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Fortified Organic Fertilizers as Alternatives to Inorganic Fertilizers for Maize Production

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ABSTRACT

This study was conducted during 2024 maize growing season to evaluate effects of nitrogen-enriched organic fertilizers on maize growth, yield, and soil nutrient status. fertilizers assessed included an enriched organic fertilizer (MFERT) and nitrogen-fortified poultry manure (PTM), compared against conventional inorganic NPK fertilizer and an unfertilized control. results indicated that maize plants grown with enriched organic fertilizers exhibited growth and yield characteristics comparable to those treated with inorganic fertilizer. At harvest, plants treated with MFERT attained an average height of 261 cm, followed closely by those receiving fortified poultry manure (254 cm) and inorganic fertilizer (254 cm). time required to reach 50% tasseling varied among treatments, with inorganic fertilizer allowing fastest tasseling at 52 days, followed by MFERT at 50 days, PTM at 54 days, and control taking longest. Grain yield was significantly influenced by fertilization, with MFERT yielding 3.96 t ha^{-1}, NPK fertilizer producing 3.55 t ha^{-1}, PTM yielding 3.14 t ha^{-1}, and control yielding lowest at 2.66 t ha^{-1}. findings suggest that enriched organic fertilizers can serve as viable alternatives to conventional inorganic fertilizers for sustaining maize growth and yield.

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INTRODUCTION

Maintaining high crop productivity in intensive agricultural systems requires adequate fertilization. The widespread reliance on synthetic fertilizers has resulted in increased soil degradation, declining fertility, and environmental concerns, including groundwater contamination and greenhouse gas emissions [1]. Excessive application of inorganic fertilizers contributes to nutrient imbalances, soil acidification, and loss of essential soil microbial populations, ultimately reducing soil sustainability [2]. Additionally, inorganic fertilizers are often expensive and inaccessible to smallholder farmers, particularly in developing regions, necessitating the exploration of alternative fertilization strategies.

Organic manures, such as poultry manure, cow dung, and crop residues, provide a sustainable solution for soil fertility management. These materials gradually release nutrients into soil, improving soil structure, water retention, and microbial biomass [3]. Organic fertilizers are also known to enhance soil aeration and root development, leading to improved plant growth and yield stability over multiple growing seasons [4]. presence of organic matter in these fertilizers promotes soil aggregation, increasing resistance to erosion and improving nutrient-holding capacity. Moreover, organic fertilizers contribute to carbon sequestration, playing a crucial role in climate change mitigation [5].

However, one of major challenges associated with organic fertilizers is their slow and inconsistent nutrient release, which may not always align with nutrient demands of crops, particularly in their early growth stages. This limitation necessitates fortification of organic fertilizers with additional nutrients to enhance their efficiency [6]. enrichment of organic manures with nitrogen sources, such as urea or ammonium sulfate, accelerates nutrient availability, ensuring adequate support for early plant development and biomass accumulation. Fortified organic fertilizers offer a balanced nutrient supply, minimizing nutrient leaching losses and reducing dependency on synthetic inputs [7].

This study aimed to evaluate effectiveness of nitrogen-enriched organic fertilizers in supporting maize growth and yield while maintaining soil fertility. By comparing fortified organic fertilizers with conventional inorganic fertilization, this research seeks to provide insights into sustainable nutrient management strategies that balance productivity with environmental stewardship.

Materials and Methods

The study was conducted at Arid Zone Research Center, DI Khan, characterized by an arid climate with short rainy seasons from July to early September. experimental soil had a sandy loam texture, low organic matter content, and a deep red-clay profile. experiment was laid out in a randomized complete block design (RCBD) with three replicates and four treatments: an unfertilized control, MFERT (nitrogen-enriched organic fertilizer), nitrogen-fortified poultry manure (PTM), and conventional NPK fertilizer (20-10-10). Each plot measured 3 × 6 m.

The maize variety 'Shahenshaw' was sown, and organic fertilizers were incorporated one week before planting. NPK fertilizer was applied two weeks after planting via ring application around

the maize plants. Manual weeding was carried out as needed. Maize was harvested at 14 weeks after planting and sun-dried to a moisture content of 14% before further analysis. Growth and yield parameters, including plant height, tasseling time, ear height, cob weight, and grain yield, were recorded. Statistical analysis was conducted using Analysis of Variance (ANOVA), and mean comparisons were performed using the Least Significant Difference (LSD) test at a 5% probability level.

