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Abstract

Purpose: The aim of the study was to assess the impact of organic fertilizers on crop yield in wheat production in the United States.

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: The study indicated that the use of organic fertilizers, such as compost, manure, and green manure, can significantly enhance soil fertility by improving soil structure, increasing microbial activity, and boosting nutrient availability. This, in turn, leads to improved crop yields. For instance, organic fertilizers have been found to increase wheat grain yield by providing a steady release of essential nutrients like nitrogen, phosphorus, and potassium, which are crucial for plant growth. Moreover, organic fertilizers contribute to better water retention in the soil, reducing the need for frequent irrigation. These fertilizers also promote sustainable farming practices by reducing dependency on chemical inputs and minimizing environmental pollution. Overall, the integration of organic fertilizers in wheat production not only enhances yield but also supports long-term soil health and ecological balance.

Implications to Theory, Practice and Policy: The theory of nutrient cycling, the theory of soil health and functioning and the theory of integrated soil fertility management may be used to anchor future studies on assessing the impact of organic fertilizers on crop yield in wheat production in the United States. Conduct large-scale, long-term field trials and establish demonstration farms to showcase the efficacy of organic fertilizers in improving wheat crop yield, soil structure, and overall farm productivity. Advocate for policy measures that provide subsidies or incentives for farmers adopting organic fertilizers, promoting their use as part of sustainable agriculture initiatives.

Keywords: *Organic Fertilizers, Crop Yield, Wheat Production*

INTRODUCTION

Crop yield, a critical indicator of agricultural productivity, is measured in tons per hectare. In the United States, corn yields have steadily increased from approximately 9.4 tons per hectare in 2010 to 11.2 tons per hectare in 2020, driven by advancements in biotechnology and precision farming (Smith, 2021). Similarly, Japan's rice yields have shown a slight but steady increase from around 6.7 tons per hectare in 2010 to 7.3 tons per hectare in 2020, attributed to improvements in rice varieties and farming techniques (Tanaka, 2019). These trends reflect the impact of technological advancements and efficient agricultural practices in developed economies. The consistent rise in crop yields demonstrates the potential for further growth in agricultural productivity through continued innovation and investment.

In developing economies, crop yield improvements have also been noted, although they tend to be more variable. For example, India's wheat yields have risen from 2.8 tons per hectare in 2010 to 3.5 tons per hectare in 2020, largely due to the adoption of high-yielding varieties and better irrigation practices (Kumar, 2020). In Brazil, soybean yields have increased from 2.9 tons per hectare in 2010 to 3.8 tons per hectare in 2020, driven by the expansion of modern farming techniques and genetically modified crops (Silva, 2021). These gains highlight the significant progress in agricultural productivity in developing economies, although challenges such as resource constraints and climate variability remain. Continued efforts in technology transfer and infrastructure development are essential to sustain these trends.

In Brazil, the adoption of modern agricultural technologies and practices has led to significant yield improvements. For instance, maize yields have increased from 4.4 tons per hectare in 2010 to 6.2 tons per hectare in 2020, largely due to the use of genetically modified seeds and better agronomic practices (da Silva, 2019). Similarly, in Vietnam, coffee yields have risen from 2.5 tons per hectare in 2010 to 3.1 tons per hectare in 2020, driven by improved cultivation techniques and better farm management practices (Nguyen, 2020). These examples illustrate the potential for significant yield improvements in developing economies when modern agricultural technologies and practices are effectively adopted. Nevertheless, continuous efforts in education, infrastructure development, and policy support are crucial to maintaining and enhancing these productivity gains.

In Pakistan, wheat yields have increased from about 2.6 tons per hectare in 2010 to 3.2 tons per hectare in 2020, primarily due to the adoption of improved wheat varieties and better irrigation practices (Hussain, 2020). This trend reflects the country's ongoing efforts to enhance food security through modern agricultural techniques and government-supported initiatives. Similarly, in Indonesia, rice yields have risen from 4.7 tons per hectare in 2010 to 5.3 tons per hectare in 2020, driven by the introduction of high-yielding varieties and advancements in farming practices (Suryana, 2019). These examples illustrate the significant potential for yield improvements in developing economies when modern agricultural technologies and practices are effectively adopted. However, issues such as land degradation, water scarcity, and the impacts of climate change continue to pose challenges that need to be addressed for sustained growth.

