

Effect of Organic and Inorganic Fertilizer Doses on Growth and Yield of Wheat Crop (*Triticum aestivum*) in Northeast Agro Ecology of Afghanistan

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ABSTRACT

A field experiment was conducted at the agriculture farm of Kunduz University during the fall season of 2023 to evaluate the effects of organic and inorganic fertilizers on the growth and yield of wheat crop in the northeast agro ecology of Afghanistan. The study included five treatments: control, 160 kg N/ha+80 kg P₂O₅/ha+10 tons of poultry manure/ha, 80 kg N/ha+40 kg P₂O₅/ha+5 tons of poultry manure and 160 kg N/ha+80 kg P₂O₅+10 tons of poultry manure. Results indicated that the combination of 160 kg N/ha + 80 kg P₂O₅/ha+10 tons of poultry manure yielded the highest plant height (107.08 cm), leaf area index (3.02), dry matter accumulation (372.81 g/plant), spike length (16.51 cm), spikes per square meter (343.67), spikelet's per spike (21.40), grains per spike (53.62), 1000-grain weight (57.73 g), grain yield (4.20 tons/ha), straw yield (6.38 tons/ha), biological yield (10.39 tons/ha), harvest index (44.61%), gross return (101,165 AFN/ha), net return (60,740 AFN/ha) and benefit cost ratio (1.73). The control plot exhibited the lowest growth, yield and economic performance. Treatment revealed the detrimental effects of inadequate fertilization underscoring the necessity for nutrient management in wheat cultivation. The results advocate for integrated nutrient management practices that leverage both organic and inorganic fertilizers to optimize agricultural productivity sustainably. These findings provide valuable insights for farmers and agricultural policymakers in Afghanistan emphasizing the need to adopt balanced fertilization techniques to enhance food security and economic stability in the region. Future research should focus on long-term effects and the sustainability of these practices to ensure continued agricultural success.

Keywords- Growth, Nitrogen, Phosphorus, Poultry Manure, Wheat, Yield.

I. INTRODUCTION

Wheat crop (*Triticum aestivum* L.) is the most significant food grain in Afghanistan, cultivated over approximately 2.5 million hectares. It accounts for around 80% of the total area dedicated to all cereals. In 2017, wheat production reached 4.3 million tonnes, representing 79% of the country's total cereal output

(FAO, 2018). The main constraints to wheat production are nutrient deficiencies in the soil, with macronutrient shortages being a prevalent issue in Afghanistan agriculture. Wheat Crop is an annual plant from the Poaceae family, originally found in the Mediterranean region and southwestern Asia, It is one of several cultivated wheat species and is now grown in temperate climates around the globe. Additionally, it has become

one of the most significant cereals cultivated extensively in tropical and subtropical areas. Wheat plays a crucial role in global trade, surpassing all other crops in importance (FAO, 2014). Integrated Nutrient Management (INM) encourages the balanced and careful application of chemical fertilizers alongside organic amendments such as poultry manure, farmyard manure, vermicompost, green manures, and micronutrient-enriched fertilizers. It also advocates for the use of bio-fertilizers that can partially replace NPK fertilizers (Hemmat *et al.*, 2023). The appropriate use of poultry manure in combination with chemical fertilizers enhances the physical, chemical, and biological properties of the soil, leading to increased crop productivity additionally, applying organic manures can boost the availability of native nutrients in the soil and improve the effectiveness of applied fertilizers. Wheat is the most extensively cultivated cereal crop, both in terms of area and yield, providing sustenance for about two-thirds of the global population. However, yields have been adversely affected by factors such as poor soil health, low-quality seeds, delayed planting and harvesting, inconsistent fertilizer application, and insufficient irrigation. Furthermore, soil degradation resulting from rapid population growth and urban development, along with subpar seed quality, has led to food insecurity in developing countries (Sharma *et al.*, 2010).