Table 1: Characteristics of soil and enriched fertilizers

Characteristic	Soil	PTM	MFERT
pH	8.3	7.13	6.2
Organic Carbon (%)	0.54	5.98	14.56
Total N (%)	0.32	0.69	2.31
Available P (ppm)	12.4	0.54	1.46
Available K (ppm)	110.7	0.57	0.13
Available Na (cmol/kg)	3.37	1.06	0.56
Available Ca (cmol/kg)	2.19	1.09	0.08
Available Mg (cmol/kg)	3.89	1.76	0.04
CEC (cmol/kg)	4.21		
Texture	Sandy Loam		

Results

Fertilization significantly influenced maize growth parameters. The tallest plants (261.63 cm) were observed in MFERT-treated plots, while those treated with NPK and PTM were slightly shorter (254.13 cm). Plants in the control plots exhibited the shortest height, emphasizing the role of fertilization in enhancing vegetative growth (Fig. 1).

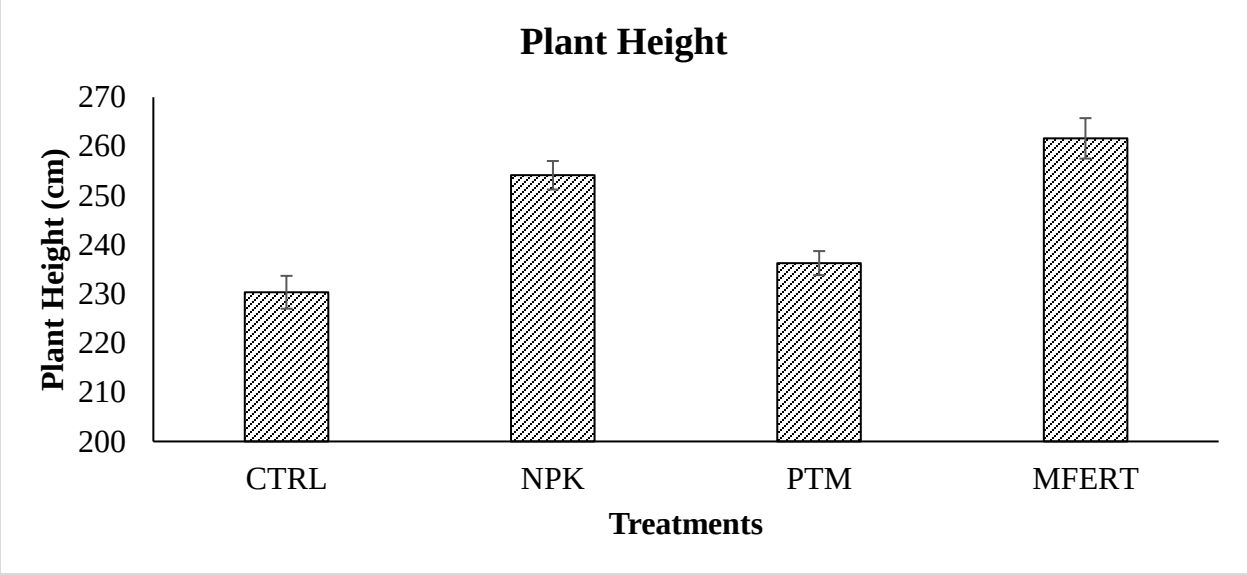

Fig.1. Effect of NPK and enriched organic fertilizers on maize plant height

The time required for 50% tasseling varied significantly among treatments, with MFERT-treated plants reaching this stage in 50 days, followed by NPK-fertilized plants in 52 days, PTM-treated plants in 54 days, and the control plants taking the longest time (Fig. 2).

