, according to the study (Luo et al., 2019).

According to the paper published on the topic "Variations of agricultural soil quality during the growth stages of sorghum and sunflower" in 2020 has found that plant species and growth stages can influence the structure and functionality of the soil microbial community. The study also discovered that management practices including soil tillage and mineral fertilization can alter soil quality. The researchers calculated a soil quality index and discovered that it dropped during plant growth, with statistically significant differences between soils with and without roots already happening after two weeks of seeding. The article found that plant growth and crop management practices have an impact on soil quality and the soil microbial community, which can have consequences for crop yield and environmental sustainability(Panico et al., 2020).

The research on the year 2019 found that plants and their environment have a reciprocal relationship in which soil physiochemical qualities influence plant morphology and metabolism while root morphology and exudates shape the environment surrounding roots. In all laboratories, plants grown in soil extract were morphologically and metabolically unique, with root hairs four times longer than in other growth environments. Plants also depleted 50%

of the examined metabolites from soil extract. According to the findings, to interact with their environment, plants not only change their morphology and generate complex metabolite combinations, but they also selectively deplete a variety of soil-derived compounds (Sasse et al., 2019).

The article by Patel and his colleagues has concluded that salinization of soil has a negative impact on Fabaceae seedling growth, water status, and nutrient accumulation. Increased soil salinity reduced tissue water potential, resulting in an internal water deficit in plants and a considerable drop in seedling growth. Proline content in tissues increased as salinity increased, while phosphorus, calcium, and magnesium concentrations fell dramatically. The content of potassium and sodium in tissues rose dramatically as salinity increased. The study also determined the salt concentration at which the dry weight of different tissues would be reduced to 50% of the control plant (Patel et al., 2010).

The paper published on the topic "Stabilization and destabilization of soil organic matter: mechanisms and controls" in 1996 stated the importance of soil physical conditions and their influence on root growth and function is discussed in this work. It also emphasizes how roots can influence their surroundings. The paper's principal conclusion is that soil physical parameters interact with root growth and development and that both soil and plant management can affect the root system. The book is intended for researchers and advanced students in soil and plant sciences, as well as agronomists and other related professionals (Sollins et al., 1996).

The paper by Onwuka in 2018 addressed how soil temperature affects soil characteristics and plant growth. The paper concludes that soil temperature is a key element influencing soil physical, chemical, and biological processes involved in plant growth. It regulates gas exchange activities between the atmosphere and the soil, controls organic matter breakdown and mineralization, and influences soil water retention, transfer, and availability to plants. Soil temperature acts as a stimulant for numerous biological processes, influencing soil moisture, aeration, and the availability of plant nutrients required for plant growth (onwuka, 2018).

Jan and Jerzy conducted a study in the year 2017 and concluded that the importance of soil physical conditions and their influence on root growth and function is discussed in this work. It also emphasizes how roots can influence their surroundings. The paper's principal conclusion is that soil physical parameters interact with root growth and development and that both soil and plant management can affect the root system. The book is intended for researchers and advanced students in soil and plant sciences, as well as agronomists and other related professionals (Jan & Jerzy, 2017).

The research on the topic Role of "Carbon cycle in soil productivity and carbon fluxes under changing climate" examined the function of the carbon cycle in soil productivity and carbon fluxes in the face of climate change. The paper's main conclusions are that soil organic carbon is important for soil health, fertility, and productivity, providing nutrients to plants and improving water availability and soil structure and that the carbon cycle is critical for human well-being, food production, and climate regulation (Farooqi et al., 2021).

The research in the year 2013 concluded that soil organic matter is critical to the maintenance and improvement of soil qualities such as physical, chemical, and biological aspects. Increases in organic matter improve certain qualities, while decreases in organic matter have the opposite effect. The report also emphasizes the ecological importance of organic matter in terms of ecosystem productivity, soil health, and climatic quality. The dynamic role of soil organic matter in the maintenance and improvement of soil qualities can help offset the depletion of agricultural land caused by population growth and increased food demand (Stockmann et al., 2013).

According to the research conducted by Reddy in 2016 has found the benefits of soil organic matter (SOM) for soil health and plant growth are discussed in this paper. The paper concludes that SOM is vital for preserving soil quality, nitrogen cycling, water-holding capacity, and drainage improvement, as well as helping to reduce soil compaction and crusting. It is responsible for healthy plants that are resistant to insect pests and diseases as well as drought tolerance, and the addition of organic matter to soil can enhance agricultural yields (Reddy, 2016).

The study by Walter in 2018 has examined the significance of soil pH in determining soil qualities and crop and pasture suitability. It is usual practice to pick crops based on soil pH or to apply lime and other additions to adapt soil reactivity to crop requirements. However, soils with similar pH levels do not necessarily have the same features or limitations for plant growth, nor can the same response to pH changes be predicted, depending on other chemical and physical aspects of the soil. As a result, various soil parameters, in addition to pH, must be considered for improved plant productivity. The paper makes no precise findings but emphasizes the significance of examining diverse soil parameters for improved plant productivity (Walter, 2018).

The paper published by Kerry on 1943 on the topic Changing the pH has addressed how soil pH affects plant development and nutrient availability. The report indicated that soil pH had a direct impact on plant nutrition availability. The majority of plant nutrients are most accessible between pH 6.0 and 6.5. Nitrogen is most soluble between soil pH 4 and soil pH 8. These findings imply that keeping soil pH within the appropriate range can increase plant growth and nutrient uptake(Kerry, 1943).

CHAPTER-3

3. MATERIALS AND METHODS

In this chapter, the focus is on detailing the materials employed in the experiment as well as outlining the experimental design.

3.1 Study Site.

The study was conducted in the experimental lab of the Department of Environmental Science, Indira Gandhi National Tribal University, located in Lal Pur, Amarkantak, Madhya Pradesh, India. This experiment took place throughout the summer months of April and May (35-37°C)

3.2 Seed Collection.

The process of seed collection entailed procuring viable *Crotalaria pallida* seeds from their indigenous habitat. This collection occurred in the month of April, specifically within the premises of Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh. Seeds were sourced from numerous mature plants that displayed robust growth and were in the flowering stage. Diligence was exercised to exclude seeds from plants exhibiting any indications of disease, infestation by pests, or physical harm.

3.3 Soil Collection.

Sampling sites were carefully selected to represent a diverse range of soil types within the study area. A total of five distinct locations were chosen, covering a variety of ecological conditions, including Dense Forest, Shrubland, Barren Land, Agricultural Land, and Home Garden. All the soil samples collected from Lal Pur Hill and nearest places, opposite to the main gate of IGNTU, Amarkantak, Madhya Pradesh.

The latitude and longitude of the soil collected area

- Dense Forest: (22° 47' 9.90" N, 81° 45" 17.68" E)
- Shrubland: (22° 47' 15.40" N, 81° 45' 3.85" E)
- Barren Land: (22° 47' 20.95" N, 81° 45' 7.89" E)
- Agricultural Land: (22° 47' 23.18" N, 81° 45' 16.97" E)
- Home Garden: (22° 47' 28.74" N, 81° 45' 8.04" E)

Figure 1. Soil Sample locations

A systematic soil sampling approach was employed to ensure representativeness. At each selected site, a random sampling scheme was applied. A spade was used to collect the soil samples from a depth of 10 centimeters at each predetermined sampling point. These samples were collected in sterile, labeled containers to avoid contamination. Each soil sample was carefully labeled with the site name. The samples are dried at atmospheric temperature and remove the gravel and debris manually. Next, the soil samples undergo analysis to assess various parameters, including pH levels, electrical conductivity (EC), organic carbon (OC), and the availability of essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K).

