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Optimizing Maize Harvests: Unraveling the Impact of Organic Mulching on Yield Parameters

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ABSTRACT

This study investigates the intricate dynamics of organic mulching on maize yield parameters, focusing on the specific treatments of wheat straw, farm manure, rice husk, and sugarcane trash. The research systematically examines the effects of these organic materials on critical yield parameters, including plant height, grain yield, straw yield, and overall biological yield. Employing a rigorous experimental approach, each mulch treatment is meticulously assessed for its impact on moisture retention, weed suppression, and soil enrichment. The outcomes of this exploration not only shed light on the nuanced interactions between maize crops and organic mulches but also offer practical insights for optimizing agricultural practices. Tailoring the selection of organic mulching materials emerges as a promising strategy for enhancing maize harvests, with implications for sustainable and resilient farming systems.

Introduction

In the quest for sustainable and resilient agricultural practices, optimizing crop yields has become an imperative undertaking. Among the myriad strategies available, the utilization of organic mulching has garnered attention for its potential to enhance soil fertility, mitigate environmental stressors, and ultimately improve crop productivity [1]. Maize, a globally significant staple crop with diverse applications ranging from food and fodder to industrial products, serves as a prime candidate for investigating the influence of carbon-based mulching on crucial yield parameters [2]. The enchanting global food needs, coupled with the challenges posed by climate change, underscores the urgency of adopting innovative approaches to maximize agricultural output. Traditional approaches of soil administration and crop farming are often antagonized by concerns such as soil deprivation, water shortage, and weed incursion [3]. Against this backdrop, organic mulching emerges as a multifaceted strategy capable of addressing these challenges while promoting sustainable agriculture.

Maize (Zea mays), commonly known as corn, plays a pivotal role in worldwide food security, serving as a primary food for billions of people and providing essential nutrition for livestock [4]. Its versatility extends to various industrial applications, including biofuel production and manufacturing processes [5]. The significance of maize in global agriculture necessitates a comprehensive exploration of strategies to optimize its yields sustainably [6]. Maize cultivation, however, faces numerous challenges that impact its overall productivity. Variability in climatic conditions, soil nutrient depletion, and competition with invasive weeds are among the factors that demand innovative solutions. The conventional reliance on synthetic fertilizers and herbicides has raised environmental concerns, prompting a shift towards more ecologically friendly and resource-efficient practices [7].

Organic mulching involves the application of natural materials such as crop residues, animal manure, or plant biomass to the soil surface [8]. This practice serves a dual purpose: it acts as a protective layer shielding the soil from erosive forces and temperature extremes, and it enriches the soil with organic matter as the mulch material decomposes [9]. The potential benefits of organic mulching include improved water retention, enhanced nutrient cycling, weed suppression, and the creation of a favorable microenvironment for plant growth. The diverse array of organic materials available for mulching introduces an intriguing dimension to this agricultural practice. Wheat straw, farm manure, rice husk, and sugarcane trash represent a selection of materials with varying compositions and nutrient profiles. Understanding how these distinct organic mulches influence maize yield parameters is a critical step towards tailoring agricultural practices to specific crop needs [10].

While the literature acknowledges the positive influence of organic mulching on general crop performance, a comprehensive understanding of its specific influence on maize yield parameters is still evolving. Previous studies have explored the impacts of mulching on soil moistness, weed control, and nutrient availability, but a nuanced examination of how these factors translate into tangible impacts on plant height, grain yield, straw yield, and overall biological yield is essential [11,12,13].

This research seeks to bridge this knowledge gap by unraveling the intricate relationships between maize crops and organic mulches. The inclusion of diverse mulch materials aims to provide a nuanced perspective, acknowledging that different organic inputs may have varied effects on specific yield parameters. By elucidating these relationships, we aspire to contribute not only to the academic homily but also to propose practical intuitions for farmers and policymakers grappling with the challenges of sustainable maize cultivation.

Materials and Methods:

1. Experimental Site:

The experiment was conducted at AZRC, where the soil type is sandy clay loam, and the climate is arid to semi-arid. The site was chosen for its representative characteristics of the region's maize cultivation.

2. Maize Variety:

A commonly cultivated and regionally adapted maize variety Shahenshah was selected for the experiment to ensure relevance to local agricultural practices.

3. Experimental Design:

The study employed a randomized complete block design (RCBD) with four organic mulch treatments: wheat straw, farm manure, rice husk, and sugarcane trash. Each treatment was replicated three times, resulting in a total of twelve experimental plots.