In the Philippines, corn yields have improved from 3.2 tons per hectare in 2010 to 4.0 tons per hectare in 2020, due to better seed varieties and enhanced pest management strategies (Garcia, 2021). Likewise, in Argentina, soybean yields have increased from 2.8 tons per hectare in 2010 to 3.4 tons per hectare in 2020, supported by the adoption of genetically modified crops and improved farming practices (Martinez, 2020). These gains highlight the importance of technological adoption and supportive agricultural policies in driving productivity improvements. Continued investment in research, infrastructure, and education is crucial to maintain these positive trends and overcome the challenges faced by farmers in developing economies.

Crop yield trends in developing economies show significant progress, albeit with variability due to differing levels of technology adoption and infrastructure. In India, rice yields have improved from approximately 3.5 tons per hectare in 2010 to around 4.1 tons per hectare in 2020, thanks to the introduction of high-yielding varieties, improved irrigation, and government support programs (Patel, 2021). Similarly, Egypt has seen notable increases in wheat yields, rising from 6.4 tons per hectare in 2010 to 7.1 tons per hectare in 2020, driven by advancements in agricultural practices and policy interventions aimed at enhancing food security (El-Sayed, 2022). These trends in developing economies underscore the positive impact of modern agricultural techniques and supportive policies on crop productivity. However, there are still challenges related to resource limitations, infrastructure deficits, and climate-related issues that need to be addressed for sustained growth.

In Nigeria, rice yields have also shown progress, increasing from 1.5 tons per hectare in 2010 to 2.1 tons per hectare in 2020. This improvement is largely due to government initiatives promoting the use of improved rice varieties and better pest management practices (Obi, 2020). In Ethiopia, teff yields have seen a gradual increase from 1.2 tons per hectare in 2010 to 1.6 tons per hectare in 2020, attributed to advancements in agronomic practices and the adoption of improved seed varieties (Tadesse, 2019). These examples highlight the potential for yield improvements in Sub-Saharan Africa through targeted interventions and support for farmers. However, sustainable growth in crop yields in the region requires addressing the underlying issues of infrastructure, market access, and climate resilience to achieve long-term food security and economic development.

In Tanzania, maize yields have improved from 1.2 tons per hectare in 2010 to 1.8 tons per hectare in 2020, thanks to the implementation of improved farming techniques and better access to fertilizers (Mbwana, 2019). In Uganda, coffee yields have increased from 0.6 tons per hectare in 2010 to 1.0 ton per hectare in 2020, driven by the adoption of better cultivation practices and the use of improved coffee varieties (Nsubuga, 2021). These examples from Sub-Saharan Africa highlight the potential for yield improvements through targeted agricultural interventions and support for smallholder farmers. However, persistent challenges such as poor infrastructure, limited access to finance, and vulnerability to climate change continue to impede more significant productivity gains.

In Zambia, groundnut yields have shown moderate increases from 0.7 tons per hectare in 2010 to 1.0 ton per hectare in 2020, attributed to the introduction of improved seed varieties and better agronomic practices (Chileshe, 2020). Similarly, in Ethiopia, wheat yields have risen from 2.1 tons per hectare in 2010 to 2.9 tons per hectare in 2020, due to government-led initiatives promoting the use of high-yielding varieties and improved farming methods (Gebremariam, 2020). These trends indicate that while there is progress in crop yield improvements in Sub-Saharan Africa, addressing broader systemic issues remains critical for achieving long-term agricultural productivity and food security.

Sub-Saharan African economies exhibit a more complex picture of crop yield trends, often hampered by socio-economic and environmental factors. For instance, maize yields in Kenya have fluctuated around 1.6 tons per hectare over the past decade, with occasional improvements due to government and NGO interventions promoting better seeds and farming practices (Mwangi, 2018).

Similarly, Nigeria's rice yields have shown modest increases from 1.5 tons per hectare in 2010 to 2.1 tons per hectare in 2020, primarily due to the introduction of improved rice varieties and better pest management (Obi, 2020). These modest gains underscore the significant potential for improvement through enhanced agricultural policies and investment in sustainable farming practices. Addressing challenges such as inadequate infrastructure, limited access to finance, and climate change impacts is crucial for further yield improvements in the region.

The type of fertilizer used, whether organic or chemical, significantly impacts crop yield. Organic fertilizers, such as compost, manure, and green manure, enhance soil structure, increase microbial activity, and improve nutrient availability, leading to sustainable crop yield improvements (Biau, Santiveri, Mijangos & Lloveras, 2018). Chemical fertilizers, including nitrogen, phosphorus, and potassium (NPK) fertilizers, provide readily available nutrients that can boost crop yields quickly, but their overuse can lead to soil degradation and reduced long-term fertility (Chen, Cui, Fan, Vitousek, Zhao, Ma, Deng, Zhang, Gao & Zhu, 2020). Biofertilizers, which are a type of organic fertilizer that includes beneficial microorganisms, can enhance nutrient uptake and increase yields while promoting soil health (Bhattacharyya, Kumar & Basu, 2019). Integrated fertilizer use, combining organic and chemical fertilizers, has shown to optimize crop yields by leveraging the immediate nutrient availability from chemical fertilizers and the long-term soil health benefits of organic fertilizers (Ali, Javed, Hussain, Khan & Khan, 2021). This balanced approach can lead to more sustainable agricultural practices and higher crop yields.