3.4 Plant Growth Experiments

3.4.1 Planting and Pot Preparation

Twenty-five small coffee cups were filled with each soil sample, making a total of 125 cups filled with various soil samples. Each cup is marked with the soil sample's name and a number ranging from 1 to 25. Prior to filling, any debris and gravel were removed, and the soil was crushed. Before planting the seeds of *Crotalaria pallida*, they were soaked in warm water and covered with floating paper for one day to enhance germination. The seeds were sown into the soil after one-day treatment. They were watered twice daily, both in the morning and evening.

3.4.2 Data Collection.

The parameters such as plant height and the number of leaves were assessed using a centimeter ruler, and these measurements were recorded at four-day intervals.

3.4.4 Statistical Analysis.

The data collected over a one-week period was used to calculate the average plant height, seed germination rate, and leaf count for Crotalaria pallida in each type of soil sample. These plant parameters were computed based on the recorded data. To visually compare the variations across different soil samples, graphs were generated, depicting the values of these plant parameters.

$$Average\ stem\ height\ = \frac{Length\ of\ all\ sampled\ seedlings\ or\ plants\ in\ a\ soil\ sample}{No.of\ sampled\ seedlings\ or\ plants\ in\ a\ soil\ samples}$$

$$Seed\ germination\ rate\ (\%) = \frac{No.of\ seedling\ sprouted\ in\ one\ soil\ sample}{Total\ no.of\ seeds\ sown\ in\ a\ soil\ sample} \times 100$$

$$No.of\ leaves\ per\ plant = \frac{Total\ no.of\ leaves\ all\ sampled\ seedlings\ or\ plants}{Total\ no.of\ plants\ sampled\ in\ a\ soil\ sample}$$

$$Survival\ rate\ (\%) = \frac{No.of\ plants\ alive\ after\ last\ week\ of\ experiment\ in\ a\ soil\ samples}{Total\ no.of\ plants\ in\ a\ soil\ sample} \times 100$$

3.5 Soil Analysis.

3.5.1 Determination of pH in Soil and Electrical Conductivity (EC).

Soil pH and Electrical Conductivity (EC) were determined using a hand-held and portable meter (also called “pen” meters used to determine pH, EC and, TDS). For each soil sample take 5gm of soil and 25ml distilled water (1:5 soil-to-water ratio), and stir the suspension with a glass rod intermittently for about 30 minutes. Then determine the soil pH by using the device. pH readings were taken in triplicate for each sample and the average value was recorded. For the assessment of EC, the same suspension was stirred with a mechanical shaker and filtered the suspension by using Whatman filter paper and EC was measured. Readings were taken in triplicate and averaged.

3.5.2 Determination of Organic Carbon in Soil (Walkley & Black, 1934)

The Walkley and Black method is a widely used technique for determining the organic carbon content in soil. It involves chemically digesting a soil sample with sulfuric acid and potassium dichromate, which oxidizes the organic carbon to carbon dioxide. The excess dichromate is then titrated, and the amount consumed is used to calculate the organic carbon content. This method is valuable for assessing soil fertility and its role in carbon cycling within ecosystems. It provides crucial insights into soil health and its potential for carbon sequestration (Walkley & Black, 1934).

3.5.3 Determination of Available Nitrogen in Soil (Subbiah & Asija, 1956)

The Subbiah and Asija method is a widely recognized technique for assessing the availability of nitrogen in soil. This method involves the chemical extraction of nitrogen from soil samples using a solution containing sodium hydroxide (NaOH) and sodium hypochlorite (NaOCl). After extraction, the nitrogen content is determined by titration. This method provides valuable information about the amount of nitrogen that is readily accessible to plants, aiding in soil fertility assessments and crop management decisions. It is a crucial tool for optimizing agricultural practices and ensuring efficient nitrogen utilization in soil ecosystems (Subbiah & Asija, 1956).

3.5.4 Determination of Available Phosphorus in Soil (Olsen et al., 1954)

The Olsen et al. method is a well-known way to figure out how much usable phosphorus is in the soil. This method takes soil samples and uses a solution with sodium bicarbonate ($NaHCO_3$) to get out the phosphorus that plants can use. After this is done, the amount of phosphorus in the solution is measured using special techniques that look at colors or light. The Olsen method is really good at telling us how much phosphorus plants can easily get from the soil. It's helpful to figure out how healthy the soil is for growing crops and helps us manage phosphorus well in farming. This method gives us important information about the nutrients in the soil and helps farmers make smart choices for their crops (Chapman & Pratt, 1961).

3.5.5 Determination of Available Potassium in Soil (Chapman & Pratt, 1961b)

The Chapman and Pratt method is a way that people often use to find out how much useful potassium is in the soil. They start by mixing soil samples with a special liquid called ammonium acetate. This liquid helps to release the potassium that plants need. After waiting for a bit, they separate the soil from the liquid by using a filter. Then, they measure how much potassium is in the liquid. They usually do this using special tools like a flame photometer or something called atomic absorption spectroscopy. The Chapman and Pratt method is really good for figuring out how much potassium plants can easily get from the soil. It gives us important information about the soil's nutrients and helps us decide how to take care of plants better (Chapman & Pratt, 1961)

Figure 2. Soil Collection and Preparation

Figure 3. Seeds of Crotalaria pallida

Figure 4. Plant Experiment

Figure 5. Soil Analysis

CHAPTER-4

4. RESULT AND DISCUSSION

This chapter outlines the present study's results and discussions according to the data collected through the experiment. The measurement and comparison of parameters such as seed germination rate, how many days takes the seeds to start to grow, the number of plant-appeared leaves, the mean value of plant height, the average leaf count of *Crotalaria pallida*, and survival rate in various soil samples and also the measurements of soil analysis are,

4.1 Comparing Seed Germination Time and Leaf Emergence

Engaging in a discussion regarding the assessment and contrast of factors like the duration it takes for seeds to initiate growth and the number of plants appearing on leaves.