The excessive use of inorganic fertilizers to meet food demand often results in nitrogen losses through various means, including ammonia volatilization, leaching, and greenhouse gas emissions, which pose significant environmental challenges and disrupt overall nitrogen balance. Currently, researchers are extensively exploring the use of organic manures from various animals (such as pigs and cows), biochar and crop residues, either individually or in mixtures. These organic manures play a crucial role in sustaining soil fertility by supplying essential plant nutrients, especially micronutrients, which promote crop growth. Additionally, the application of manures enhances the physical, chemical, and biological properties of the soil, resulting in lasting benefits for future crops. Key sources of organic matter—such as green manure, farmyard manure, press mud (a byproduct of sugar production), and wheat residue—can significantly boost soil fertility and improve plants' ability to utilize fertilizers effectively. Farmyard manure contributes to better soil structure, increased water and nutrient retention, improved root penetration, enhanced microbial activity, and greater nutrient exchange capacity, all of which collectively enhance soil fertility. The application of various manures, such as press mud, poultry manure, and farmyard manure, in wheat crop has been shown to enhance crop yields and increase the concentrations of DTPA-extractable micronutrients (Zn, Cu, Fe, and Mn) in the soil in north-western India. (Sarwar *et al.*, 2017) reported that combining organic and inorganic fertilizers

leads to improved growth and yield characteristics in both rice and wheat. A long-term study spanning 40 years of soybean-maize rotation demonstrated that applying organic manures to brown soil not only boosted crop yields but also improved soil properties. Furthermore, farmyard manure is preferred over other organic fertilizers because it breaks down more quickly than alternative sources. Apart from organic manures, residue retention has also been promoted as a viable. Using soil amendments can enhance crop yields while reducing reliance on chemical fertilizers. As crop production increases, so does the amount of crop residue generated each year. Incorporating this residue back into the soil contributes to improved organic matter levels and enhances the physical, chemical, and biological properties of the soil, thereby maintaining its fertility. Research indicates that retaining crop residue positively affects crop yields. For example, incorporating rice residue into sandy loam soil in north-western India significantly improved wheat yields compared to untreated plots. Moreover, maintaining crop residue in the rice-wheat cropping system has increased the micronutrient content in the crops. Existing literature often examines either organic or inorganic fertilizers in isolation, without comprehensive studies comparing their combined effects or optimal ratios.

There is a need for research that evaluates the synergistic effects of varying doses of both types of fertilizers on wheat growth and yield in this specific region. The impact of different fertilizer applications on soil health, including nutrient availability, microbial activity and long-term soil fertility is underexplored in the context of Northeast Afghanistan. Understanding these interactions is crucial for sustainable agricultural practices. While growth and yield responses to fertilizers are often documented, there is insufficient research assessing the economic implications of using organic versus inorganic fertilizers in this region. Cost-benefit analyses that consider local farmer practices and market conditions are needed. Research is needed to evaluate the environmental sustainability of different fertilization strategies in Northeast Afghanistan. The environmental consequences of using various fertilizer types, particularly in terms of soil and water quality have not been adequately addressed in the existing literature. Research is needed to evaluate the environmental sustainability of different fertilization strategies in Northeast Afghanistan. Future studies can contribute valuable insights into optimizing fertilizer use for wheat production in Northeast Afghanistan, promoting both agricultural productivity and sustainability.

II. MATERIALS AND METHODS

The research was conducted at the research farm of Kunduz university which is located in northeast of Afghanistan, The study aimed to evaluate the effects of organic and inorganic fertilizers on growth and yield

of wheat crop in northeast agro ecology of Afghanistan, randomized complete block design (RCBD) was employed with 5 treatments and 3 replications. Each treatment was randomly assigned to plots within each block to minimize variability, the treatments were evaluated: Absolute Control, 160 kg N/ha+80 kg P₂O₅/ha +10 ton Poultry Manure/ha, 80 kg N/ha+40 kg P₂O₅+5 ton Poultry Manure and 160 kg N/ha+80 kg P₂O₅+10 ton Poultry Manure. Chont variety was selected for this study due to its significance in the region's agriculture. Seeds were sourced from Department of Research, Kunduz-DAIL, ensuring high germination rates and uniformity. Soil was tilled to a depth of 30 cm, and plots were leveled to ensure uniform drainage. Plot Size was 3*3=9m² Plot and replication distance were 0.5m and 2 m respectively. Fertilizers were applied according to the specified rates for each treatment. Poultry manure was incorporated into the soil broadcasting after prepare all plots at least 3 days before planting. Seeds were sown on 25 November 2023 at a depth of 3-4 cm, Spacing between plants and rows was maintained as per standard practices for 10 cm and 20 cm respectively. Irrigation was applied as needed based on weather conditions and soil moisture levels. Data Collected on plant height at harvest, leave area index, dry matter accumulation at 90 Days after sowing from taken 5 plants, also all other yield component, yield and economic parameters taken after harvest from net plot area. Data were subjected to analysis of variance (ANOVA) using OPSTAT to determine significant differences among treatments. Standard error of means (SEm+) and least significant difference [LSD (P=0.05)] level of significance worked out for each parameter.