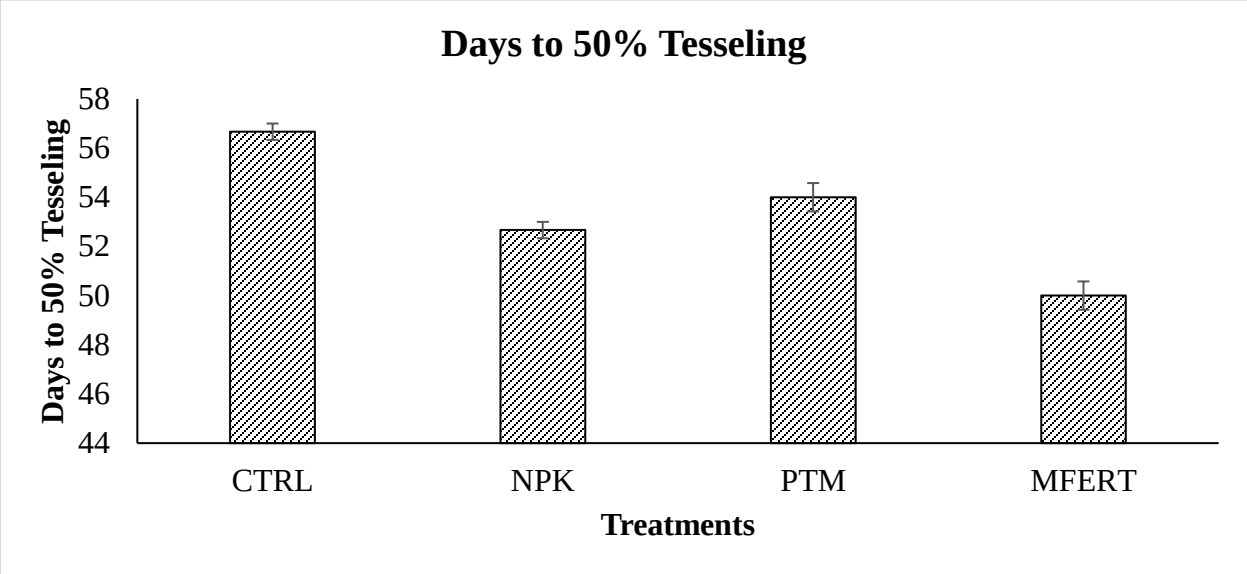

Fig. 2. Effect of NPK and enriched organic fertilizers on days to 50% tasseling of maize

Ear height was significantly higher in MFERT-treated plants compared to the control, indicating better nutrient uptake and enhanced growth (Fig. 3). The cob length was significantly greater in fertilized treatments, ranging from 12 to 13 cm, whereas control plants produced shorter cobs of approximately 11 cm (Fig. 4).

