Pak. J. Agri., Agril. Engg., Vet. Sci., 2024, 40 (1): 38-44
ISSN: 1023-1072 (Print), ISSN: 2663-7863 (Online)
https://doi.org/10.47432/2024.40.1.5

INFLUENCE OF INTEGRATED USE OF POULTRY MANURE ALONG WITH MINERAL FERTILIZER ON SOIL PROPERTIES, GROWTH TRAITS, AND WHEAT YIELD

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ABSTRACT

Soil quality and health, in the environment of agrarian ecosystems, pose significant enterprises due to environmental decline and overreliance on chemical inputs. To address this challenge, there is a pressing need to borrow and incorporate an approach that combines both organic and inorganic sources of plant enriched. In pursuit of this objective, a field trial was led in rabi season 2023 to evaluate the synergistic effect of organic and mineral nutrient sources on soil characteristics and the growth and yield of wheat crops. The experimental design featured four distinct treatments planned in a randomized complete block design (RCBD), each with four replicates. These treatments involved the application of poultry manure at varying rates: T_1 0 ton ha^{-1}, T_2 4 ton ha^{-1}, T_3 6 ton ha^{-1}, and T_4 8 ton ha^{-1}. The chosen wheat variety for cultivation was Benazir. Notably, the treatment involving the application of 650 kg ha^{-1} of poultry manure alongside half of the recommended dose of inorganic fertilizer (Treatment 4) yielded the most promising results. This treatment yielded a wheat crop with a maximum plant height of 73 cm, an average of 14 tillers per plant, a spike length of 12.51 cm, and an impressive grain yield of 3268 kg ha^{-1}. The grain yield was increased by 11.4% over the control treatment. Consequently, this study's findings suggest that farmers may benefit from adopting the practice of applying 650 kg ha^{-1} of poultry manure in combination with half of the recommended quantity of chemical fertilizer. Such an approach not only reduces the reliance on chemical fertilizers but also enhances soil quality and overall soil health. Soil organic matter was enhanced by 24% at the dose of treatment 4. Additionally, it contributes to lowering production costs and improving the livelihoods of small-scale farmers.

Keywords: soil quality, soil health, organic and inorganic nutrients, poultry manure, sustainable agriculture

INTRODUCTION

Wheat is indeed a significant staple food in Pakistan and many other parts of the world. The grain is consumed by humans directly or indirectly, and the straw is used to feed animals (Pandey *et al*., 2020; Ahmad *et al*., 2022). In Pakistan, during 2022-2023 wheat was grown on 9 m ha with a mean yield of 3056 kg ha^{-1} (GoP, 2023). The mean yield is extremely small contrasted with other high-level nations worldwide. The low yield of wheat in Pakistan might be credited to many variables remembering awkwardness for compost application. Nitrogen, phosphorus, potassium, and soil organic matter are severely lacking in Pakistan's calcareous and alkaline soils; consequently, use of compost is viewed as basic for expanding crop productivity (Ahmed, *et al*., 2022). Mineral composts assume a huge part in helping. The addition of organic waste in Pakistan's alkaline calcareous soils support crop production (Memon *et al*., 2012). Despite the expanded utilization of composts, per hectare yield has not been expanded relatively yet rather inactivity happens (Rajput *et al*., 2017). This has been credited to the imbalanced utilization of mineral composts and improper strategies for their application that finished in low effectiveness. Constant utilization of synthetic composts even in adjusted extent cannot support crop efficiency because of crumbling in soil wellbeing. Use of natural composts or a few natural squanders alone was found helpful,