4.1.1 Agricultural Land

The number of seedlings that started growth and the number of plant-appeared leaves are being measured and compared in soil samples from agricultural land are,

Table 2

Number of Seeds Started Germination (AL)

Number of Weeks	Number of Seeds Started to Germination
Week-1	20
Week-2	21
Week-3	24
Week-4	25
Week-5	23
Week-6	22
Week-7	16
Week-8	12

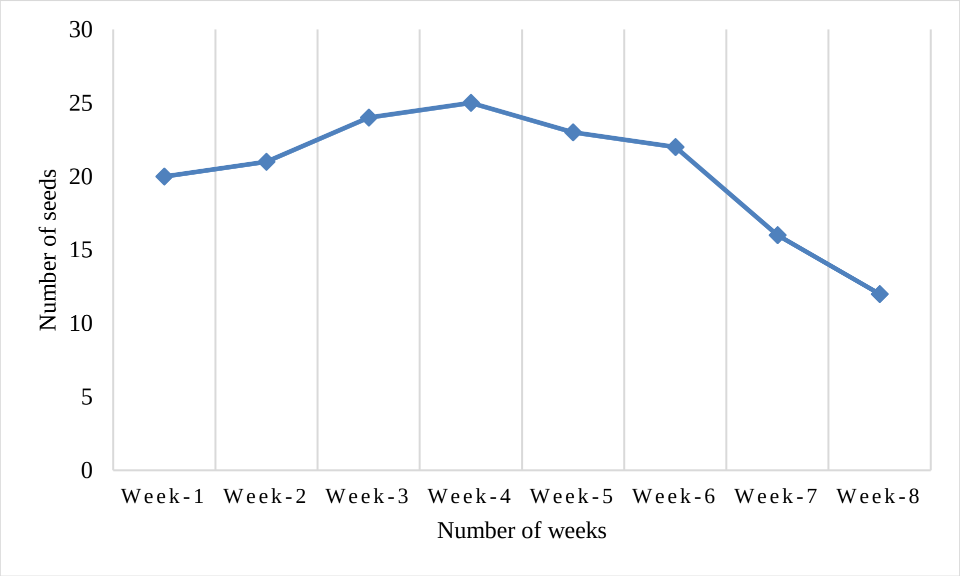

Figure 6. Number of seeds started to grow (AL)

As per the above table and graph, it can be seen that the maximum number of seeds (25 out of 25) started to grow on week four. In the last week of the experiment, some plants were dried completely. twelve plants survived after eight weeks on agricultural soil.

Table 3

Number of Plants Showing Leaves (AL)

Number of Weeks	Number of Plants Appeared Leaves
Week-1	0
Week-2	11
Week-3	17
Week-4	22
Week-5	23
Week-6	22
Week-7	18
Week-8	12

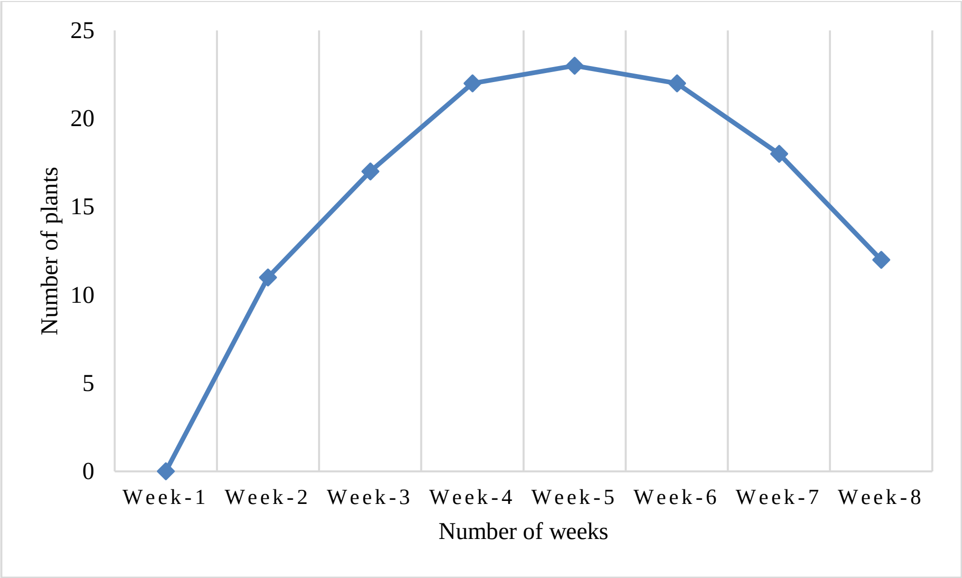

Figure 7. Number of plants appeared leaves

The table and graph above clearly depict the most significant number of plants (23 out of 25) that appeared leaves on week five. After week 5 some of the plants started to dry.

4.1.2 Barren Land.

The number of seedlings that started to shoot growth and the number of plant-appeared leaves of *Crotalaria pallida* are being measured and compared in barren land samples are,

Table 4

Number of Seeds Started Germination (BL)

Number of Weeks	Number of Seeds Started to Germination
Week-1	14
Week-2	18
Week-3	18
Week-4	13
Week-5	9
Week-6	7
Week-7	4
Week-8	1

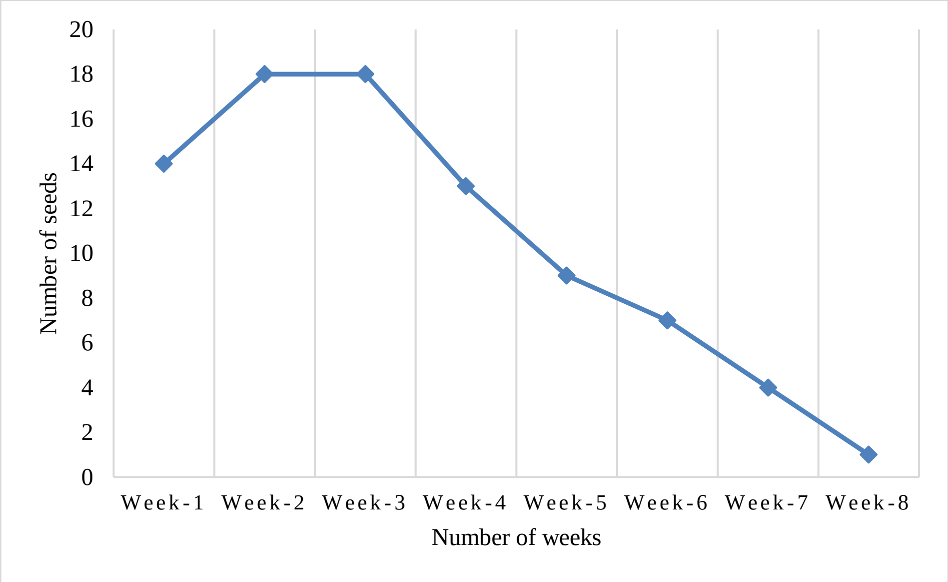

Figure 8. Number of seeds started to grow (BL)

The table and graph above illustrate that the most seeds (28 out of 25) began to arise on both week three and week four. During the final week of the assessment, entire plants except one were entirely desiccated. After eight weeks on barren land, only one plant survived.