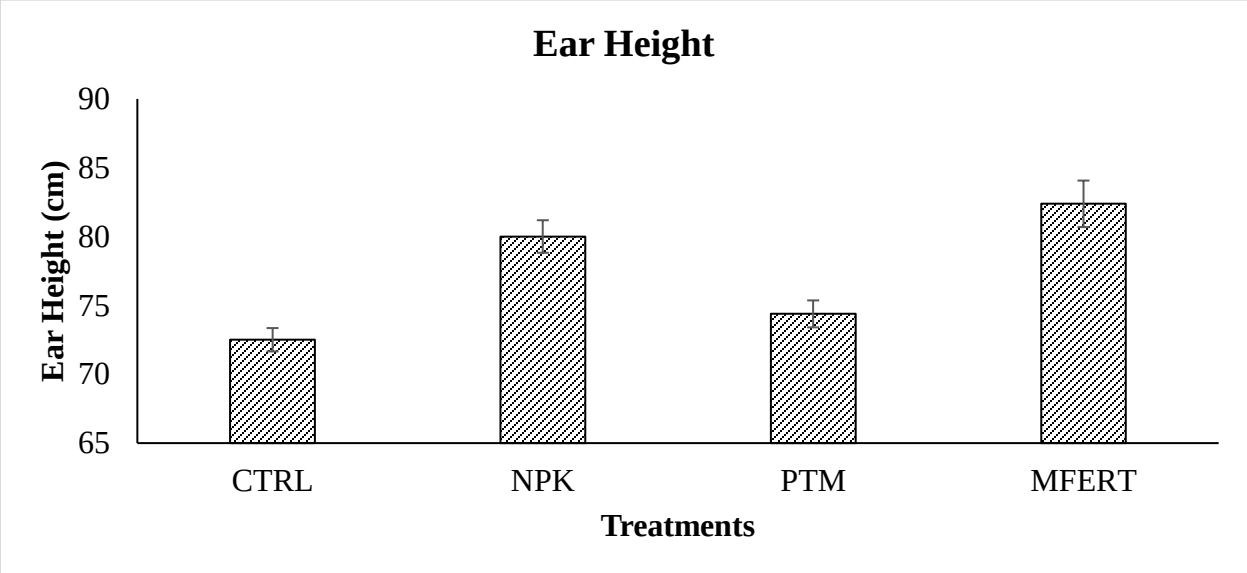

Fig. 3. Effect of NPK and enriched organic fertilizers on ear height of maize

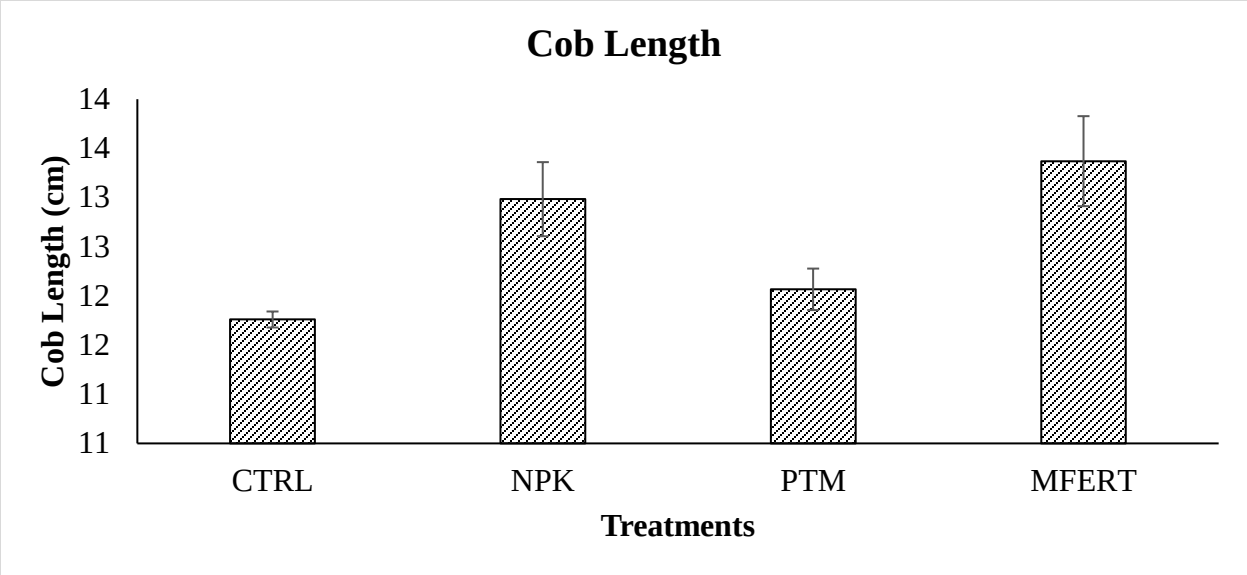

Fig. 4. Effect of NPK and enriched organic fertilizers on cob length of maize

Average cob weight was also higher in fertilized plots, ranging from 135 to 172 g, while the control plants produced smaller cobs with an average weight of 114 g (Fig. 5).