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however incorporated utilization of natural squanders and compound manure has demonstrated really fulfilling (Sayara *et al*., 2020). The restricted accessibility of extra land for crop creation, alongside the declining yield of significant food crops, has uplifted worries about farming and its capacity to take care of the developing populace expected to surpass 7.5 billion constantly 2020. Upcoming procedures for expanding horticultural efficiency should zero in on utilizing accessible supplement assets all the more proficiently, successfully, and on an economical premise to maintain agriculture productivity over the long term, integrated nutrient management will be crucial for appropriate plant growth, water use, soil and land management (Wang, 2022). A combined approach of organic or inorganic application to the management of soil nutrients must be included in the plan for increasing and maintaining high crop yields. Concluded that the soils are the storehouse of the majority of plant nutrients required for crop growth and high productivity (Anwar-ul-Haq, 2014). Further, the application of manures, a significant amount of waste from Pakistan's major cities, towns, and villages, which pollute the air in these areas, can be used to increase crop yields and soil fertility. In light of these facts, this study was to investigate the effects of organic manures (farmyard manure, poultry manure, and municipal waste) and mineral N (urea) on wheat crop (Muhammad *et al*., 2020). Soil health quality, resulting from the unbalanced and insufficient application of fertilizers and the removal of biomass, along with limited utilization of organic manures, represents significant factors contributing to declining agricultural productivity (Ayyoub *et al*., 2023). In many developing countries, factors such as the high cost of chemical fertilizers, marketing challenges, and inadequate infrastructure have led to only a limited number of farmers applying inorganic fertilizers, often at rates below recommended levels. Over time, the exclusive use of chemical fertilizers in continuous cropping systems creates nutrient imbalances in the soil, negatively impacting both soil quality and crop yield (Rajput, 2018). Conversely, the continuous use of organic fertilizers enhances soil organic matter and soil productivity. However, the nutrients in organic fertilizers are released more slowly and do not yield rapid increases in crop yield compared to inorganic fertilizers (Negassa *et al*., 2007). Consequently, relying solely on organic fertilizers does not significantly boost crop yields due to their lower nutrient content. This has prompted the exploration of integrated nutrient management as a sustainable solution to optimize resource utilization while maintaining crop productivity. By combining various fertilizer sources within an appropriate cropping system, it is possible to increase soil health, and crop yield, and create a more sustainable environment for future generations. In Pakistan and other tropical countries, recent research has shifted towards using organic waste as a nutrient source in crop production due to the high cost and limited availability of mineral fertilizers. However, a substantial quantity of organic waste is required necessitates the combination of different types and the integration of chemical fertilizers to reduce the required quantity and enhance nutrient release. Previous research has demonstrated the superior effects of integrated nutrient supply compared to the sole use of either inorganic or organic sources in terms of balanced nutrient provision, improved soil health, and crop yield (Memon *et al*., 2012; Rajput *et al*., 2015). In the upcoming decade, agriculture faces the dual challenge of nourishing growing populations while safeguarding the environment. The objective of this study was to assess the integrated use of poultry manure and inorganic fertilizer application on soil properties and yield of wheat crops.

MATERIALS AND METHODS

A field study was planned at the Research field during Rabi 2021-22 in the Soil and Environment Research Institute Tandojam, Sindh. The soil of the experimental site was silty clay loam. The organic source of fertilizer was poultry manure with Benazir variety was sown. These treatments involved the application of poultry manure at varying rates: T_1 0 ton ha^{-1}, T_2 4 ton ha^{-1}, T_3 6 ton ha^{-1}, and T_4 8 ton ha^{-1}. The inorganic fertilizer treatment 150-90-60 NP_2O_5 K_2O kg ha^{-1} is used compulsory all the treatments. The organic manure was applied at the time of sowing and the mineral N (urea) was applied in three splits i.e., sowing, tillering, and booting stage of the crop. The experiment was laid out according to Randomized Complete Block design (RCBD) and was replicated three times, the Plot size was 25 m^2. Phosphorous (P) and potassium (K) was applied in the form of single super phosphate as basal dose to the crop. All other cultural practices were adopted

