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Comparative Analysis of Organic Manure Amendments on the Growth and Yield of Wheat

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ABSTRACT

Manure is an important agricultural amendment that contains essential nutrients for the soil structure as well as organic matter present in the soil. It contains nutrients such as phosphorous, nitrogen and potassium that provides elevated yield of crop by improving the structure of soil and without deteriorating the ecosystem as compared to the use of inorganic amendments. A field experiment was conducted at Hohai University, Nanjing, China to determine the efficiency of different types of manure on the production and yield of wheat during winter growing season 2023-2024. To evaluate the effects of different treatments like control (T0), sheep manure (T1), cow manure (T2) and poultry manure (T3) randomized complete block design (RCBD) was employed using three replicates. It is concluded that poultry manure was much effective in promoting the wheat growth as compared to the other treatments with sheep manure and cow manure. It has been noted that the incorporation of poultry or farmyard manure significantly improved the grain yield to 6.752 t ha^{-1}, biological yield to 15.674 t ha^{-1}, and grain protein content to 14.7125%. These results showed that poultry manure has tendency to elevate the soil conditions and can increase the wheat growth and yield.

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Introduction

Wheat scientifically known as *Triticum aestivum L*. is a vital food crop all over the world that provides a lot of nutrients including carbohydrates, protein, some vitamins and minerals that are part of human diet (Iqbal et al., 2022). Due to the overpopulation it is concerning to increase the food production to fulfil the basic human needs. Wheat is widely consumed grain crop that's production needs to be increased per unit area and for sustainable agriculture this

can be possible by switching the traditional wheat types and the use of inorganic fertilizers to more environmental friendly techniques (Filip et al., 2023). Several studies showed that soil organic matter content plays very important role in plant nutrition and crop productivity (Oldfield et al., 2019). For instance, analysis conducted by Smith et al. (2022) showed increase in 1% of soil organic matter can increase an average 15% in wheat output.

Manure contains some essential nutrients that helps to increase the chemical, physical as well as biological properties of soil (Geng et al., 2019). Although use of organic manure works slowly and have low nutrients but its repeated application to the soil can give us long term benefits that it can increase the soil organic content without any side effects on environment (Adekiya et al., 2020). Organic manure provides appropriate soil compaction, increases the soil CEC and WHC that helps to improve the nutrient accessibility and can also enhance the soil microbial communities (Singh et al., 2022).

Manure application is getting more attention as compared to the employment of inorganic or chemical fertilizers because it is an environmental friendly approach that has no adverse effects on environment (Khoshnevisan et al., 2021). Its application promotes the wheat production by integrating farming systems (Wang et al., 2021) and also mitigates the feedlots environmental impacts (Wang et al., 2022). Excessive use of chemical fertilizers has led to adverse environmental impacts such as their use can deteriorate the soil quality and environment leading to poor human health. That is why, globally people are appreciating the use of organic amendments over chemical fertilizers particularly in developed countries (Bisht and Chauhan, 2020). Organic amendments such as manures can act as chelating agents that binds and retains the vital minerals released from soil matrix. Concurrently, the decomposition of organic matter generates acids that enhance mineral nutrient availability to plants (Hamid et al., 2020).

This study was designed to find out the efficiency of different types of manure such as sheep manure, cow manure and poultry manure as sustainable agriculture amendments leading towards the increase in growth and production of yield. By comparing these amendments we will assess the efficiency of these organic amendments on wheat yield as well as on sustainable agriculture. This research will assess the influence of these organic soil amendments on crop yield, soil quality and economic feasibility, contributing to the development of more sustainable agricultural practices.

Literature Review

Manure contains organic matter that plays an important role in improving the soil structure and soil fertility. It provides essential nutrients for crop growth and development including nitrogen, phosphorus and potassium (Köninger et al., 2021). These nutrients help to improve soil health and also enhance the crop yield. As compare to inorganic fertilizers manure is more environment friendly option as it improves soil quality without degrading the environment (Iqbal et al., 2023).

Manures specifically organic ones, offers slow-release source of nutrient for crop that can improve long and short-term soil fertility. According to the several studies, manures has higher level of organic matter which is important for enhancing the water retention in soil, microbial activity and nutrient holding capacity (Das et al., 2023). This is particularly significant in dry areas where water retention and soil's health are the main issues. In addition to improve plant growth and nutrient uptake the macronutrients like N, K and P, manure helps to improve crop yield production. According to the study by Fu et al., 2022 addition of

manure in soil improves the soil physical characteristics like porosity and aggregation of soil which enhance the nutrient availability and development of root.

The type of manure has great impact on increase in yield of crop. Due to the worldwide importance wheat and it is also a subject of many studies comparing the effects of different kinds of manure like sheep, chicken and cow dung on a range of crops. Among the other kinds of manure like animal manure poultry manure is considered as one of the most nutrient dense form of organic fertilizer because it provides greater concentrations of phosphate and nitrogen (Asfaw, 2022). According to the research by Zahid et al., 2021 poultry manure has greater nitrogen content which enhances the protein content, grain development and wheat growth. In addition, poultry manure improves the structure of soil by enhancing the capacity of soil to retain moisture which is essential during the dry periods. These results are supported by the findings of current studies which showed that the use of chicken manure significantly increased the wheat grain yield upto 6.752 t ha^{-1} and biological production upto 15.674tha^{-1} (Li et al., 2021).

