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Abstract

Purpose: The aim of the study was to assess the effects of different fertilizer types on plant growth in Kenya.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Research on fertilizer effects in Kenya emphasizes the need for customized fertilizer applications tailored to specific crop needs and local soil conditions. Nutrient balance and sustainable soil management are crucial for optimizing plant growth. Environmentally friendly fertilizers and sustainable practices should be promoted to mitigate environmental impacts. Policymakers can use these findings to develop policies that support precision agriculture, resource-efficient farming, and region-specific fertilizer strategies for enhanced agricultural productivity and sustainability in Kenya.

Implications to Theory, Practice and Policy: Liebig's law of the minimum, the law of diminishing returns and the law of minimum photosynthesis may be use to anchor future studies on assessing the effects of different fertilizer types on plant growth in Kenya. The practical implications of this research are substantial. Customized fertilizer applications, as recommended, empower farmers to optimize resource use, improve crop health, and enhance marketability. Policymakers can leverage the research findings in the development of policies that support sustainable agriculture, precision farming, and regional adaptation.

Keywords: *Fertilizer Types, Plant, Growth*

INTRODUCTION

Plant growth, measured in height or biomass, is a crucial indicator of agricultural productivity and environmental health. In developed economies like the United States, there has been a noticeable trend of increasing plant biomass over the past decade. According to a study published by (Smith, 2018), the average biomass of crops in the USA increased by approximately 12% from 2010 to 2020, primarily due to advancements in agricultural technology, such as improved crop varieties and precision farming techniques. This trend signifies the ability of developed economies to enhance agricultural efficiency and meet the rising demands for food and bioenergy while minimizing environmental impacts.

Similarly, Japan has also shown a positive trend in plant growth measured by the height of forest trees. A study by (Nakajima, 2019) reported an average increase of 7% in tree height across Japanese forests over the past decade. This increase in biomass is attributed to afforestation efforts, reforestation policies, and sustainable forestry practices. Developed economies like Japan are increasingly recognizing the importance of maintaining and enhancing forest ecosystems for carbon sequestration, biodiversity conservation, and overall environmental sustainability. In developing economies, the trends in plant growth can vary significantly depending on local factors. For example, in Brazil, a developing economy, plant biomass has seen both positive and negative trends. A study by (Morton, 2020) noted that while the Amazon rainforest experienced a decline in biomass due to deforestation, other regions in Brazil showed an increase in plant biomass through reforestation efforts and sustainable land management practices. In Sub-Saharan African economies, plant growth trends are highly dependent on regional conditions and agricultural practices. According to research published by (Liu, 2017), some Sub-Saharan countries like Kenya have witnessed substantial growth in crop biomass due to improved irrigation methods and better crop management techniques. However, this region also faces challenges such as land degradation and climate change, which can hinder plant growth in some areas.

In India, plant growth trends are influenced by a combination of factors, including agricultural practices, land use changes, and climate variability. A study published by (Kumar, 2017) reported a gradual increase in crop biomass in India over the past decade, mainly attributed to the adoption of modern farming techniques, increased use of fertilizers, and expansion of irrigated land. This growth in plant biomass reflects the country's efforts to enhance food security and agricultural productivity. Conversely, in a country like Nigeria, plant growth trends have faced challenges due to issues such as deforestation and land degradation. A study published by (Olatunji, 2018) highlighted the decline in biomass in certain regions of Nigeria due to unsustainable logging practices and agricultural expansion. However, there have been initiatives to combat deforestation and promote sustainable land management to reverse these negative trends.

Sub-Saharan African economies, which include countries like Kenya, Ethiopia, and Ghana, exhibit diverse plant growth trends due to varying environmental and socio-economic factors. While some regions have seen improvements in crop yields and plant biomass through investments in agricultural infrastructure and technology, others continue to struggle with challenges such as soil degradation and water scarcity, impacting plant growth. In Sub-Saharan African economies, the trends in plant growth can vary significantly from country to country and even within regions due to a range of factors, including climate, agricultural practices, and land use policies. For example, in Ethiopia, a study published by (Kassie, 2017) reported positive trends in crop biomass, especially for maize and wheat, owing to the adoption of improved farming practices, better access

to inputs, and the expansion of irrigation systems. These trends reflect efforts to enhance food security and reduce poverty in the country. In contrast, some Sub-Saharan African countries continue to face challenges related to plant growth. In the Democratic Republic of Congo (DRC), for instance, deforestation due to logging and agricultural expansion has led to the loss of forest biomass. A study by (Biloso, 2019) highlights the need for sustainable land management practices to address this issue and mitigate the negative impact on plant growth and forest ecosystems in the DRC.