uniformly. Initial soil sample was collected from the field and was analyzed for physio-chemical properties (Table 1). Soil pH and EC (1:2 ratio) was determined by (Richard, 1954), texture by the hydrometer method (Moodie *et al*., 1959), organic matter by Walkley and Black method (Asai *et al.,* 2009). soil nitrogen by Kjeldahl digestion method and available P was determined by Olsen Method in (Table 1). Total nitrogen, phosphorus and potassium was determined by AOAC methods (Fink *et al*., 1979). Agronomical parameters included plant height (cm), No of tillers plant^{-1}, Spike length plant^{-1} (cm), grain yield (kg ha^{-1}) and seed index were recorded. The collected data were statistically analyzed through SPSS statistical version 8.1. Basic properties of the before and after experimental site was soil Texture (Silt clay loam), pH (1:25 suspension) 8.54 and 8.30, EC (1:25 suspension) 1.5 dSm^{-1} and 1.3 dS m^{-1}, Organic matter 0.46% and 0.42%, $NaHCO_3$ extra-P 2.5 and 2.3 mg kg^{-1} total N 0.024% and 0.022 (Table 1). Chemical composition in Poultry manure was recorded (Table 2).

RESULTS AND DISCUSSION

Plant height (cm)

The influence of various levels of integrated poultry manure and inorganic fertilizer treatments on plant height. Notably, plant height was significantly affected by these treatments. The control plot exhibited the lowest plant height, measuring 100.9 cm, while treatment 2, which received half the recommended dose of inorganic fertilizer (4 ton ha^{-1}), showed a slightly increased height of 114.9cm. In contrast, treatment 4, also with half the recommended dose of inorganic fertilizer, achieved the highest plant height at 118.9 cm. It's important to note that all treatments exhibited statistically significant differences (P<0.05) in terms of plant height (Figure 1a). Furthermore, examination of the data presented in Figure 1a reveals that when integrated with adequate poultry manure (8 ton ha^{-1}), the addition of inorganic fertilizer resulted in a remarkable 15.1% increase in plant height compared to the control plot. This study highlights the significant influence of integrated poultry manure and inorganic fertilizer treatments on wheat crop attributes, particularly plant height, which can have important implications for optimizing yield and crop productivity. Similarly, in study of Kibria *et al*. (2013) and Rasool *et al*. (2023) detected that combined usage of poultry manure plus chemical fertilizer not only improved crop yield but also plant growth. Application of poultry manure with inorganic fertilizers improves the availability of nutrients as well as fertilizer use efficiency (Abbas *et al*., 2012).

Number of tillers (plant^{-1})

The data shown in Figure 1b indicated that, the combined use of poultry manure and inorganic fertilizer had a significant impact on the number of tillers produced by each plant in all the different treatments. In simple terms, it affected that how many branches or shoots grew from each plant. In every treatment, the number of tillers per plant was different. The control group had the minimum tillers (8.8), and Treatment 2 (4 ton ha^{-1}) of integrated poultry manure with inorganic fertilizer, which is half the recommended amount had more tillers per plant, specifically 11 tillers. However, the most tillers per plant (13.9) were shown in Treatment 4, where they used 8 tons ha^{-1} of poultry manure along with half the recommended inorganic fertilizer. The important thing to note is that all the treatments were different from each other when it came to the number of tillers (P<0.05), which means these differences are meaningful. While closer look at the data in Figure 1b, shows that when you use the right amount of poultry manure along with half the recommended dose of inorganic fertilizer, the number of tillers per plant increases by 37% compared to the control group. This means that using these treatments can make the plants produce more branches or shoots, which can be beneficial for crop growth and yield. Our findings align with Abbas *et al*. (2012); Enujeke (2013) research, indicating that the use of integrated poultry manure enhances plant growth. This enhancement is attributed to the increased availability of nutrients, which are readily absorbed by the recipient plants, resulting in accelerated growth and development and ultimately leading to a higher tiller plant^{-1}.

Spike length plant^{-1}

The data in Figure 1c, indicate that the integrated poultry manure and inorganic fertilizer rates significantly affected the production of spike length per plant in all treatments. All treatments were significantly varied (P<0.05) with each in production of spike length except T_2 (4 tons ha^{-1} and T_3 (6 tons ha^{-1}) integrated poultry manure along with inorganic fertilizer, which was non-significant with each other. The minimum spike length per plant was recorded in the control treatment, followed by the T_2 and T_3

(4 tons ha^{-1} and 6 tons ha^{-1}) with half recommended dose of inorganic fertilizer where 15.1 and 18.4 cm spike length per plant were recorded respectively. However maximum spike length per plant (20.2 cm) was recorded, where poultry manure was applied at the rate of 8ton ha^{-1} (T_4) along with half the recommended dose of inorganic fertilizer. The critical analysis of data furnished in Figure 1c, elucidated that adequate poultry manure with half of the recommended dose of inorganic fertilizer enhanced spike length per plant by 34% over control. Similar results were shown by Abbas *et al*., 2012).