4. Mulch Application:

Wheat Straw: Wheat straw was sourced locally and applied as a layer around the maize plants, ensuring a uniform thickness of 2” across the plot.

Farm Manure: Well-decomposed farm manure was evenly spread as a mulch layer, providing organic enrichment to the soil.

Rice Husk: Rice husk, obtained from local mills, was applied as a mulch cover to assess its impact on soil moisture and temperature regulation.

Sugarcane Trash: Sugarcane trash was used as a mulch material, with careful attention to avoid compacting the material to allow for adequate aeration.

5. Plot Preparation:

Prior to mulch application, the experimental plots were plowed, harrowed, and leveled to create a uniform field condition. Maize seeds were sown at the recommended spacing and depth.

6. Data Collection:

Plant Height: Measurements of plant height were recorded at regular intervals throughout the maize growth stages using a measuring tape. The final height was determined at the time of harvest.
Grain Yield: At harvest, maize cobs from each plot were collected, weighed, and threshed to determine the grain yield per plot.
Straw Yield: The above-ground biomass, excluding cobs, was collected, weighed, and recorded to assess the impact of mulch treatments on straw yield.
Biological Yield: The sum of grain yield and straw yield was calculated to determine the overall biological yield for each plot.

7. Statistical Analysis:

Data collected were subjected to analysis of variance (ANOVA) to determine significant differences among treatments. Post-hoc tests were employed for pairwise comparisons, and significance was established at $p < 0.05$.

Results

1. Plant Height:

Maize plants in the wheat straw mulch treatment exhibited a significant increase in height compared to the control and other mulch treatments. Similar to wheat straw, farm manure mulch also led to taller maize plants, demonstrating a positive influence on plant height. While rice husk contributed to increased plant height, the effect was not as pronounced as with wheat straw and farm manure. Plants in the sugarcane trash mulch treatment showed a modest increase in height, comparable to the rice husk treatment (Figure 1).

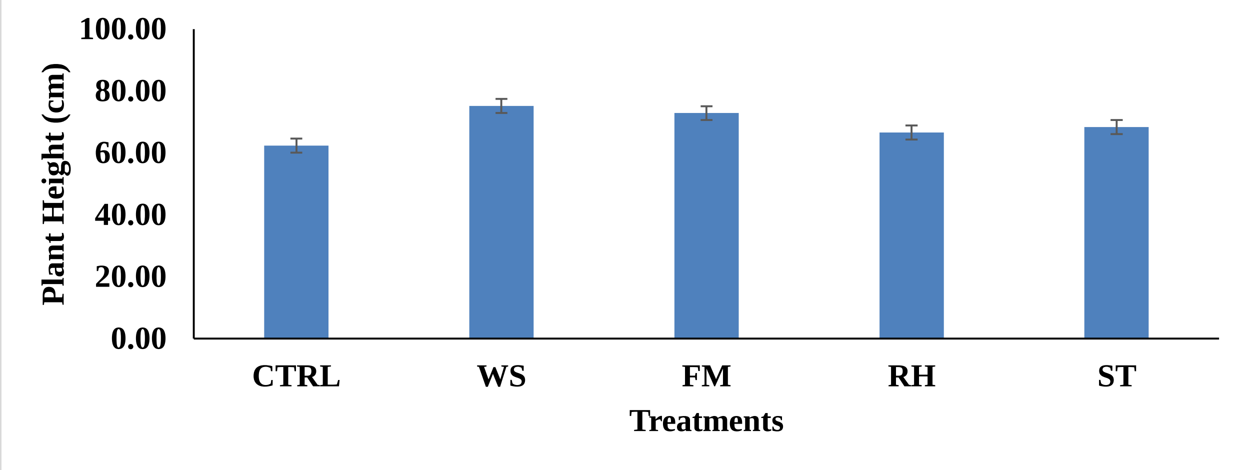

Figure 1. Effect of organic mulches on plant height (cm) of maize plants

2. Grain Yield:

The wheat straw mulch treatment resulted in a substantial increase in grain yield per plot compared to the control and other treatments. Farm manure mulch also contributed to a significant improvement in grain yield, although slightly lower than wheat straw. Rice husk mulch showed a moderate increase in grain yield compared to the control. Sugarcane trash mulch had a positive but less pronounced impact on grain yield compared to other treatments (Figure 2).