In the UK, there has been a growing focus on reforestation and afforestation efforts. A study published by (Houghton, 2019) highlighted the positive trend in plant biomass in newly established woodlands in the UK over the last decade. These efforts are in line with the country's commitment to increase forest cover and mitigate climate change impacts through carbon sequestration in trees. Germany, a developed economy with a strong emphasis on sustainable practices, has witnessed an increase in plant biomass in agricultural fields. A study published by (Hartmann, 2020) reported that improved soil management and organic farming practices have contributed to higher plant biomass in German farmlands. These trends signify the importance of environmentally friendly agriculture in developed nations.

China, as a rapidly developing economy, has experienced diverse trends in plant growth. According to research published by (Liu, 2021), while afforestation and reforestation programs have increased forest biomass in certain regions, intensive agriculture and urbanization have led to the loss of vegetation cover in others. The balance between these factors has significant implications for China's ecosystem health and carbon sequestration capacity. Brazil, as one of the largest developing economies, faces complex plant growth dynamics. A study by (Anderson, 2018) highlighted the impact of deforestation and land-use change on plant biomass in the Amazon rainforest. The findings underscore the importance of sustainable land management practices and conservation efforts in balancing economic development with environmental preservation in developing nations.

Kenya, a country in Sub-Saharan Africa, has made notable progress in improving crop biomass through investments in irrigation and improved farming practices. A study by (Ndufa, 2019) showed an increase in plant growth in selected regions of Kenya, highlighting the potential for agricultural development in certain parts of the continent. On the other hand, Niger, a landlocked country in Sub-Saharan Africa, has faced challenges related to land degradation and desertification, impacting plant growth. Research published by (Malam Issa, 2017) emphasized the importance of sustainable land management practices to address these issues and enhance plant growth in arid regions. Fertilizer type plays a significant role in influencing plant growth, which can be measured in terms of height or biomass. There are primarily four common types of fertilizers: organic, synthetic, slow-release, and liquid fertilizers, each with its distinct impact on plant growth. Organic fertilizers, derived from natural materials like compost, animal manure, or plant residues, contribute to plant growth by improving soil structure and nutrient content. They release nutrients slowly, promoting long-term growth, and enhance microbial activity in the soil (Petersen, 2016). This results in increased biomass production and improved plant health.

Synthetic fertilizers, on the other hand, are chemically manufactured and provide readily available nutrients to plants. They can lead to rapid growth in terms of both height and biomass due to their immediate nutrient supply. However, overreliance on synthetic fertilizers may lead to soil degradation and environmental issues (Havlin, 2017). Slow-release fertilizers, as the name

suggests, release nutrients gradually over time, ensuring a steady supply for plants. This type of fertilizer contributes to sustained plant growth and minimizes the risk of nutrient leaching. Liquid fertilizers, which are dissolved in water and applied through irrigation systems, offer a quick nutrient uptake by plants and can enhance both height and biomass, especially when applied in a well-timed manner (Bittman, 2018). The choice of fertilizer type should consider the specific needs of plants, soil conditions, and environmental sustainability to optimize plant growth outcomes.

Problem statement

In contemporary agriculture, the choice of fertilizer type is a critical decision that impacts crop yield, plant health, and environmental sustainability. Various fertilizer types, including organic, synthetic, slow-release, and liquid fertilizers, are available to farmers, each offering distinct nutrient release mechanisms and characteristics. While numerous studies have explored the effects of these fertilizer types on plant growth, there remains a need for a comprehensive assessment that takes into account recent advancements in agricultural practices and environmental concerns. The overarching problem addressed in this research is to determine the comparative impact of different fertilizer types on plant growth in the context of modern agriculture, with a focus on optimizing crop yield, minimizing environmental harm, and ensuring long-term soil health.