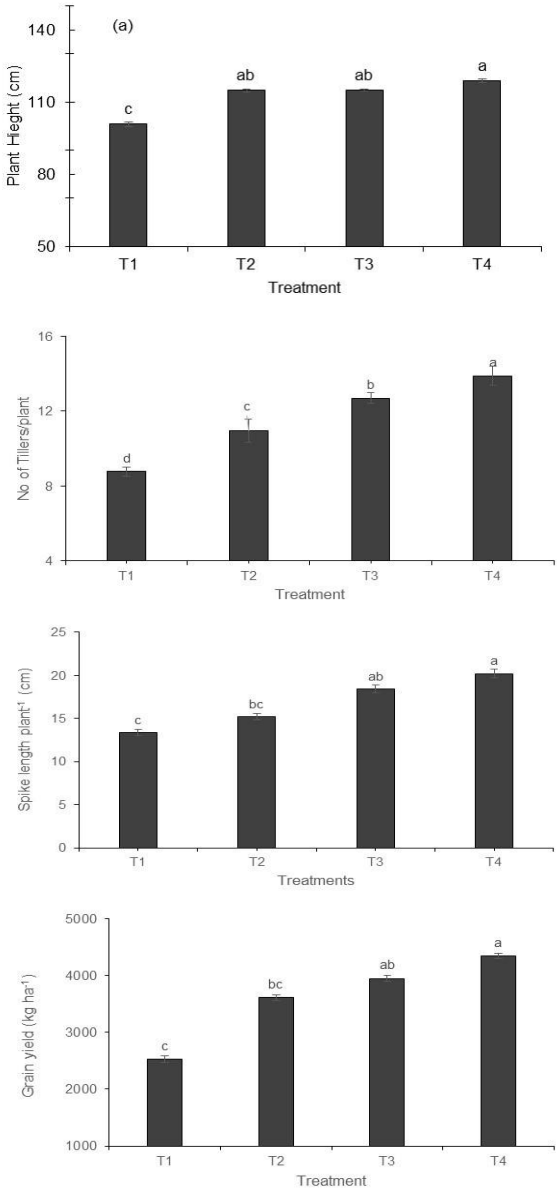

Figure 1. Integrated impact of poultry manure and inorganic fertilizer on growth traits of wheat crop

Yield kg ha^{-1}

The data in Figure 1d, indicate that the integrated poultry manure and inorganic fertilizer rates significantly affected the yield of wheat crops in all treatments. All treatments were significantly varied (P<0.05) with each in yield of wheat crop. The minimum grain yield was recorded in the control treatment (2529 kg ha^{-1}), followed by the T_2 and T_3 (4 tons ha^{-1} and 6 tons ha^{-1}) with half of the recommended dose of inorganic fertilizer where 3612 and 3950kg ha^{-1} yield were recorded respectively. However maximum yield (4344.3 kg ha^{-1}) was recorded, where poultry manure was applied at the rate of 8tons ha^{-1} (T_4) along with half the recommended dose of inorganic fertilizer. The critical analysis of data furnished in Figure 1d, elucidated that adequate poultry manure (8 tons ha^{-1}) with half the recommended dose of inorganic fertilizer enhanced the yield of wheat crops by 42% over control. Current research has depicted the positive effect of organic fertilizers on growth, yield, and physiological parameters. The yield of wheat crops showed a positive increase with reduced tillage and combined treatments with organic amendments. (Ayyoub *et al*., 2023).