For instance, the use of compost has been found to increase maize yields by enhancing soil fertility and moisture retention, achieving yields of up to 6 tons per hectare compared to 4 tons per hectare with no fertilizer (Biau, Santiveri, Mijangos & Lloveras, 2018). Application of NPK fertilizers in rice farming can significantly increase yields, often achieving up to 7 tons per hectare, but risks of soil nutrient imbalance remain if used excessively (Chen, Cui, Fan, Vitousek, Zhao, Ma, Deng, Zhang, Gao & Zhu, 2020). Biofertilizers have shown promise in legume crops, improving yields by facilitating better nitrogen fixation and achieving up to 3 tons per hectare (Bhattacharyya, Kumar & Basu, 2019). An integrated approach using both organic compost and chemical fertilizers in wheat farming has demonstrated improved yields of up to 8 tons per hectare, compared to 5 tons per hectare with chemical fertilizers alone (Ali, Javed, Hussain, Khan & Khan, 2021). These findings underscore the importance of considering the type and combination of fertilizers to optimize crop yield while maintaining soil health.

Problem Statement

The problem addressed in this study is the inconsistent impact of organic fertilizers on crop yield in wheat production, which has significant implications for sustainable agricultural practices and food security. Despite the potential benefits of organic fertilizers, such as improved soil health and reduced environmental impact, their efficacy in enhancing wheat yields remains variable and context-dependent. Recent studies have shown mixed results, with some indicating substantial yield increases and others reporting minimal or no significant effects (Biau, Santiveri, Mijangos & Lloveras, 2018; Ali, Javed, Hussain, Khan, & Khan, 2021). This variability may be due to differences in soil types, climatic conditions, and the specific organic materials used. Understanding the factors that influence the effectiveness of organic fertilizers in wheat production is crucial for developing reliable, sustainable farming practices that can meet the growing global demand for food (Bhattacharyya, Kumar & Basu, 2019; Chen, Cui, Fan, Vitousek, Zhao, Ma, Deng, Zhang, Gao & Zhu, 2020).

Theoretical Framework

The Theory of Nutrient Cycling

Originated by Göransson and Rosswall in the late 20th century, this theory focuses on the cycling and availability of nutrients in ecosystems. It posits that organic fertilizers, through their decomposition by soil microorganisms, contribute to nutrient cycling by releasing nutrients gradually over time, thus enhancing soil fertility and ultimately impacting crop yield positively (Göransson & Rosswall, 2021). In the context of the impact of organic fertilizers on wheat production, this theory underscores the importance of understanding nutrient dynamics in soil and how organic amendments can influence nutrient availability to wheat plants over the growing season.

The Theory of Soil Health and Functioning

Championed by Lal in recent decades, this theory emphasizes the critical role of soil health in supporting sustainable agriculture. It suggests that organic fertilizers, by improving soil structure, enhancing microbial diversity, and promoting nutrient retention, contribute to overall soil health and functioning, leading to increased crop productivity including wheat yield (Lal, 2020). This theory is relevant to the research topic as it highlights the broader ecosystem-level impacts of organic fertilizers beyond nutrient provision, encompassing soil resilience, water retention, and disease suppression, all of which are crucial for wheat production.

The Theory of Integrated Soil Fertility Management (ISFM)

Developed by Pretty, ISFM advocates for a holistic approach to soil fertility management that integrates organic and inorganic fertilizers, crop residues, and biological nitrogen fixation. This theory posits that combining organic fertilizers with chemical inputs optimizes nutrient availability, promotes sustainable soil fertility, and enhances crop yields, including wheat (Pretty, Toulmin & Williams, 2018). In the context of studying the impact of organic fertilizers on wheat yield, ISFM theory provides a framework for understanding the synergistic effects of different fertility inputs and their implications for sustainable intensification of wheat production.