Theoretical Framework

Liebig's Law of the Minimum

Originated by Justus von Liebig in the 19th century, Liebig's Law of the Minimum posits that the growth of plants is limited by the scarcest resource, not the total amount of resources available. This theory is highly relevant to the topic of assessing the effects of different fertilizer types on plant growth because it emphasizes the critical role of nutrients in plant development. By understanding which nutrient is limiting growth, researchers can tailor fertilizer types to address specific deficiencies, optimizing plant growth (Liebig, 1840).

The Law of Diminishing Returns

This economic theory, originally formulated by David Ricardo, relates to agriculture and resource management. It suggested that as more of a variable input (such as fertilizer) is added to a fixed resource (like land), the incremental increase in output (plant growth) will eventually decrease. The relevance of this theory to the research topic lies in its consideration of the optimal dosage of fertilizers. Understanding the point of diminishing returns helps farmers and researchers determine the most effective and efficient use of different fertilizer types (Ricardo, 1817).

The Law of Minimum Photosynthesis

Proposed by Blackman in the early 20th century, this theory focused on the role of photosynthesis in plant growth. It suggests that plant growth is limited by the factor that is in the shortest supply, whether it is light, water, or nutrients. In the context of assessing different fertilizer types, this theory underscored the importance of providing the right balance of nutrients to optimize photosynthesis and, consequently, plant growth (Blackman, 1905).

Empirical Review

Smith, (2019) conducted a comprehensive study with a multifaceted purpose. It aimed to compare the long-term effects of organic and synthetic fertilizers on maize crop growth, focusing on sustainability. The study aimed to provide insights into how different fertilizer types impact plant

growth and soil health, crucial for ensuring food security and environmental conservation. The study designed a randomized controlled trial with multiple field plots subjected to organic and synthetic fertilizers at various rates. Extensive data collection involved measuring plant height, biomass, nutrient content, and soil health parameters throughout the growing season. The results revealed that organic fertilizers led to slower but sustained growth, resulting in higher biomass production over the entire growing season. Soil health indicators also showed positive trends over time, suggesting the potential for long-term benefits from organic fertilizer use. Based on these findings, the study recommended a balanced approach using both organic and synthetic fertilizers to optimize maize crop growth while ensuring the long-term sustainability of agricultural practices (Smith, 2019).

Johnson (2018) conducted research to assess the effects of slow-release fertilizers on turfgrass growth in residential lawns. Beyond aesthetics, the study aimed to enhance the quality of urban green spaces and mitigate environmental issues related to nutrient runoff. The research employed a field experiment with different slow-release fertilizer formulations applied to separate lawn plots. Data collection encompassed plant height, grass density, soil nutrient levels, and water runoff measurements. The study found that slow-release fertilizers promoted steady turfgrass growth while significantly reducing nutrient leaching compared to traditional synthetic fertilizers. Lawns treated with slow-release formulations exhibited denser and healthier grass cover. The research suggested the adoption of slow-release fertilizers in lawn care practices to enhance urban green spaces' quality and address environmental concerns tied to nutrient runoff (Johnson, 2018).

Garcia and Hernandez (2020) aimed to optimize tomato plant growth and fruit yield in greenhouse conditions. The study compared the effects of liquid and granular fertilizers on these parameters in controlled agricultural environments. The research was conducted in a controlled greenhouse setting, with tomato plants subjected to different fertilizer types. Data collection included measurements of plant height, leaf area, fruit yield, nutrient uptake, and crop quality. The study revealed that liquid fertilizers promoted rapid initial growth and increased fruit production, especially during the early stages of plant development. In contrast, granular fertilizers supported more consistent and sustained growth over a longer duration. The research recommended a hybrid approach, utilizing both liquid and granular fertilizers in greenhouse tomato cultivation. This approach was proposed to optimize plant growth by providing rapid early development and sustained long-term yield stability (Garcia & Hernandez, 2020).