Soil organic matter

The organic content within the soil heavily influences nearly all soil properties, and the incorporation of carbon-based fertilizers significantly improves soil health. The data in Figure 2a, indicates that the integrated poultry manure and inorganic fertilizer rates significantly affected the soil organic matter in all treatments. All treatments were significantly varied (P<0.05) with each soil organic matter. The minimum soil organic matter was recorded in the control treatment (0.41%), followed by the T_2 and T_3 (4 tons ha^{-1} and 6 tons ha^{-1}) with half recommended dose of inorganic fertilizer where 0.45 and 0.49% organic matter were recorded respectively. However maximum soil organic matter (0.54%) was recorded, where poultry manure was applied in the rate of 8tons ha^{-1} (T_4) along with half the recommended dose of inorganic fertilizer. The critical analysis of data furnished in Figure 2a, elucidated that adequate poultry manure (8 tons ha^{-1}) with half the recommended dose of inorganic fertilizer enhanced soil organic carbon by 24.1% over control. In a study conducted by Nazia *et al*. (2019), it was demonstrated that the combination of carbon-based organic manure with mineral fertilizers represents an effective

method for improving soil health. The synergistic use of carbon-based manure and mineral fertilizers not only enhances their efficiency but also contributes to increased agricultural productivity within the framework of sustainable farming. Furthermore, the incorporation of poultry manure results in a notable rise in soil nitrogen content, with the potential for further enhancement through the concurrent application of chemical fertilizers. This integrated approach can elevate the development, quality, and yield of wheat crops, as highlighted by Mian *et al*., 2021 in their research.

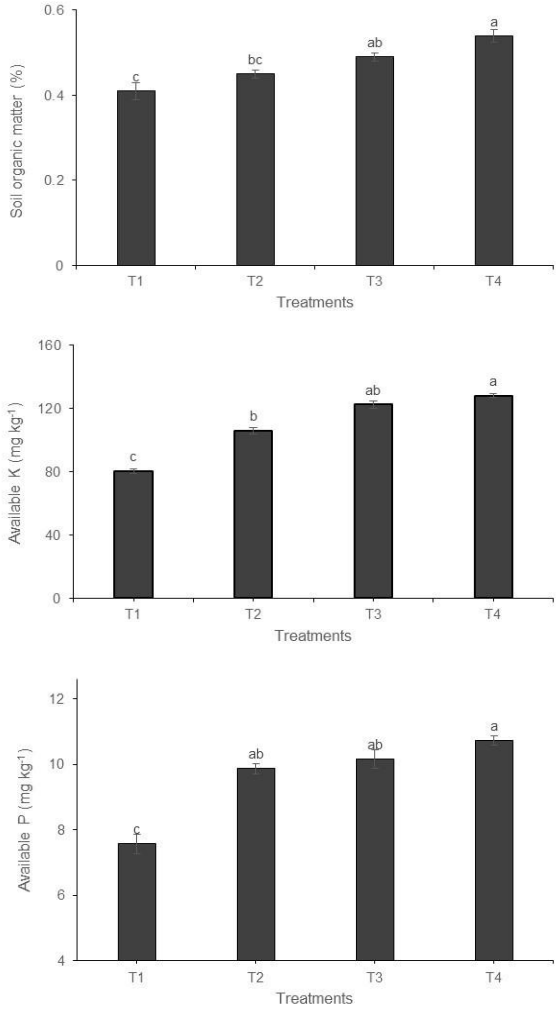

Figure 2. Integrated impact of poultry manure and inorganic fertilizer on soil properties