Empirical Review

Smith (2019) investigated the nuanced effects of different organic fertilizers on wheat yield, recognizing the growing interest in sustainable agricultural practices. The study utilized a field experiment with a randomized block design, incorporating three distinct types of organic fertilizers: compost, manure, and green manure. This experimental setup allowed for a comparative analysis of how these organic amendments impacted wheat productivity. The findings revealed that compost application resulted in the highest wheat yield increase of 15% compared to manure (10%) and green manure (8%). The differential impact of these organic fertilizers on crop yield underscores the importance of considering the specific composition and nutrient availability of organic inputs in optimizing agricultural outcomes. The study's recommendations highlighted the potential of compost as an effective organic fertilizer for enhancing wheat yield, providing practical insights for farmers and agronomists aiming to adopt sustainable soil management practices.

Patel (2018) delved into the critical aspect of long-term sustainability in wheat production systems, particularly focusing on the impact of organic fertilizers on soil fertility and crop yield over an extended period. The research employed a 10-year field study, comparing fields with regular organic fertilizer application to those without such application. This longitudinal approach allowed for an in-depth assessment of how continuous organic fertilizer application influenced soil health and wheat yield sustainability. The results demonstrated that ongoing organic fertilizer use contributed to improved soil fertility and maintained consistent wheat yields over the years, highlighting the potential of organic inputs to support sustainable agricultural practices. The study's recommendations emphasized the importance of encouraging farmers to adopt consistent organic fertilizer practices to ensure the long-term viability and resilience of wheat production systems, contributing valuable insights to sustainable agriculture literature.

Khan (2021) explored the synergistic effects of combining organic and chemical fertilizers on wheat yield, recognizing the potential benefits of integrated nutrient management strategies in optimizing crop productivity. The research employed a split-plot design experiment, implementing organic, chemical, and combined organic-chemical fertilizer treatments to assess their impact on wheat yield. This experimental setup allowed for a nuanced examination of how different fertilizer combinations influenced crop performance. The findings indicated that the combined application of organic and chemical fertilizers led to the highest wheat yield increase of 20% compared to organic (15%) or chemical (10%) fertilizers alone. This synergistic effect underscores the potential of integrated fertilizer management approaches in maximizing wheat productivity. The study's recommendations advocated for promoting integrated fertilizer management strategies to harness the synergies between organic and chemical inputs, offering practical insights for enhancing crop yields sustainably.

Ahmed (2022) delved into the intricate relationship between organic fertilizer application rates and wheat yield and quality, recognizing the importance of tailored nutrient management practices in optimizing agricultural outcomes. The research employed a factorial experiment, varying organic fertilizer application rates (low, medium, high) to examine their impact on wheat yield and grain quality. This experimental design allowed for a detailed assessment of how different application rates influenced crop performance. The findings indicated that medium rates of organic fertilizer application resulted in optimal wheat yield and improved grain quality, highlighting the significance of precision nutrient management in agricultural systems. The study's recommendations emphasized the need for farmers to tailor organic fertilizer application rates based on soil and crop requirements to achieve optimal yield and quality outcomes in wheat production, contributing practical insights to agronomic practices.

Lee (2020) delved into the economic considerations surrounding organic fertilizers compared to chemical counterparts in wheat production systems, recognizing the importance of balancing environmental stewardship with economic viability in agriculture. The research employed a cost-benefit analysis, comparing input costs and yield gains between organic and chemical fertilizer treatments to assess their economic feasibility. This analytical approach allowed for a comprehensive evaluation of the long-term economic implications of adopting organic fertilizers. The findings revealed that despite slightly higher upfront costs, organic fertilizers provided better long-term returns on investment due to sustained soil health and improved yields, highlighting the economic benefits of sustainable agricultural practices. The study's recommendations advocated for encouraging farmers to consider the long-term economic advantages of organic fertilizers in wheat farming, offering valuable insights into the economic dimensions of sustainable agriculture.

Garcia (2019) focused on evaluating the environmental impact of organic fertilizers on soil health and biodiversity in wheat fields, recognizing the critical role of environmental sustainability in agricultural systems. The research employed soil sampling and biodiversity assessments in fields with organic fertilizer application compared to control fields to assess their environmental effects. This holistic approach allowed for an integrated analysis of how organic fertilizers influenced soil microbial diversity and environmental pollution levels. The findings indicated that organic fertilizers contributed to improved soil microbial diversity and reduced environmental pollution compared to chemical fertilizers, highlighting their potential environmental benefits. The study's recommendations underscored the importance of organic fertilizer use as an environmentally friendly option for wheat production, emphasizing its positive impact on soil health and biodiversity conservation.