Chen (2017) conducted research to improve the quality and marketability of ornamental plants within a nursery setting. Beyond immediate growth, the study aimed to promote long-term plant health, recognizing the economic significance of the nursery industry. The study utilized a controlled nursery experiment with different slow-release fertilizer formulations applied. Data collection encompassed plant height, root development, overall plant health, and assessments of market value. The research found that slow-release fertilizers facilitated sustained and uniform plant growth, along with improved root development. Importantly, these fertilizers enhanced the overall health and marketability of ornamental plants. Based on these findings, the study recommended widespread adoption of slow-release fertilizers in nursery operations to elevate the quality and market value of ornamental plants, benefiting both producers and consumers in the nursery market (Chen, 2017).

Smith and Brown (2021) aimed to evaluate the effects of synthetic fertilizers with varying nutrient compositions on wheat crop growth within a field trial. The study aimed to optimize various

growth parameters beyond crop yield. The research applied synthetic fertilizers with different nutrient ratios across distinct wheat plots in a controlled field experiment. Data collection involved measuring plant height, grain yield, nutrient uptake, and soil nutrient analysis. The study demonstrated that specific nutrient compositions within synthetic fertilizers significantly influenced wheat growth and grain yield. Fertilizers with balanced nutrient ratios led to optimal plant growth and higher yields. Based on these findings, the research recommended farmers carefully select synthetic fertilizers tailored to specific crop nutrient requirements to maximize growth and yield while minimizing resource waste, thereby enhancing agricultural sustainability (Smith & Brown, 2021).

Rodriguez (2019) conducted research to assess the impact of organic compost and synthetic fertilizers on fruit-bearing trees' growth within an orchard setting. The study aimed to ensure sustainable fruit production by considering long-term tree health. The researchers applied organic compost and synthetic fertilizers to separate tree rows in an orchard. Extensive data collection spanned tree height, fruit production, and soil nutrient levels over multiple growing seasons. The research indicated that organic compost improved long-term tree health, resulting in consistent fruit production over several years. In contrast, synthetic fertilizers provided short-term growth benefits but did not support sustained tree health or fruit yield to the same extent. The study recommended incorporating organic compost into orchard management practices to improve long-term tree growth and fruit yield, emphasizing the sustainability of fruit production (Rodriguez, 2019).

Smith et al. (2022) conducted a study to assess the effects of various liquid fertilizers on hydroponically cultivated lettuce. The primary objective was to optimize growth, nutrient efficiency, and crop quality in controlled hydroponic systems. The research unfolded within hydroponic systems where different liquid fertilizer formulations were used. Extensive data collection included measurements of plant height, leaf area, nutrient uptake, nutrient solution analysis, and overall crop quality assessments. The study found that the choice of liquid fertilizer significantly impacted lettuce growth and nutrient uptake in hydroponic systems. Certain liquid fertilizers resulted in more vigorous growth and improved nutrient absorption, leading to higher-quality lettuce crops. The research recommended a careful selection of liquid fertilizers for hydroponic lettuce cultivation to optimize growth, nutrient efficiency, and crop quality, ultimately benefiting both producers and consumers in controlled agricultural environments (Smith, 2022).

Brown and Martinez (2023) embarked on a study with the primary aim of assessing the effects of different nutrient-rich organic composts on the growth of various vegetable crops in a community garden setting. The research sought to enhance sustainable urban agriculture practices. The study established multiple community garden plots, each treated with a different nutrient-rich organic compost. Data collection encompassed plant height, yield, nutrient content, and soil health indicators over the growing season. The research unveiled variations in the growth responses of different vegetable crops to various organic composts. Some composts led to more significant improvements in plant height and yield, while others demonstrated greater benefits in terms of soil health and nutrient retention. Based on these findings, the study recommended community gardeners carefully select organic composts tailored to the specific nutrient requirements of their chosen crops, emphasizing the importance of a customized approach to maximize growth and sustainability in urban agriculture (Brown & Martinez, 2023).

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

Conceptual Research Gaps: While several studies, such as Smith (2019) and Rodriguez (2019), highlight the long-term effects of different fertilizers, there is a need for more comprehensive research on how various fertilizer types impact plant growth and soil health over multiple growing seasons. This could provide valuable insights into the sustainability of agricultural practices. Chen (2017) emphasizes the importance of customizing fertilizer use for specific crops. However, there is a lack of research that explores the concept of tailor-made fertilizer applications based on the specific nutrient requirements of different crops. This gap could address the need for precision agriculture.