Table 5

Number of Plants Showing Leaves (BL)

Number of Weeks	Number of Plants Appeared Leaves
Week-1	0
Week-2	0
Week-3	5
Week-4	3
Week-5	3
Week-6	7
Week-7	4
Week-8	1

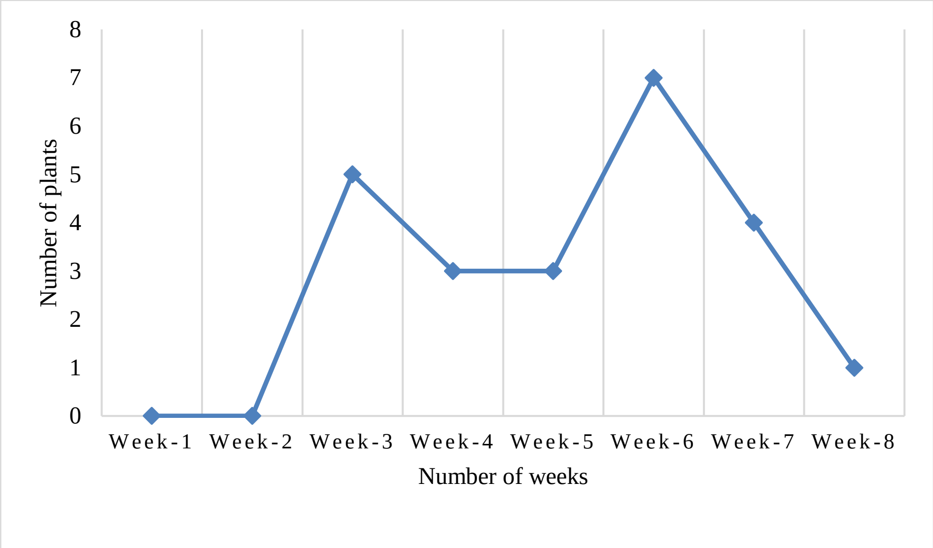

Figure 9. Number of plants appeared leaves (BL)

The highest number of plants (7 out of 25) appeared leaves on week six, according to the above table and graph. Only after two weeks did the seedlings begin to sprout leaves. After week six, most of the plants began to dry out.

4.1.3 Dense Forest.

The number of seedlings of *Crotalaria pallida* started to shoot growth and the number of plant-appeared leaves were measured and compared in dense forest soil samples are**,**

Table 6

Number of Seeds Started Germination (DF)

Number of Weeks	**Number of Seeds Started to Germination**
Week-1	19
Week-2	22
Week-3	25
Week-4	25
Week-5	23
Week-6	18
Week-7	16
Week-8	12

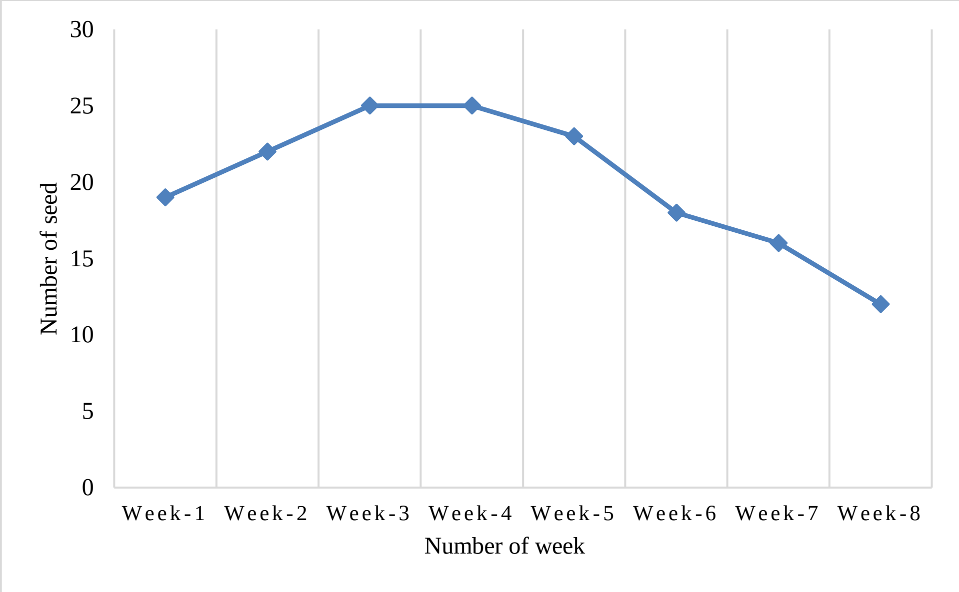

Figure 10. Number of seeds started to grow (DF)

According to the table and graph above, the most seeds (25 out of 25) began to sprout on week three. During the final week of the trial, some plants were entirely desiccated. After eight weeks, on soil from a dense forest, twelve plants survived.

Table 7

Number of Plants Showing Leaves (DF)

Number of Weeks	Number of Plants Appeared Leaves
Week-1	0
Week-2	5
Week-3	12
Week-4	19
Week-5	21
Week-6	18
Week-7	16
Week-8	12

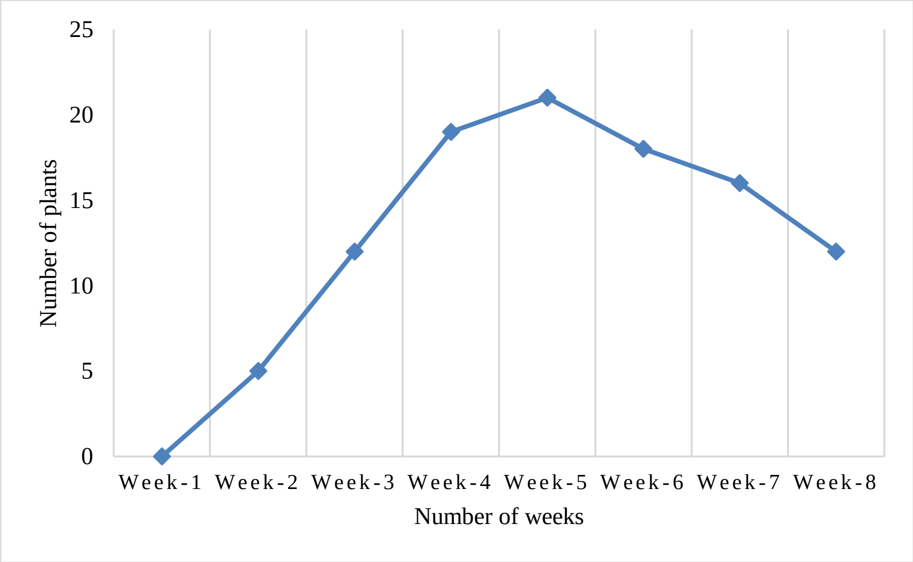

Figure 11. Number of plants appeared leaves (DF)

It can be observed from the table and graph above that the maximum number of plants (21 out of 25) that appeared leaves on week five. After week five some of the plants started to dry.

4.1.4 Home Garden

Here the measurement and the comparison of the number of seedlings of *Crotalaria pallida* is started to shoot grow and the number of plants-appeared leaves on the soil sample from the home garden is,

Table 8

Number of Seeds Started Germination (HG)

Number of Weeks	Number of Seeds Started to Germination
Week-1	14
Week-2	21
Week-3	22
Week-4	22
Week-5	20
Week-6	15
Week-7	14
Week-8	11