III. RESULTS AND DISCUSSIONS

The results presented in (Table 1) indicate that the application of both organic and inorganic fertilizers significantly influenced growth parameters. The highest plant height (107.08 cm), Leaf Area Index (LAI) at 90 days after sowing (DAS) (3.02), and Dry Matter Accumulation (DMA) (372.81 g) were observed in the treatment combining 160 kg N/ha+ 80 kg P₂O₅+ 10 tons of poultry manure per hectare. This was followed by the treatment with 80 kg N/ha +40 kg P₂O₅/ha+5 tons of poultry manure, which recorded a plant height of 99.62 cm, an LAI of 2.03 at 90 DAS, and a DMA of 277.50 gr. Both the application of 10 tons of poultry manure per hectare and the combination of 160 kg Nitrogen and 80 kg P₂O₅ per hectare were equally effective in enhancing plant height at harvest. In contrast, the shortest plant height (87.22 cm) was recorded in the control treatment. Additionally, the treatments with 10 tons of poultry manure per hectare and 160 kg Nitrogen + 80 kg P₂O₅ per hectare showed similar effectiveness regarding Leaf Area Index at harvest, with values of 2.03 and 1.92, respectively. The lowest LAI was observed in the control plot. For Dry Matter Accumulation, the application of 10

tons of poultry manure per hectare yielded a DMA of 208.34 g, while the treatment with 160 kg N + 80 kg P₂O₅ resulted in a DMA of 161.07 g. The minimum DMA was recorded in the control plot.

Table (1): Effect of organic and inorganic fertilizers on growth parameters

Treatments	Plant Height at Harvest (cm)	LAI at 90 DAS	DMA at 90 DAS (gr/plant)
Control	87.22 ^d	1.38 ^d	148.31 ^c
160 kg N/ha+80 kg P ₂ O ₅ /ha	92.28 ^c	1.92 ^c	161.07 ^d
10 ton Poultry Manure/ha	92.73 ^c	2.03 ^c	208.34 ^c
80 kg N/ha+40 kg P ₂ O ₅ +5 ton Poultry Manure	99.62 ^b	2.57 ^b	277.50 ^b
160 kg N/ha+80 kg P ₂ O ₅ +10 ton Poultry Manure	107.08 ^a	3.02 ^a	372.81 ^a
SE m±	2.453	0.03	44.751
CD (P=0.05)	2.949	0.328	12.595
CV	1.635	7.967	2.864

Our result is in close to (Kowsar *et al.*, 2014) conducted a study to assess the impact of poultry manure along with fertilizers on the morphology and growth characteristics of bread wheat, with a focus on long-term sustainability and environmental pollution concerns. The results indicated significant effects on various growth and morphological parameters. When comparing bio fertilizers to organic fertilizers and poultry manure, a new product containing 48% humic acid along with N, P, K, Cu, Fe, Zn, Mo, and Mn—demonstrated superior growth performance compared to sole applied fertilizers. (Sajid Islam *et al.*, 2017) reported that phosphorus application along with poultry manure had significantly increased plant height of wheat. Plant height showed no significant correlation with effective tillers/plant both at the phenotypic and genotypic levels (Khaleeq *et al.*, 2023).

The results presented in (Table 2) indicate that the application of both organic and inorganic fertilizers significantly affected yield components. The highest spike length (16.51 cm) was recorded in the treatment with 160 kg N/ha+80 kg P₂O₅+10 tons of poultry manure, followed by a treatment that recorded a spike length of 15.63 cm, which was equally effective. The minimum spike length was observed in the control plot. Both organic and inorganic fertilizers significantly influenced the number of spikes per square meter (spike/m²). The maximum was recorded in the treatment with 160 kg N/ha+80 kg P₂O₅+10 tons of poultry manure, followed by the treatment with 80 kg N/ha+40 kg P₂O₅+ 5 tons of poultry manure, which recorded 237.37 spikes/m². The absolute control plot recorded the lowest number of spikes.