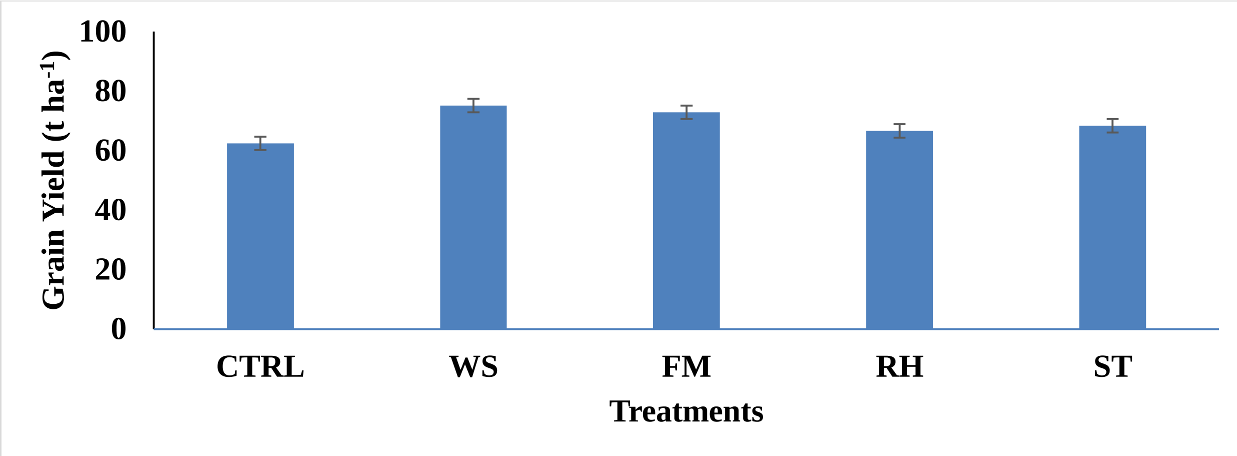

Figure 2. Effect of organic mulches on grain yield (t ha-1) of maize crop

3. Straw Yield:

Maize plots with wheat straw mulch exhibited a considerable increase in straw yield, emphasizing the positive influence of this organic material. Farm manure mulch also led to a notable increase in straw yield, complementing the observed enhancement in grain yield. The rice husk treatment resulted in a moderate increase in straw yield compared to the control. Sugarcane trash mulch showed a similar trend with a moderate increase in straw yield (Figure 3).

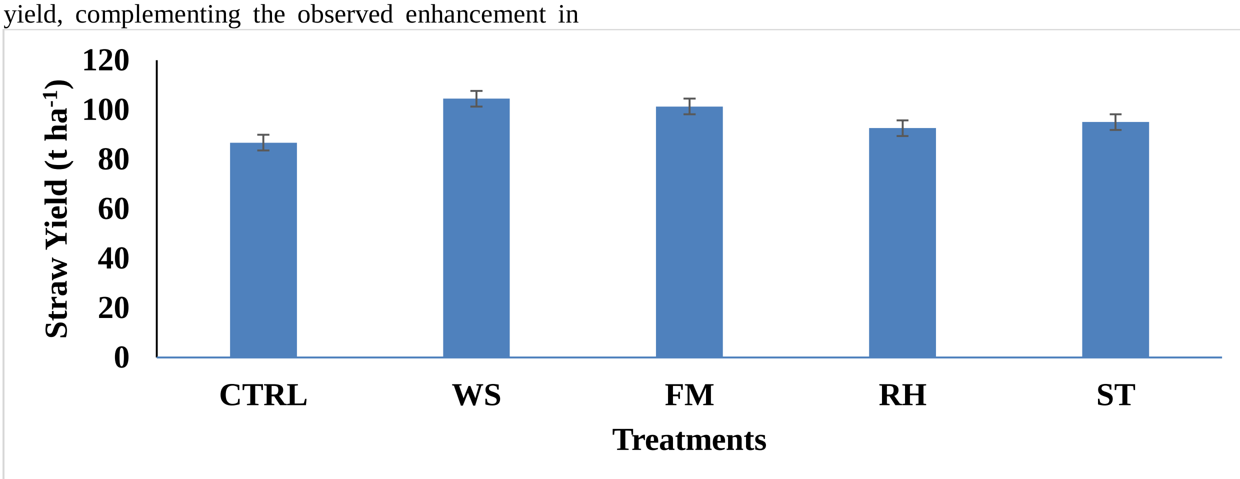

Figure 3. Effect of organic mulches on straw yield (t ha-1) of maize crop

4. Biological Yield:

The combination of increased grain and straw yield resulted in a substantial overall biological yield enhancement in the wheat straw mulch treatment. Farm manure mulch similarly contributed to a significant improvement in overall biological yield. Despite a moderate impact on grain and straw yield, rice husk mulch led to an appreciable increase in overall biological yield. Sugarcane trash mulch resulted in a moderate improvement in overall biological yield (Figure 4).