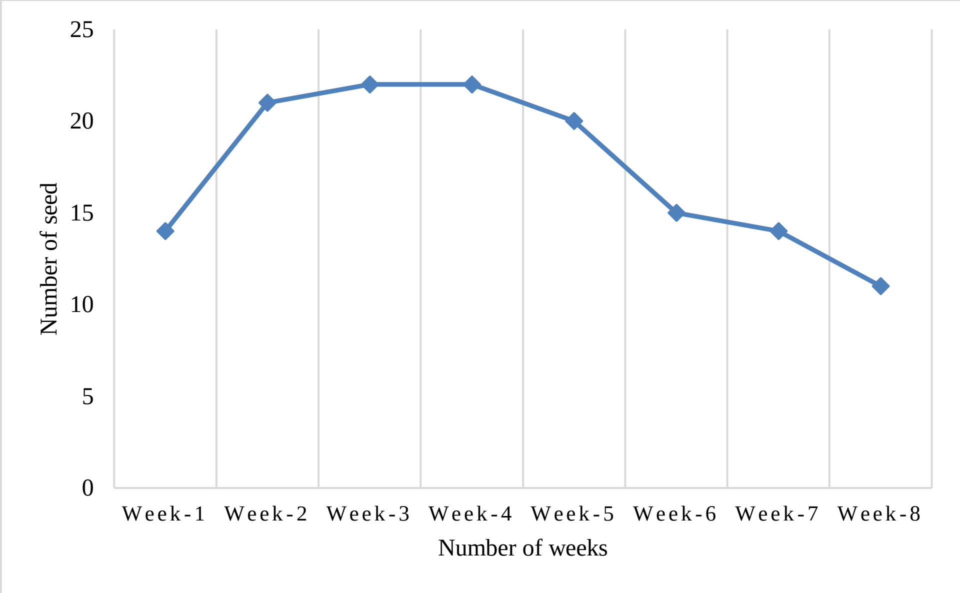

Figure 12. Number of seeds started to grow (HG)

By examining the data in the table and graph above, one can deduce that the highest number of seedlings (22 out of 25) started to grow in both week three and week four. At the end of the examination, fourteen plants are entirely dried out.

Table 9

Number of Plants Showing Leaves (HG)

Number of Weeks	Number of Plants Appeared Leaves
Week-1	0
Week-2	3
Week-3	12
Week-4	16
Week-5	20
Week-6	15
Week-7	14
Week-8	11

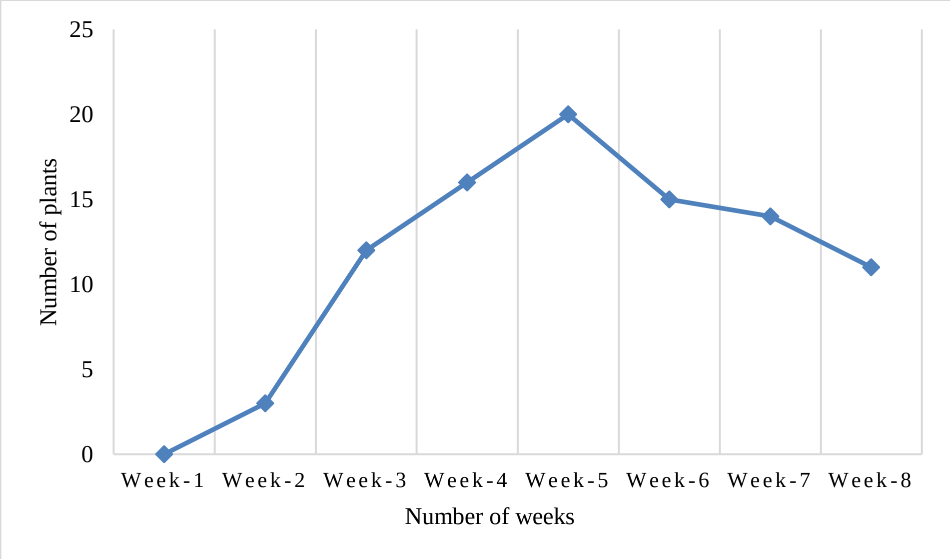

Figure 13. Number of plants appeared leaves (HG)

The information in the above table and graph suggests that, the highest count of plants (20 out of 25) that displayed leaves on week five. After eight weeks on home garden soil, eleven plants persisted.

4.1.5 Shrub Land

The measurement and comparison of the growth of *Crotalaria pallida* seedlings and the number of plants exhibiting leaves were initiated in soil samples from the Shrub Land.

Table 10

Number of Seeds Started Germination (SL)

Number of Weeks	Number of Seeds Started to Grow
Week-1	13
Week-2	18
Week-3	24
Week-4	23
Week-5	22
Week-6	19
Week-7	13
Week-8	9

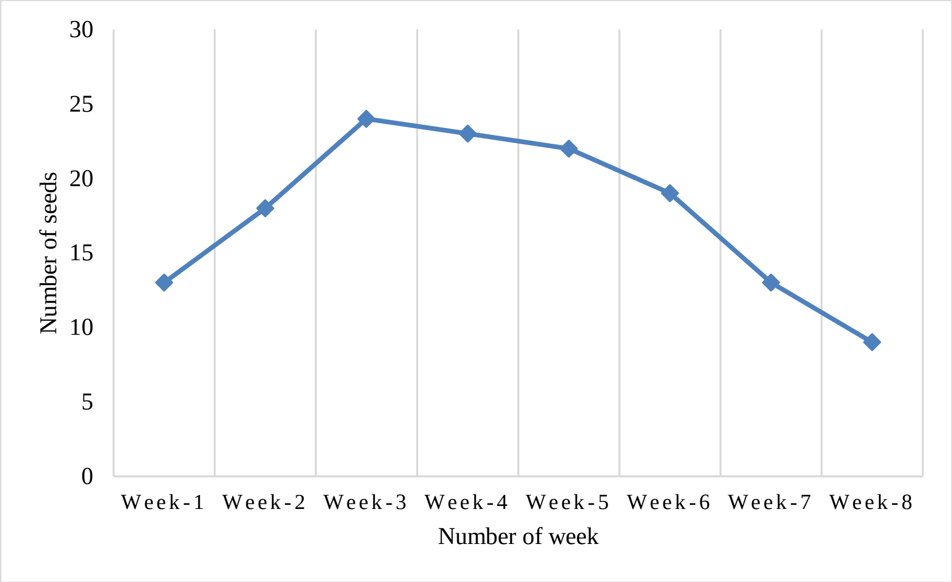

Figure 14. Number of seeds started to grow (SL)

From the information presented in the above table and graph, it is evident that the majority of the seedlings (23 out of 25) began their growth in week four. At the conclusion of the experiment, all sixteen plants were fully dried out.

Table 11

Number of Plants Showing Leaves (SL)

Number of Weeks	**Number of Plants Appeared Leaves**
Week-1	0
Week-2	3
Week-3	13
Week-4	22
Week-5	22
Week-6	19
Week-7	13
Week-8	9