The application of organic and inorganic fertilizers also affected the number of spikelets per spike in the wheat crop. The maximum was recorded at 21.40 in the treatment with 160 kg N/ha+80 kg P₂O₅+ 10 tons of poultry manure, followed by the second treatment with 80 kg N/ha+40 kg P₂O₅+ 5 tons of poultry manure, which observed 17.82 spikelets. The minimum was recorded at 15.84 in the control plot. Both types of fertilizers influenced the grains per spike parameter, with maximum values recorded at 53.62 grains/spike, 49.26 grains/spike, and 41.04 grains/spike for treatments with 160 kg N/ha + 80 kg P₂O₅ + 10 tons of poultry manure, 80 kg N/ha + 40 kg P₂O₅ + 5 tons of poultry manure, and 10 tons of poultry manure/ha, respectively. The minimum grains per spike were recorded at 33.81 in the absolute control plot. Furthermore, both organic and inorganic fertilizers affected the 1000-grain weight parameter. The maximum weights recorded were 57.73 g, 50.51 g, 42.58 g, and 38.63 g for treatments with 160 kg N/ha + 80 kg P₂O₅ + 10 tons of poultry Manure, 80 kg N/ha + 40 kg P₂O₅ + 5 tons of poultry manure, 10 tons of poultry manure/ha, and 160 kg N/ha + 80 kg P₂O₅/ha, respectively. The minimum 1000-grain weight was recorded at 37.64 g in the absolute control plot.

Table (2): effect of organic and inorganic fertilizers on yield component of wheat crop

Treatments	Spike length (cm)	Spike/ m ²	Spikel et/Spik e	Grains /Spike	1000-grain Weight (gr)
Control	13.55 ^b	232.29 ^d	15.84 ^c	33.81 ^d	37.64 ^d
160 kg N/ha+80 kg P ₂ O ₅ /ha	14.31 ^b	241.51 ^{cd}	15.93 ^c	41.04 ^c	38.63 ^d
10 ton Poultry Manure/ha	14.48 ^b	278.94 ^c	16.33 ^b	41.31 ^c	42.58 ^c
80 kg N/ha+40 kg P ₂ O ₅ +5 ton Poultry Manure	15.63 ^a	237.37 ^b	17.82 ^c	49.26 ^b	50.51 ^b
160 kg N/ha+80 kg P ₂ O ₅ +10 ton Poultry Manure	16.51 ^a	343.67 ^a	21.40 ^a	53.62 ^a	57.73 ^a
SE m±	0.257	17.764	0.611	3.821	2.803
CD (P=0.05)	0.954	7.936	1.471	3.68	3.152
CV	3.402	1.58	4.474	4.462	3.686

(Usman Kadir., 2022) reported The application rates of Nitrogen and Phosphorus with poultry manure fertilizers had a highly significant impact ($P < 0.01$) on spike length and the interaction between NP fertilizers and seed rate also significantly influenced this parameter. The longest spikes measured 8.37 cm achieved with the combined application of both 150 and 200 kg NPS fertilizer at a seed rate of 150 kg/ha. In contrast, the shortest spikes, measuring 6.33 cm, were observed with 0 kg NPS at the same seed rate. These

findings indicate that higher rates of NPS fertilizer lead to increased spike length, likely due to the adequate application of NPS, which promotes better spike development. Also aligns with the conclusions of (Nazir *et al.*, 2022), who noted that increasing nitrogen levels significantly enhanced wheat spike length.

The results presented in (Table 3) indicate that the application of organic and inorganic fertilizers significantly influenced yield components. The highest grain yield (4.20 t/ha) was observed in the treatment with 160 kg N/ha+80 kg P₂O₅+ 10 tons of poultry manure, followed by a treatment with application of 80 kg N/ha+40 kg P₂O₅+5 ton Poultry Manure that yielded 3.26 t/ha. The lowest grain yield (2.87 t/ha) was recorded in the absolute control plot. Both organic and inorganic fertilizers also had a significant impact on straw yield. The maximum straw yield was recorded at 6.38 t/ha for the treatment with 160 kg N/ha+80 kg P₂O₅+ 10 tons of poultry manure, followed by a treatment with 80 kg N/ha+40 kg P₂O₅+5 tons of poultry manure, which yielded 5.66 t/ha. The minimum straw yield was observed at 4.97 t/ha in the absolute control plot. Additionally, the application of organic and inorganic fertilizers affected the biological yield of the wheat crop. The maximum biological yield was recorded at 10.39 t/ha for the treatment with 160 kg N/ha+80 kg P₂O₅+10 tons of poultry manure, followed by a second treatment with 80 kg N/ha +40 kg P₂O₅+ 5 tons of poultry manure, which yielded 9.08 t/ha. The minimum biological yield was recorded at 7.85 t/ha in the absolute control plot.