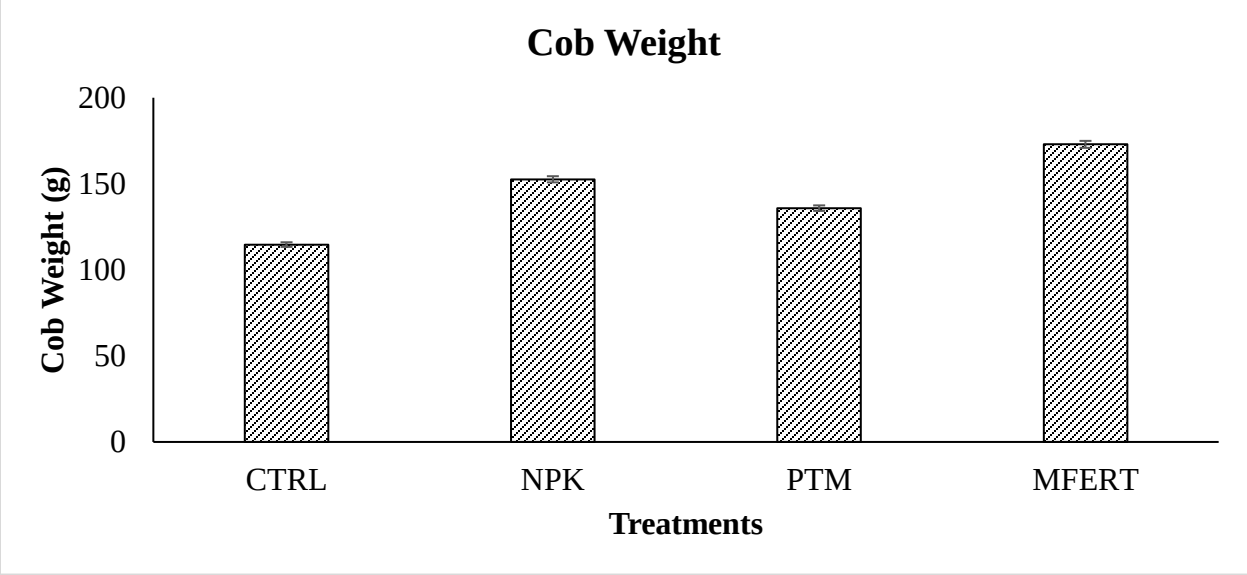

Fig. 5. Effect of NPK and enriched organic fertilizers on cob weight of maize

The total number of seeds per cob was highest in MFERT-treated plants, followed by PTM and NPK-fertilized plants. The unfertilized control produced the lowest number of seeds per cob (Fig. 6). The 100-seed weight showed a similar trend, with significantly higher values observed in

fertilized treatments (Fig. 7). This indicates that enriched organic fertilizers contribute positively to seed development, improving overall grain quality and yield.

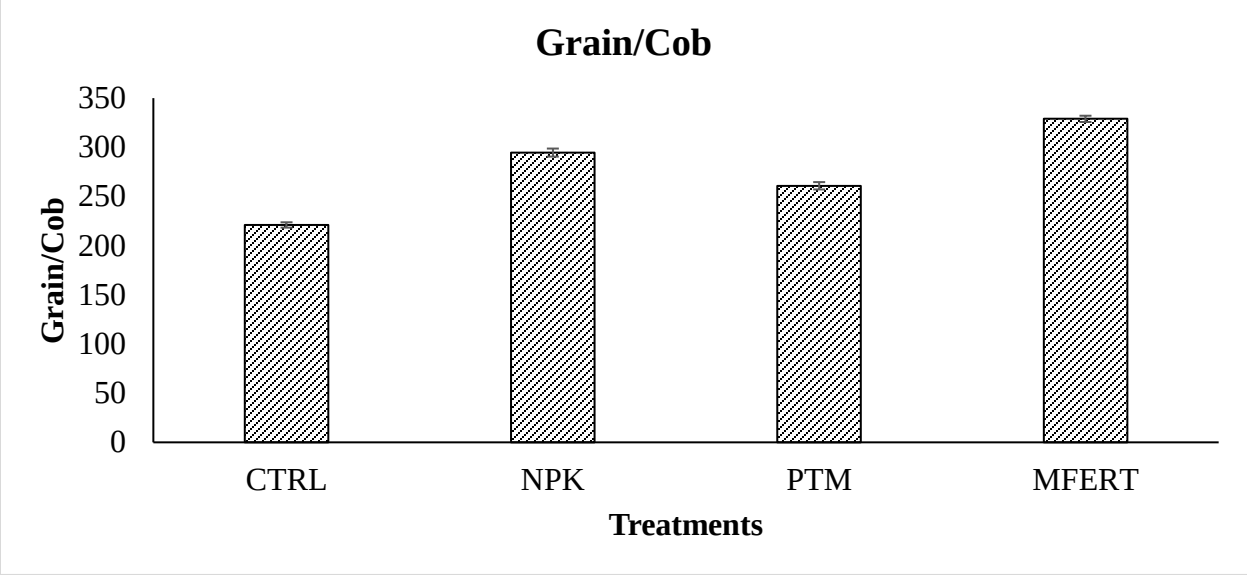

Fig. 6. Effect of NPK and enriched organic fertilizers on number of grains per cob of maize