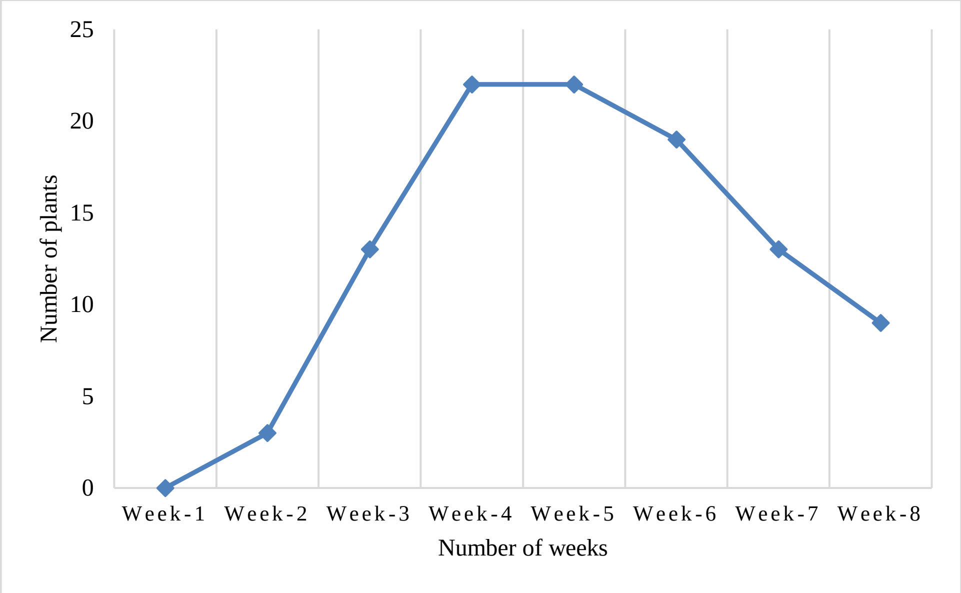

Figure 15. Number of plants appeared Leaves (SL)

It is evident from the table and graph above that, during both week four and week five, the majority of plants (22 out of 25) were leafed out. After spending eight weeks on shrubland soil, only nine plants persevered.

4.2 Comparison of Seed Germination Rate

From the above data, the seed germination rate (%) in different soil samples were,

Table 12

Seed Germination Rate

Soil Type	Germination Rate (%)
AG	100%
BL	72%
DF	100%
HG	88%
SL	96%

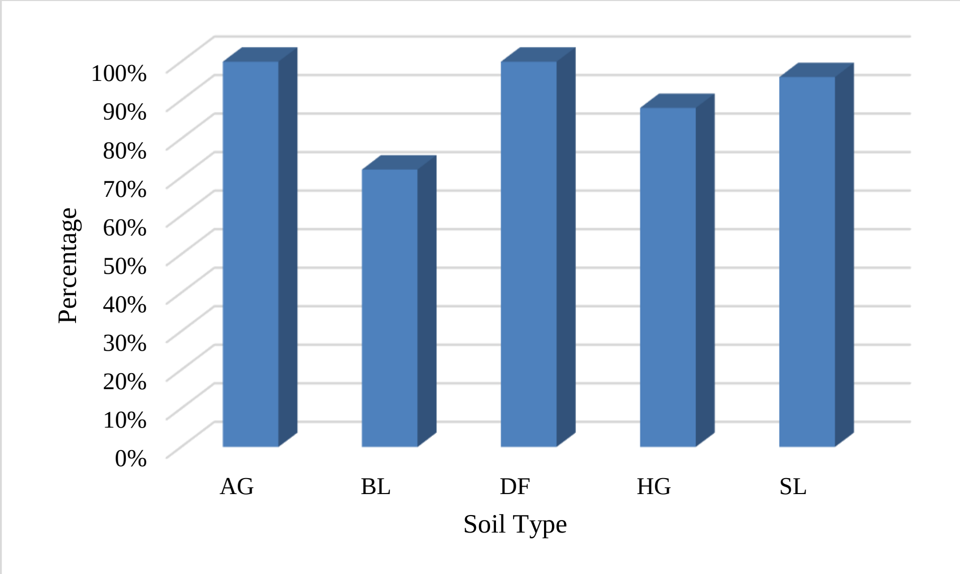

Figure 16. Seed Germination Rate

The table and graph above offer a noticeable representation of the fact that the seedlings on Agricultural Land and Dense Forest acquired a 100% germination rate on week four and week three respectively. The lowest germination rate was observed on Barren Land with 72%.

4.3 Comparison of Survival Rate of Plants

The survival rate of Crotalaria pallida plants in different soil samples during the last week was observed.

Table 13

Plant Survival Rate (%)

Soil Type	Survival Rate (%)
AL	49%
BL	4%
DF	49%
HG	44%
SL	36%

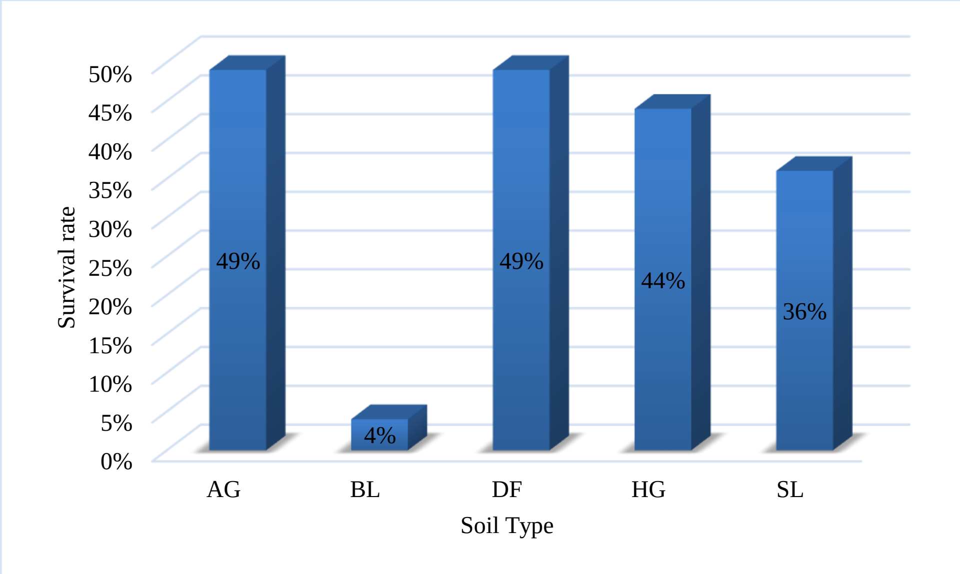

Figure 17. Survival Rate

From the information presented in the above table and bar graph, it is evident that the highest survival rate, at 49%, was observed in Agricultural Land and Dense Forest soil types. Following closely, Home Garden displayed the second-highest survival rate of 44%. Shrubland exhibited a survival rate of 36%, while Barren Land had the lowest survival rate at just 4%.

4.4 Number of Leaves Per Plant.

The number of leaves per plant is determined by tallying the leaves of plants that have survived through the last week.