Table (3): Effects of organic and inorganic fertilizers on yield parameters

Treatments	Grain yield (tones/ha)	Straw Yield (tones/ha)	Biological Yield (tones/ha)	Harvest Index %
Control	2.87 ^d	4.97 ^d	7.85 ^d	42.20 ^b
160 kg N/ha+80 kg P ₂ O ₅ /ha	3.05 ^c	5.19 ^c	8.24 ^c	42.28 ^b
10 ton Poultry Manure/ha	3.19 ^{bc}	5.31 ^c	8.36 ^c	42.77 ^b
80 kg N/ha+40 kg P ₂ O ₅ +5 ton Poultry Manure	3.26 ^b	5.66 ^b	9.08 ^b	43.47 ^{ab}
160 kg N/ha+80 kg P ₂ O ₅ +10 ton Poultry Manure	4.20 ^a	6.38 ^a	10.39 ^a	44.61 ^a
SE m±	0.007	0.011	0.017	0.657
CD (P=0.05)	0.158	1.877	0.249	1.526
CV	2.525	0.195	1.505	1.882

The rate of nitrogen mineralization from poultry manure is quicker than from farmyard manure

(FYM) due to its higher content of uric acid and urea, which rapidly release ammonium nitrogen ($\text{NH}_4\text{-N}$). In a laboratory study, approximately 45% of the total nitrogen in poultry manure was mineralized within four weeks, whereas only 12% was mineralized from FYM. (Ahmadi *et al.*, 2024) demonstrated that nitrogen from poultry manure was just as effective as urea nitrogen in enhancing rice yield and nitrogen uptake, and it also had a significant residual effect equivalent to 40 kg N/ha for wheat. The use of poultry manure positively influenced soil health and the sustainability of the wheat-soybean system. In experiments by Shah *et al.* in Peshawar, Pakistan, the highest wheat grain yield was achieved with a treatment that included 25% nitrogen from poultry manure and 75% from fertilizers. (Ahmadi *et al.*, 2024). Found that applying poultry manure at 10 t/ha along with 75% of the recommended NPK dosage resulted in significantly higher wheat yields compared to the full NPK treatment. A residual effect of poultry manure was noted in the subsequent wheat crop, providing an equivalent of 30 kg N/ha and 13 kg P/ha. Other researchers, such as (Seerat *et al.*, 2024). Have also found a significant impact of phosphorus sources on plant height. The number of spikes per meter squared was notably influenced ($p \leq 0.05$) by varying phosphorus levels. The plots receiving 90 kg P_2O_5 per hectare produced the highest number of spikes per meter squared (363), which was statistically similar to the results from plots treated with 75 kg P_2O_5 per hectare. Conversely, the control plots recorded the lowest number of spikes per meter squared (167). Additionally, (Samim *et al.*, 2023) reported that the number of spikes per meter squared in wheat increased significantly with higher

phosphorus application rates. An increase in the number of tillers contributes to a stronger crop stand, ultimately enhancing yield, as noted by (Jamwal *et al.*, 2024). (Sajid Islam., X., 2017) also reported the data presented indicate the biological yield of wheat in relation to various phosphorus levels. Statistical analysis showed a significant effect ($p \leq 0.05$) of phosphorus application on the biological yield. The plots applied with 90 kg P_2O_5 per hectare achieved the highest biological yield (13,056 kg ha⁻¹), which was statistically comparable to those receiving 60 and 75 kg P_2O_5 per hectare. In contrast, the control plots recorded the lowest biological yield at 11,556 kg/ha.