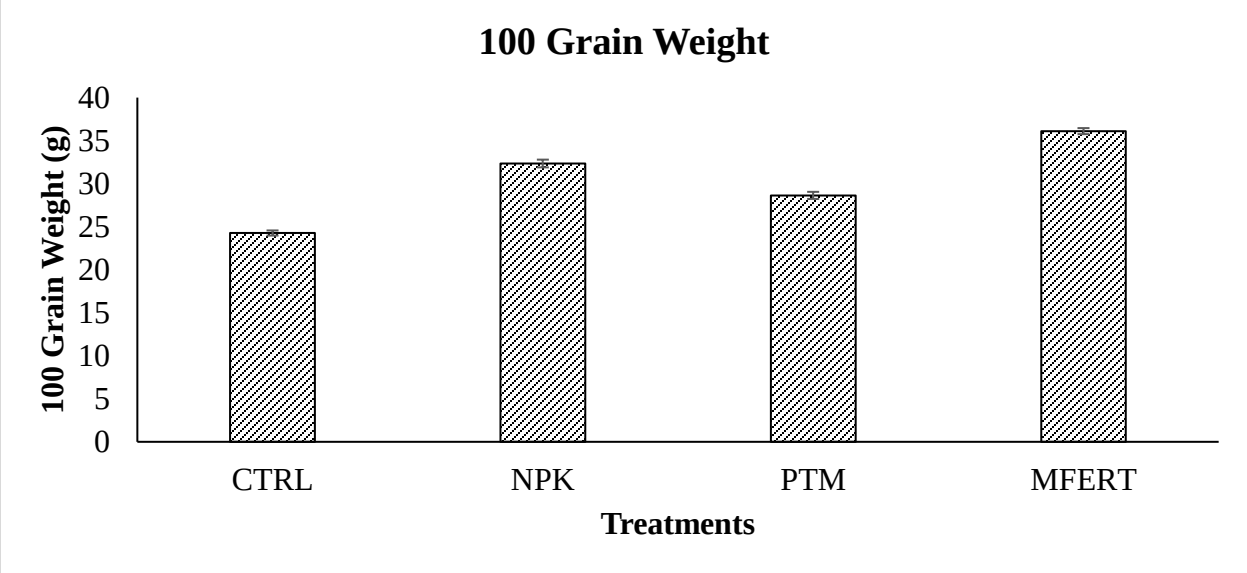

Fig. 7. Effect of NPK and enriched organic fertilizers on 100 grain wieght of maize

Grain yield followed a similar pattern, with MFERT producing the highest yield of 3.96 t ha^{-1}, followed by NPK (3.55 t ha^{-1}) and PTM (3.14 t ha^{-1}). The control yielded significantly less at 2.66 t ha^{-1}, demonstrating the necessity of fertilization for optimal maize production (Fig. 8). The comparable performance of MFERT and NPK fertilizers suggests that enriched organic manures can effectively substitute for inorganic fertilizers in maize cultivation.