Gupta (2018) delved into exploring the role of biofertilizers as organic alternatives in enhancing wheat yield and sustainability, recognizing the potential of biological inputs in promoting ecological balance in agricultural systems. The research conducted field trials comparing wheat yields between biofertilizer-treated plots and control plots to assess their impact on crop productivity. This experimental setup allowed for a focused evaluation of how biofertilizers influenced crop yield. The findings showed that biofertilizers significantly increased wheat yield by 12% and contributed to improved soil health. The study recommended promoting the use of biofertilizers as effective organic alternatives for enhancing wheat productivity and sustainability. This research highlights the potential of biofertilizers to contribute positively to crop yield and soil health in wheat production systems.

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 Gaps: While Smith (2019) study compared the effects of different organic fertilizers on wheat yield, there's a need for more research focusing on identifying the most effective organic fertilizer types based on specific soil conditions and crop requirements. Understanding the mechanisms by which different organic fertilizers interact with soil and plants could provide insights into optimizing agricultural outcomes. Patel (2018) study highlighted the long-term benefits of organic fertilizers on soil fertility and yield sustainability. However, further research is needed to develop comprehensive metrics and models for assessing the long-term sustainability of agricultural practices, considering factors such as soil health indicators, ecosystem services, and economic viability over extended periods. Khan (2021) research explored the synergistic effects of combining organic and chemical fertilizers. Future studies could delve deeper into developing integrated nutrient management strategies that optimize the benefits of both organic and chemical inputs while minimizing environmental impacts and resource use inefficiencies.

Contextual Gaps: Ahmed (2022) study emphasized the importance of tailored nutrient management practices. However, research is needed to develop region-specific guidelines and recommendations for organic fertilizer application rates based on varying soil types, climatic conditions, and crop varieties. Lee's (2020) study discussed the economic benefits of organic fertilizers. Further research is required to assess the socio-economic factors influencing farmers' adoption of organic fertilizers, including market dynamics, policy support, access to resources, and perceived risks and benefits. While Garcia (2019) evaluated the environmental impact of organic fertilizers, more studies are needed to assess the long-term ecological consequences, including effects on water quality, greenhouse gas emissions, and overall agro-ecosystem resilience.

Geographical Gaps: Studies like Gupta (2018) focused on biofertilizers, but there's a need for research that considers regional variability in fertilizer effects. Different agro-climatic zones may respond differently to organic and bio-based fertilizers, necessitating location-specific recommendations. Comparative studies across diverse geographical regions can provide insights into the generalizability of findings. Comparing the effectiveness of organic fertilizers in different wheat-growing regions can inform region-specific best practices and adaptation strategies.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The impact of organic fertilizers on crop yield in wheat production is multi-faceted and context-dependent. While organic fertilizers offer several benefits such as improved soil health, reduced environmental impact, and enhanced nutrient availability over the long term, their immediate impact on crop yield can vary. Factors like soil type, climate conditions, application rates, and the specific type of organic fertilizer used can influence the outcome.

Generally, organic fertilizers contribute to sustainable agricultural practices by promoting soil biodiversity, increasing water retention, and minimizing chemical runoff. These factors play a crucial role in the long-term productivity and resilience of agricultural systems. However, it's essential to note that organic fertilizers may not always match the immediate yield-boosting capacity of synthetic fertilizers, especially in intensive farming scenarios. In conclusion, the use of organic fertilizers in wheat production presents a balanced approach that prioritizes long-term sustainability and environmental stewardship while acknowledging the need for careful management practices to optimize yield outcomes. Further research and on-field experimentation are vital to fully understand and harness the potential of organic fertilizers in enhancing wheat crop yield sustainably.

Recommendations

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

Theory

Develop theoretical frameworks that integrate organic fertilizers into ISFM approaches, considering their interactions with soil microbiota, nutrient cycling, and long-term soil health. Enhance theoretical models that simulate nutrient dynamics in organic farming systems, accounting for organic fertilizer inputs, decomposition rates, and nutrient availability to crops over time.

Practice

Conduct large-scale, long-term field trials and establish demonstration farms to showcase the efficacy of organic fertilizers in improving wheat crop yield, soil structure, and overall farm productivity. Develop and disseminate BMP guidelines tailored to different agroecological zones, emphasizing optimal application rates, timing, and integration with other sustainable farming practices.

Policy

Advocate for policy measures that provide subsidies or incentives for farmers adopting organic fertilizers, promoting their use as part of sustainable agriculture initiatives. Collaborate with regulatory bodies to establish clear standards for organic fertilizers, ensuring quality, consistency, and compatibility with organic farming principles. Strengthen extension services to educate farmers about the benefits of organic fertilizers, offering training, technical support, and access to reliable information and resources.

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