Available phosphorus

Soil Phosphorus is an important element required for plant growth and plays a fundamental role in ATP molecules and nucleic acids, contributing to crop maturation (Solangi *et al*., 2023). When combined with inorganic fertilizer, poultry manure serves as an excellent phosphorus source and enhances the accessibility of this essential nutrient in the soil. The data in Figure 2b, indicates that the integrated poultry manure and inorganic fertilizer rates significantly affected the soil available P in all treatments. All treatments were significantly varied (P<0.05) with each other. The minimum phosphorus was recorded in the control treatment (7.57 mg kg^{-1}), followed by the T_2 and T_3 (4 tons ha^{-1} and 6 tons ha^{-1}) with the half-recommended dose of inorganic fertilizer where 9.9 and 10.2 mg kg^{-1} available P were recorded respectively. However maximum soil available P (10.17 mg kg^{-1}) was recorded, where poultry manure was applied at the rate of 8 tons ha^{-1} (T_4) along with half the recommended dose of inorganic fertilizer. The critical analysis of data furnished in Figure 2b, elucidated that adequate poultry manure (8 tons ha^{-1}) with half the recommended dose of inorganic fertilizer enhanced available P by 29.47% over control. These findings align with the conclusions drawn by Fiyyaz *et al*., 2021. Likewise, Kondal *et al*., 2024 observed that the use of poultry dung led to improvements in all aspects of soil properties, including physical, chemical, and biological attributes.

Available K

The data in Figure 2c, indicates that the integrated poultry manure and inorganic fertilizer rates significantly affected the soil available K in all treatments. All treatments were significantly varied (P<0.05) with each other. The minimum available K was recorded in the control treatment (80.3 mg kg^{-1}), followed by the T_2 and T_3 (4 tons ha^{-1} and 6 tons ha^{-1}) with half recommended dose of inorganic fertilizer where 106 and 122 mg kg^{-1} available K were recorded respectively. However maximum soil available K (128 mg kg^{-1}) was recorded, where poultry manure was applied in the rate of 8 tons ha^{-1} (T_4) along with half the recommended dose of inorganic fertilizer. The critical analysis of data furnished in Figure 2c, elucidated that adequate poultry manure (8 tons ha^{-1}) with half the recommended dose of inorganic fertilizer enhanced soil available K by 37.2% over control. The findings presented here are in alignment with the observations made by Rahman *et al*. (2024) where they noted a significant enhancement in soil nutrient status attributable to the utilization of poultry manure.

Table 1. Soil properties of the experimental area of the wheat crop

Parameters	Values
Texture	Silty clay loam
pH (1:2 suspension)	8.52
EC (1:2 suspension)	1.53 dS m^{-1}
$CaCO_3$ equivalent	18.5 %
Organic matter	0.47%
$NaHCO_3$ extract P	2.51 mg kg^{-1}
Total N	0.025%

pH: soil pH, EC: Electrical conductivity, $NaHCO_3$ extract P: Sodium bicarbonate to extract available Phosphorus.

Table 2. Chemical composition of organic waste (Poultry manures)

Nutrients	Values
Nitrogen (N)	2-4.5
Phosphorus (P)	4.6-6
Potassium (K)	1.2-2.4

CONCLUSION AND RECOMMENDATIONS

On the basis of our findings, it is concluded that combined use of poultry manures along with mineral fertilizers at the rate of 8tons ha^{-1} proved to be the most effective treatment for increasing wheat yield and preserving soil health, particularly in terms of soil physio-chemical properties i.e. organic matter, nitrogen, phosphorus, and potassium content. Poultry manure is a readily available and often cost-free resource for farmers, reducing the need to purchase expensive chemical fertilizers. This can significantly lower production costs, improving farmers' profitability. Combining it with chemical fertilizers can help balance nutrient levels in the soil, promoting healthier plant growth and higher yields. Integrating poultry manure reduces the dependency on synthetic fertilizers, which can have harmful effects on soil health and water quality. By using organic resources, farmers contribute to sustainable agriculture and environmental conservation. Considering these findings, it is strongly recommended that farmers consider integrating poultry dung or other waste materials with chemical fertilizers as a valuable strategy for enhancing crop yields and ensuring the overall health of the soil.

AUTHOR'S CONTRIBUTION

N. K. Katyar: Conceptualization and conduct the experiment.

N. Rais: Data collection, analysis and wrote the initial draft.

A. Rajput: Reviewed the manuscript, statistical analysis, and proof reading.

S. A. Qureshi: Technical guidance and financial assistance.

N. A. Deho: Managed the experimental field.

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(Received: December 21, 2023; Accepted: May 14, 2024)