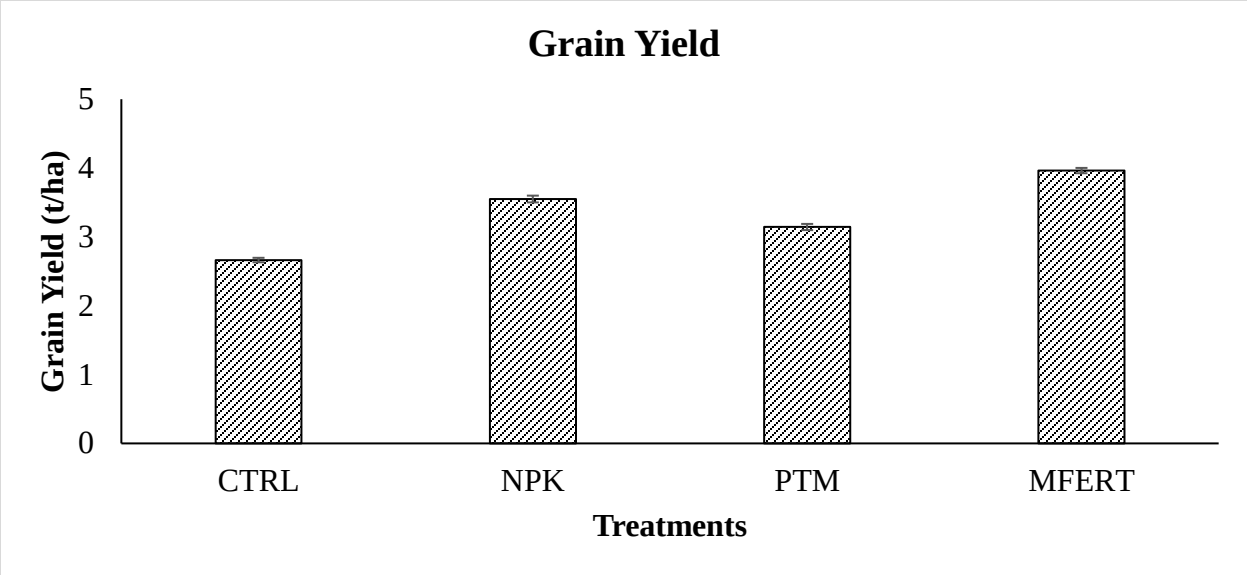

Fig. 8. Effect of NPK and enriched organic fertilizers on grain yield of maize

Discussion

The findings of this study demonstrate that maize growth and yield were significantly influenced by the application of enriched organic fertilizers. The greater plant height and leaf area observed in maize plants treated with organic fertilizers, compared to those receiving inorganic fertilizers alone, suggest that the organic fertilizers provided a sustained release of nutrients. While inorganic nitrogen fertilizers are known for their immediate availability, delayed effectiveness observed in this study indicates that they had not yet fully assimilated into soil at time of measurement. improved maize growth under enriched organic fertilizer treatments underscores potential of organic amendments, fortified with inorganic nutrients, to provide adequate nourishment for optimal crop development.

The comparable growth performance observed between two organic fertilizer treatments highlights influence of nutrient composition and fortification frequency. Notably, MFERT treatment was pre-enriched with organic manure before addition of urea, whereas poultry manure was fortified only once during experiment. This suggests that poultry manure may require more frequent fortification to achieve similar performance levels. results indicate that nutrient availability and uptake efficiency can be enhanced by strategic organic-inorganic nutrient integration.

Maize grain yield was significantly increased by fertilization, affirming role of nutrient supplementation in improving crop productivity. ability of enriched organic fertilizers to produce yields comparable to those obtained with inorganic fertilizers alone suggests that these amendments can serve as viable alternatives. Previous studies have also reported increased nutrient use efficiency with combined organic and inorganic fertilizer applications. Akpan et al.[8] found that maize yield was highest when NPK fertilizer was combined with poultry manure, as opposed to sole applications. Similarly, Anisuzzaman et al.[9] reported that a mixture of organic and inorganic

fertilizers resulted in significantly higher maize yields than organic fertilizers alone, suggesting that sole organic fertilization may not always be sufficient to maximize productivity.

Complementary fertilization with organic and inorganic nutrients likely contributed to improved nutrient uptake and utilization efficiency. Ghosh et al.[10] noted that combined organic and mineral fertilization enhances crop nutrient use efficiency, a trend that was evident in the current study. Maize, being an aggressive feeder, benefited from the quick-release nutrients in inorganic fertilizers while also leveraging the sustained nutrient availability from organic sources. The reduction in inorganic fertilizer rates in combination treatments did not negatively impact yield, indicating that organic amendments effectively supplemented nutrient demands.

Similar findings have been reported for other crops. Zhang et al.[11] demonstrated that the integration of organic manures with chemical nitrogen fertilizers enhanced maize dry matter yield. Yang et al.[12] found that an optimum rice grain yield was achieved with the application of 10 t ha^{-1} farmyard manure complemented with 120 kg N, outperforming both sole organic and sole inorganic fertilization. Kilic et al.[13] reported higher sorghum grain yields when organic manure was supplemented with half-rate NP inorganic fertilizer, further supporting the benefits of integrated nutrient management.

The benefits of enriched organic fertilizers extend beyond yield improvement. Enhanced soil fertility, as indicated by increased nitrogen, phosphorus, and potassium levels post-fertilization, suggests that organic amendments contribute to soil nutrient replenishment. Studies have shown that continuous cropping without fertilization leads to rapid soil nutrient depletion. Serri et al.[14] (1983) reported significant nutrient deficiencies in African soils within short cultivation periods, with nitrogen being the most depleted element.

The superior performance of MFERT over other organic sources aligns with previous findings indicating its higher nutrient availability. The efficient nutrient cycling in MFERT, attributed to direct dietary intake and waste excretion patterns, makes it a superior organic amendment. As shown in this study, the NPK requirements of maize can be met through enriched organic fertilization, reducing dependency on inorganic fertilizers while promoting soil health and long-term agricultural sustainability.

Conclusion

This study demonstrates that nitrogen-enriched organic fertilizers can effectively support maize growth and yield while maintaining soil fertility. comparable performance of MFERT to NPK fertilizer suggests that enriched organic manures can serve as viable alternatives to inorganic fertilizers. This finding has significant implications for sustainable agriculture, particularly in regions where synthetic fertilizers are costly or inaccessible. Future research should explore long-term soil fertility impacts and economic feasibility to further validate these findings.

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