The economic analysis presented in Graph 1 illustrates the gross returns associated with various fertilization treatments. The highest gross returns were observed for the following treatments: 160 kg N/ha + 80 kg P_2O_5 + 10 tons of poultry manure (101,165 AFN/ha), 80 kg N/ha + 40 kg P_2O_5 + 5 tons of poultry manure (87,045 AFN/ha), 10 tons of poultry manure/ha (78,867 AFN/ha), 160 kg N/ha + 80 kg P_2O_5 (78,311 AFN/ha). In stark contrast the control plot, which did not receive any fertilization treatment, yielded the lowest gross return of 74,149 AFN/ha. These findings indicate that the application of both nitrogen and phosphorus fertilizers in conjunction with organic amendments such as poultry manure significantly enhances gross returns compared to untreated plots. This analysis underscores the importance of optimizing fertilization strategies to maximize economic returns in agricultural practices. Further research may be warranted to explore the long-term sustainability and environmental impacts of these treatments.

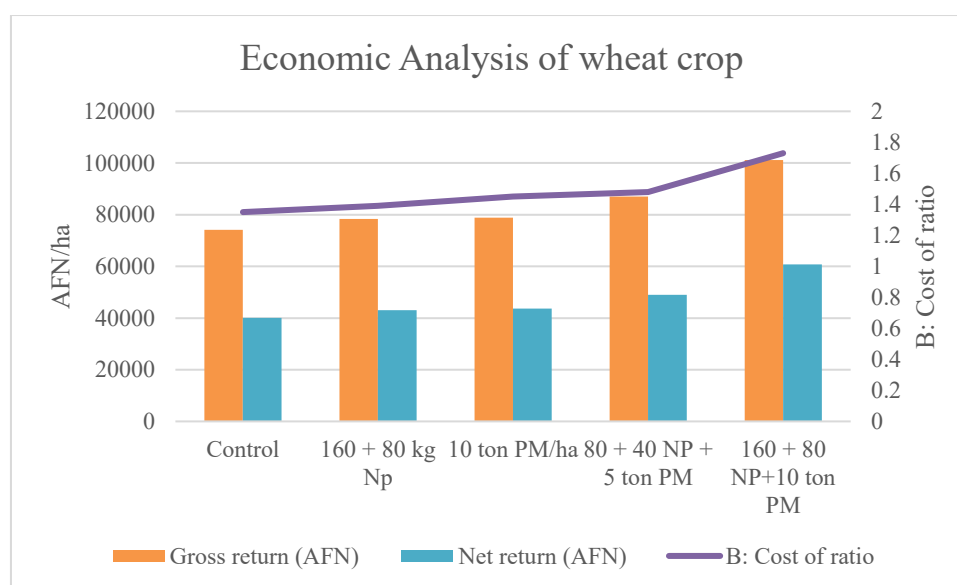


Figure (1): Effects of organic and inorganic fertilizers on economic analysis

Our results align with those of (Ghasal *et al.*, 2017), (Shahane *et al.*, 2017) and (Zulfiqar *et al.*, 2020). The increased gross returns can be attributed to

the higher grain and straw yields of wheat observed in the respective treatments. Both organic and inorganic fertilizers led to greater net returns, a finding also noted

by (Shahane et al., 2017) and (Rehman et al., 2019). The highest benefit of cost ratio was achieved with the soil application of 160 kg N/ha+80 kg P₂O₅ + 10 tons of poultry manure. Conversely, a significantly lower benefit of cost ratio was recorded for the treatment with 160 kg N/ha+80 kg P₂O₅ + 10 tons of poultry manure. Similar results regarding yield attributes, yields, and net returns for wheat in Afghanistan were reported by (Shahane et al., 2017) and (Ghasal et al., 2017).

IV. CONCLUSION

The field experiment at agriculture farm of Kunduz University demonstrated that the optimal combination of 160 kg N/ha+80 kg P₂O₅/ha+10 tons of poultry manure significantly enhanced wheat growth and yield compared to other treatments including the absolute control. This treatment resulted in the highest metrics for plant height, leaf area index, dry matter accumulation and overall yield, underscoring the critical role of balanced fertilization in wheat cultivation. The study highlights the necessity for integrated nutrient management practices that utilize both organic and inorganic fertilizers to sustainably boost agricultural productivity in Afghanistan. These findings serve as crucial guidance for farmers and policymakers, advocating for improved fertilization strategies to enhance food security and economic viability in the region. Future research should explore the long-term sustainability of these practices to ensure ongoing agricultural success.

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