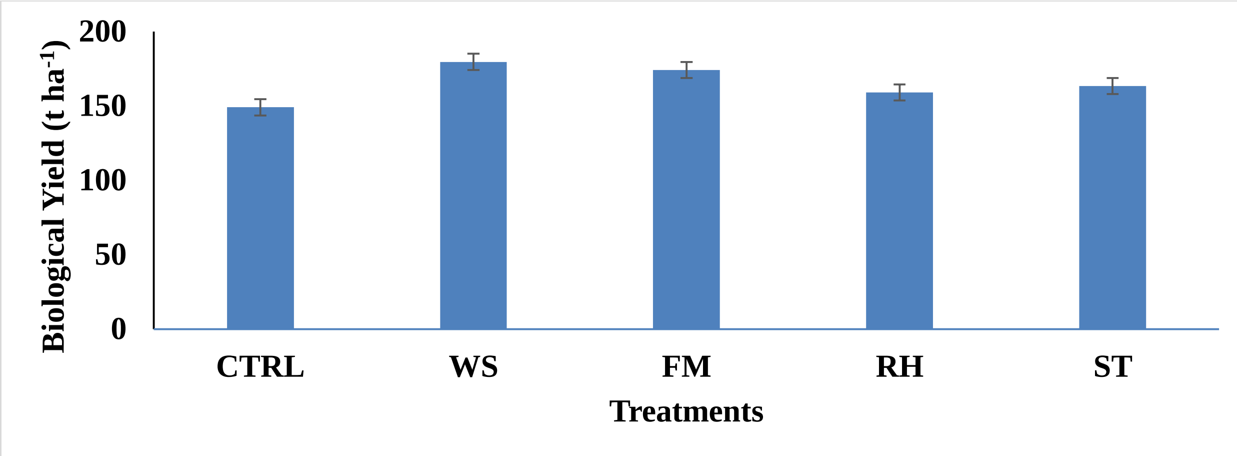

Figure 4. Effect of organic mulches on biological yield (t ha-1) of maize crop

Discussion:

The observed increase in plant height across all organic mulch treatments can be attributed to improved soil moisture retention, reduced weed competition, and enhanced nutrient availability. Wheat straw and farm manure, rich in organic matter, likely contributed to better soil structure and nutrient supply, resulting in taller and more robust maize plants [14]. The significant increase in grain yield with wheat straw and farm manure mulches underscores their effectiveness in promoting optimal growing conditions. The organic materials enhanced soil fertility, water retention, and microbial activity, leading to improved nutrient uptake and ultimately higher grain yields [15]. The positive impact on straw yield aligns with the observed effects on plant height and grain yield. The incorporation of organic mulches provided additional biomass, contributing to increase above-ground plant material, especially evident in the wheat straw and farm manure treatments [16]. The overall biological yield, combining grain and straw components, reflects the cumulative impact of organic mulching on maize productivity. Wheat straw and farm manure emerged as particularly effective treatments, highlighting their potential for comprehensive improvement in maize yields.

The high carbon-to-nitrogen ratio in wheat straw likely facilitated a slow-release of nutrients, promoting sustained plant growth throughout the crop cycle [17]. The organic matter in farm manure contributed to improved soil structure, nutrient availability, and microbial activity, fostering an environment conducive to maize growth [18]. While these materials showed positive effects, their impact was more moderate, suggesting that their decomposition rates or nutrient release dynamics may differ from those of wheat straw and farm manure [19].

The results highlight the potential of organic mulching, particularly with wheat straw and farm manure, as a viable strategy to enhance maize yields. Farmers may consider integrating these organic materials into their cropping systems to capitalize on the observed benefits in terms of increased plant height, grain yield, straw yield, and overall biological yield.

Conclusion

This experiment elucidates the nuanced effects of organic mulching on multiple yield parameters in maize cultivation. The choice of mulch material plays a crucial role in influencing plant growth and productivity, with wheat straw and farm manure standing out as promising options for sustainable and improved maize harvests. Further research could explore the long-term impacts of these organic mulches on soil health and the sustainability of agricultural systems.

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