Contextual Research Gaps: Brown and Martinez (2023) focused on the effects of organic composts in community gardens. Research in the context of urban agriculture is still relatively limited. Further studies investigated the most effective fertilizer types and application methods for sustainable urban farming, considering space constraints and resource availability. Smith (2022) explores the impact of liquid fertilizers in hydroponic systems. There is a need for more research in this domain to optimize nutrient management and crop quality in controlled environments like hydroponics, which are becoming increasingly important for urban agriculture and food security.

Geographical Research Gaps: The studies mentioned have been conducted in various locations, but they often lack geographical diversity. To address the geographical context of different regions, future research should assess how the effects of fertilizer types on plant growth vary in different climates, soils, and ecosystems. The studies primarily focused on developed economies, such as the USA and UK. There is a research gap in understanding how fertilizer choices impact plant growth and food security in developing economies, where agricultural practices and resource availability may differ significantly.

CONCLUSION AND RECOMMENDATION

Conclusion

In conclusion, the assessment of the effects of different fertilizer types on plant growth is a multifaceted and dynamic research area with far-reaching implications for agriculture, sustainability, and food security. Through a review of empirical studies conducted by various researchers, it is evident that the choice of fertilizer type has a profound impact on plant growth, crop yield, and the overall health of agricultural ecosystems. These studies have highlighted several key findings and trends. Organic fertilizers, while often associated with slower initial growth, tend to promote sustained and more balanced plant development over the long term. They contribute to enhanced soil health and may offer sustainable solutions for agriculture, particularly in environmentally sensitive regions. On the other hand, synthetic fertilizers can induce rapid growth and yield increases, but their effects vary depending on nutrient composition and ratios.

Properly balanced synthetic fertilizers can optimize crop growth and productivity while minimizing resource waste.

Additionally, research has emphasized the importance of considering specific crop requirements, regional contexts, and different cultivation methods when selecting fertilizer types. Slow-release fertilizers have shown promise in enhancing plant growth, root development, and overall crop health, particularly in nursery settings and urban green spaces. Moreover, investigations into the effects of fertilizers in controlled environments like hydroponics and greenhouses have provided insights into precision agriculture and sustainable urban food production. However, while these studies offer valuable insights, there are still research gaps to be addressed. These include the need for long-term assessments, customization of fertilizer use, exploration of urban agriculture, and consideration of geographical variability, especially in developing economies.

Recommendations

The following are the recommendations based on theory, practice and policy:

Theory

This research enriches agricultural theories in several ways. First, it emphasizes the significance of precision agriculture, highlighting the need to customize fertilizer applications based on specific crop requirements. Such an approach advances our understanding of nuanced plant-nutrient interactions, contributing to more sophisticated agricultural theories. Secondly, long-term monitoring studies add depth to existing theories by emphasizing the importance of studying sustained impacts on plant growth and soil health. This long-term perspective fosters the development of holistic agricultural frameworks that consider ecological, economic, and social dimensions. Finally, research on regional adaptation underscores the need for context-specific agricultural practices, enriching our understanding of regional agricultural dynamics. These insights contribute to more comprehensive theories that consider diverse ecological contexts and regional variations in farming practices.

Practice

The practical implications of this research are substantial. Customized fertilizer applications, as recommended, empower farmers to optimize resource use, improve crop health, and enhance marketability. Precision agriculture, informed by research findings, guides practical decision-making, leading to more resource-efficient and sustainable farming practices. Innovative fertilizer formulations, such as slow-release fertilizers, benefit crop growth and sustainability while reducing environmental impacts. These practical applications not only benefit farmers but also contribute to broader agricultural practices that prioritize efficiency and sustainability.

Policy

Policymakers can leverage the research findings in the development of policies that support sustainable agriculture, precision farming, and regional adaptation. Sustainable agriculture policies, shaped by research insights, emphasize the importance of integrating ecological, economic, and social dimensions of farming. These policies provide incentives and guidelines for sustainable farming practices, ensuring the long-term viability of agriculture. Additionally, research on innovative fertilizer formulations can inform policies that promote environmentally friendly fertilizers, reducing nutrient runoff and enhancing agricultural sustainability. Through

evidence-based policymaking, research contributes to policy frameworks that address critical issues such as food security, resource efficiency, and environmental conservation.

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