Table 14

Number of Leaves per Plant

Soil type	No. of leaves per plant
AG	4
BL	2
DF	4
HG	5
SL	5

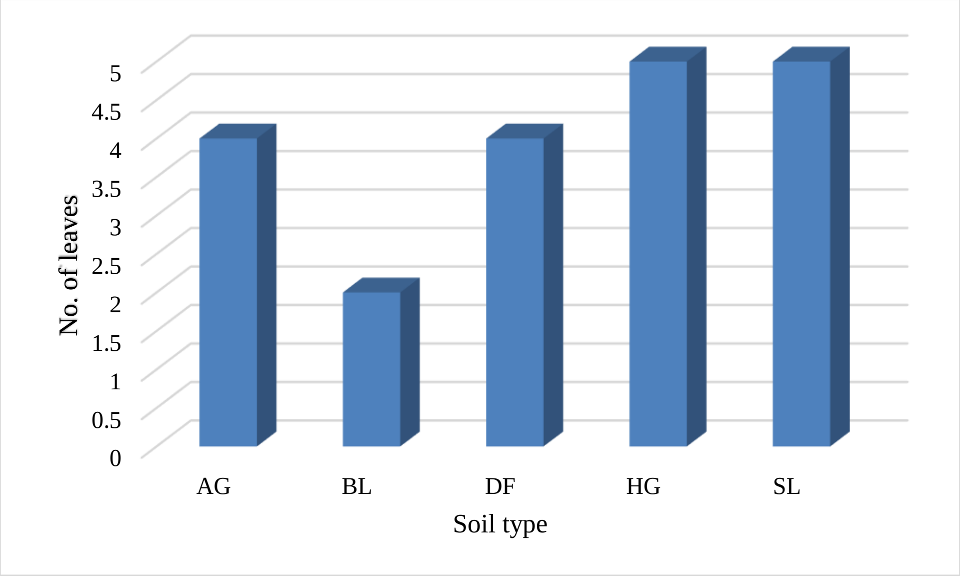

Figure 18. Number of Leaves per Plant

The information in the above table and graph suggests that, among the soil types, Home Garden and Shrubland exhibit the greatest number of leaves per plant, both with a count of five. Agricultural Land and Dense Forest rank second, each boasting four leaves per plant. Barren Land, on the other hand, has the fewest leaves per plant, with a total of just two.

4.5 Comparison of Growth Rate of Seedlings in Different Soil Types

Discussing the differences in plant height across various soil samples such as Agricultural Land, Barren Land, Dense Forest, Home Garden, And Shrubland.

Table 15

Growth Rate of Seedings

Soil Type	Mean Value (In cm)
AL	4.79
DF	5.28
HG	5.7
SL	6.8
BL	3.9

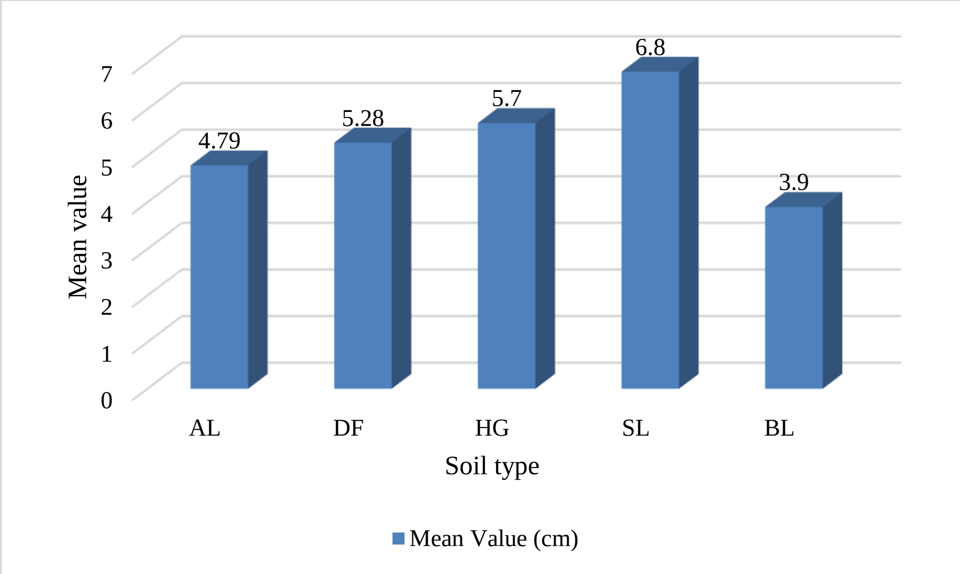

Figure 19. Growth Rate of Seedling in Different Soil Types

AL-Agricultural Land, DF-Dense Forest, HG-Home Garden, SL-Shrubland, BL-Barren Land

The data presented in the table and graph above indicates that, following a two-month observation period, *Crotalaria pallida* exhibited the greatest growth in Shrubland, with a growth rate of 6.8 centimeters, while the slowest growth was observed in Barren Land, where it only grew by 3.9 centimeters. The growth rate in alternative soil samples like Agricultural Land, Dense Forest, and Home Garden measures at 4.7, 5.28, and 5.7 centimeters, respectively.

These variations in growth rates can be attributed to a multitude of factors. Firstly, the health and vitality of the seeds play a crucial role. Healthy seeds are more likely to germinate and grow vigorously compared to seeds that may be compromised in some way.

Secondly, soil properties exert a significant influence. Soil characteristics encompass physical properties (like texture, structure, and moisture content), chemical properties (such as nutrient levels and pH), and biological properties (including the presence of beneficial microorganisms). These properties collectively create a unique environment that can either support or hinder plant growth.

Lastly, the ambient temperature of the surroundings also plays a part. Different plants have different temperature preferences for optimal growth, and variations in temperature can affect metabolic processes within plants, ultimately influencing their growth rates.

4.6 Soil Analysis

This includes measurements for critical parameters such as pH (acidity/alkalinity), Electrical Conductivity (EC), Organic Carbon content, and the availability of essential nutrients. These measurements are crucial in understanding the overall health and quality of soil samples.

Organic carbon in the soil plays a varied role in *Crotalaria pallida* germination and growth. It improves soil structure, holds moisture, stores and releases nutrients, and encourages beneficial microbial activity, all of which can help this plant establish and grow successfully, even in settings where nutrient availability (N, P, K) is initially limited.

Table 16

Soil pH, EC, and Organic Carbon

Soil Type	pH	EC (µs)	OC (%)
AL	6.02	110.2	1.5
BL	5.72	157.2	0.26
DF	6.26	94.9	1.95
HG	6.32	116.7	0.59
SL	6.92	100.7	0.82

EC- Electric Conductivity, OC- Organic Carbon

The pH of a material determines whether it is acidic, neutral, or alkaline, which is important information for identifying its compatibility for various crops or plant species. EC, on the other hand, evaluates the soil's or solution's ability to conduct electrical current, which can indicate salinity or nutrient content, so assisting in the development of appropriate irrigation or fertilization techniques. According to the data, it is clear that among the five soil samples, Agricultural Land (AL), Dense Forest (DF), and Home Garden (HG) all demonstrate an acidic character, with approximately equal pH values. In comparison to the other soil samples, Barren Land (BL) has a much higher amount of acidity. Finally, Shrub Land (SL) stands out with a pH value near to 7, indicating that it is neutral.

Organic carbon concentration reveals the existence of organic matter in the sample, which is important for soil fertility and ecosystem health. Based on the statistics in the table above, it is clear that Agricultural Land (AL) and Dense Forest (DF) have extremely high levels of organic carbon content. Shrub Land (SL) and Home Garden (HG) both have a high concentration of organic carbon in their samples. Barren Land (BL), on the other hand, has a very low organic carbon concentration.

Table 17

Available Nutrients in Different Soil Samples

Soil Types	Available Nutrients (kg ha^{-1})		
	N	**P**	**K**
AL	250.88	11.02	319.28
BL	275.96	6.5	597.76
DF	225.79	29.18	896.16
HG	326.14	16.89	408.24
SL	338.68	13.45	457.44

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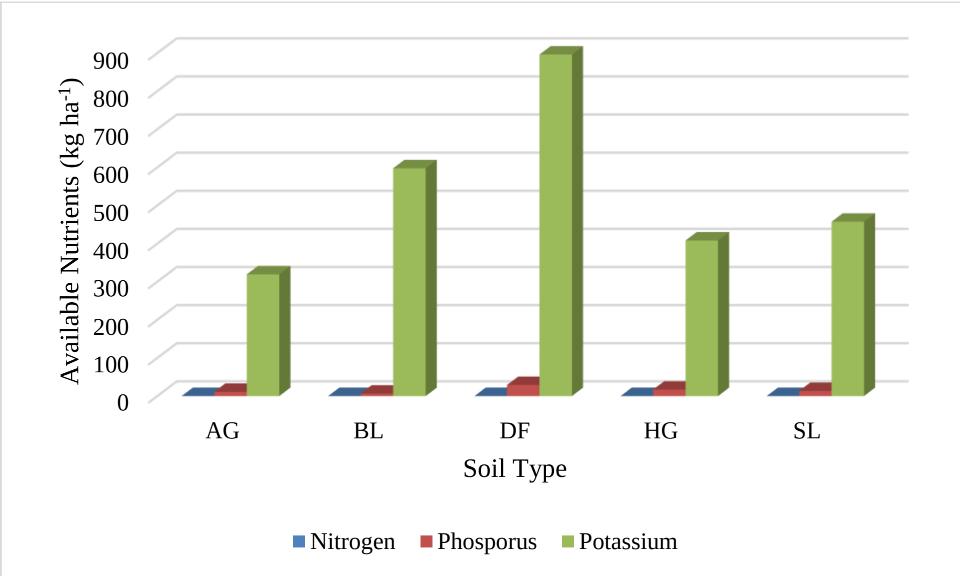

Figure 20. Available Nutrients in Different Soil Samples

The proper balance of these nutrients is essential for healthy plant growth. A correct N:P: K ratio is required to maintain healthy development, strong structures, efficient photosynthesis, and proper reproductive activities. Imbalances in these nutrients can cause a variety of growth problems, lower yields, and overall poor plant health. Understanding and regulating soil N, P, and K levels is therefore critical for fostering successful and productive plant growth.

CHAPTER-5

5. SUMMARY AND CONCLUSION

The dissertation "Growth Variation of Crotalaria pallida in Different Soil Samples" investigates how variations in soil composition, specifically nutritional levels (N, P, K), soil pH, electrical conductivity (EC), and organic carbon content, affect the growth of Crotalaria pallida in five different soil samples: Agricultural Land, Barren Land, Dense Forest, Home Garden, and Shrub Land. Crotalaria pallida, a widely distributed leguminous plant, plays an important role in soil development due to its nitrogen-fixing properties and potential for ecological restoration. The research was carried out during April and May 2023 at the Department of Environmental Science, Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh. The plant experiment is carried out during the summer season when the ambient temperature ranges between 34 and 37°C. *Crotalaria pallida*, like most plants, has a temperature range in which it thrives. Heat stress can occur if temperatures rise above this range. This stress can have a number of detrimental consequences, including decreased photosynthesis, poor water intake, and cellular structural damage. Long-term exposure to high temperatures can cause plant withering and mortality (Carvalho et al., 2020). Elevated temperatures can increase the rate of transpiration, leading the plant to lose water more quickly. This increased water consumption can cause water stress, especially in areas with low water resources. *Crotalaria pallida's* growth can be significantly hampered if it does not have enough water.

The data show considerable differences in Crotalaria pallida development and germination among the five soil types. The most robust development was observed in Agricultural Land, Dense Forest, Shrub Land, and Home Garden, which were distinguished by elevated organic carbon concentrations (in the order DF > AL > SL > HG), moderate pH levels in the range of 6 to 7, and sufficient nutritional levels (N, P, K). Barren Land, on the other hand, had the slowest growth due to its low nutritional concentration and acidic pH. Furthermore, the research revealed links between key soil factors and plant development. Notably, higher organic carbon content was found to be beneficial to plant growth, whereas higher electrical conductivity (EC) and pH levels were found to be unfavorable.

The germination and survival rates of Crotalaria pallida are notably high in soil sourced from Agricultural Land and Dense Forest. Following closely behind are Shrub Land and Home

Garden soils. Conversely, in Barren Land, the germination rate is considerably lower, and the survival rate is as low as 4%. This finding suggests that, even if the initial levels of accessible nutrients (N, P, K) in the soil are low, organic carbon can continue to aid Crotalaria pallida during the growth phase by delivering nutrients and regulating soil moisture. This is especially significant since Crotalaria pallida, like other leguminous plants, can fix atmospheric nitrogen via nitrogen-fixing bacteria in its root nodules. Organic carbon in the soil can support the microbial populations required for nitrogen-fixing.

Crotalaria pallida thrive on soils with a slightly acidic to neutral pH range, often between 6.0 and 7.0. Germination and survival rates are strongest in this pH range. Soil pH levels below the ideal (more acidic) range are reported in Barren Land soil, which can hinder plant germination and survival.

High atmospheric temperatures can negatively impact Crotalaria pallida development dynamics through various processes, including heat stress, reduced photosynthesis, increased water requirements, and changes in nutritional equilibrium. Warmer temperatures may increase the spread of pests and diseases that threaten Crotalaria pallida. The increased presence of these pests and diseases can weaken the plant, hamper its growth, and even result in plant death.

5.1 Major Findings

- Maintaining the soil pH within the recommended range is critical for optimizing Crotalaria pallida germination and survival rates. Soil pH management, such as adding lime to acidic soils to raise pH or sulfur to alkaline soils to lower pH, can help produce a more friendly environment for this leguminous plant.
- Soil organic carbon promotes *Crotalaria pallida* growth through increasing soil structure, moisture retention, nutrient storage and release, and nurturing beneficial bacteria. This promotes plant establishment and development even when nutrient supply (N, P, K) is limited.
- Higher atmospheric temperature harm *Crotalaria pallida* by causing heat stress, lower photosynthesis, greater water needs, and nutrient imbalances. Warmer conditions can also boost pests and diseases that harm the plant, weakening growth and potentially causing death.

5.2 Limitations of the Study

- *Less Number of Replication*: The less number of replication in the study restricts its capacity to make solid and statistically meaningful findings. Replication aids in verifying the consistency of results and limiting the impact of random fluctuations.
- *Seasonal Bias*: Conducting the study just in the summer may add a seasonal bias. Growth patterns and plant responses can differ greatly between seasons, and the findings of this study may not be indicative of Crotalaria pallida's performance in other seasons.
- *Limited Soil Parameters*: The investigation is primarily concerned with soil parameters such as pH, organic carbon content, electrical conductivity (EC), and the availability of important nutrients (N, P, K). It does not investigate the dynamics of other secondary and micronutrients, which can potentially have an impact on plant development and health.
- *Sample Diversity***:** Soil samples for the study are confined to a few land types (Agricultural Land, Barren Land, Dense Forest, Home Garden, and Shrub Land). This limited selection may not represent the complete range of soil conditions seen in different areas or ecosystems.

5.3 Conclusion

The availability of essential nutrients, the concentration of organic carbon, and the pH of the soil all have a direct relationship with Crotalaria pallida growth performance, resulting in overall plant health and size.

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