Cow manure is common substitute in organic farming because of its availability and relatively balanced nutrient composition. As compare to poultry manure, it is less nutrient dense but it greatly increases the soil organic matter content and microbial activity which enhancing the soil's nutrient cycling (Gosh et al., 2004). According to the research conducted by Guo et al.,2016 when cow manure combined with other organic amendments it increases the soil fertility and yield of wheat. As compare to the poultry manure, cow manure has positive effects but it requires large application rates or other treatments to match the performance with poultry manure. Sheep manure is also an important source of organic matter and it also contains different valuable nutrients like phosphorus and nitrogen but in less amount as compare to poultry manure. According to the study by Duby et al., 2022 sheep manure enhances the wheat yield and soil organic carbon but it has not same results as chicken manure. Additionally, the study showed that in water scarce areas sheep manure increases the moisture retention and enhances the soil structure. Sheep manure has good impact on wheat crop it was found that as compare to poultry manure it is less effective (Guo et al., 2016).

There are several mechanisms through which wheat manure affects the growth and yield of wheat. The organic matter present in manure releases consistent supply of essential nutrients for the growth of plant (Chen et al., 2024). It also stimulates the soil microbial activity to breakdown the organic matter and convert it into nutrients for plants (Bhardwaj et al., 2023). This process increases the soil biological activity which promotes the absorption of nutrients like phosphorus, potassium and nitrogen for the development of wheat. Additionally, manure has the ability to enhance the soil structure that is important for the moisture retention and root growth these factors are vital for the wheat production particularly in low water supply regions (Oyetunji et al., 2022).

Numerous comparative studies have evaluated the effects of various manures on wheat quality and productivity. According to a study by Chen et al., 2020 as compare to cow and sheep manures chicken manure not only produces the greater protein content but also increases the wheat yield. Similar to this study Sharma et al., 2021 found that poultry manure improves the wheat yield, grain quality, grain size and higher protein content (Thakur et al., 2021).

According to the study by Muduli et al. (2019) poultry manure is quite affective in contrast to cow and sheep manure. Cow and sheep manure also provides significant advantages when

they combined with different organic amendments such as biochar and compost. It is important to considered the local conditions of soil and nutrient availability when selecting the certain type of manure for specific crop (Sharma et al., 2021).

The current study focuses on the advantages of organic amendments especially manure in enhancing the crop productivity and health of soil. It supports that poultry manure has high nutritional content and is very useful for increasing grain protein content and wheat yield. Cow and sheep manure also provides benefits but has not noticeable results like poultry manure. Further studies in future are required on applying various manure types and their combinations to maximize the sustainable agricultural benefits.

Materials and Methods

Area of study

The research experiment was organized at the research area of Hohai University, Nanjing, China in the winter season (November 2023- June 2024).

Collection of soil samples

For sampling, the soil was collected from 30 cm depth before planting the seeds and were analysed in lab.

Determination of the physicochemical parameters of soil

Soil physicochemical properties (showed in Table 1 and 2) such as soil textural class, pH, available phosphorous (P), electrical conductivity (EC), total nitrogen, total calcium carbonates Carbonate (CaCO3), soluble calcium (Ca^{2+}), soluble magnesium ($Mg^{2+)}$, soluble sodium (Na^{+}), soluble potassium (K^{+}), soluble chlorides (Cl^{-}) and soluble bicarbonates (HCO^{3-}) were determined by following the protocols provides by Stevenson (1982).

Determination of the nutritional content of manure

The nutrient composition of sheep, cow, and poultry manures was determined following the analytical procedures outlined by Faithfull (2002). Parameters such as total nitrogen, phosphorus, potassium, organic matter, and other essential micronutrients were quantified to assess the fertilizer value of these organic inputs are in Table 1.

Table 1: Physico-chemical Properties of Soil under Different Organic Amendments

Parameter	Value
Sand	115.4 g kg^{-1}
Silt	523.6 g kg^{-1}
Clay	361.0 g kg^{-1}
pH	7.27
Electrical Conductivity (EC)	0.17 dS m^{-1}
Organic Matter	1.36%

Available Phosphorus (P)	14.46 ppm
Total Calcium Carbonate ($CaCO_3$)	24.5%
Available Total Nitrogen	0.11%
Soluble Calcium (Ca^{2+})	1.7 meq L^{-1}
Soluble Magnesium (Mg^{2+})	1.9 meq L^{-1}
Soluble Potassium (K^+)	0.056 meq L^{-1}
Soluble Sodium (Na^+)	0.056 meq L^{-1}
Soluble Bicarbonate (HCO^{3-})	2.0 meq L^{-1}
Soluble Chloride (Cl^-)	0.2 meq L^{-1}

Table 2: Some chemical properties of sheep, cow and poultry manures (used in the study)

Organic fertilizers	pH	EC dS m^{-1}	N%	Available P (ppm)	soluble K^+ meq L^{-1}	soluble Na^+ meq L^{-1}
Sheep manure	7.79	2.05	1.46	275.42	13.06	14.05
Cow manure	8.02	5.38	1.13	445.86	27.35	21.38
Poultry manure	7.35	12.53	1.74	453.63	116.96	119.95

Experimental procedure

For this experiment randomized complete block design was selected for statistical analysis with three replicated, utilizing 2 x 3-meter plots. The experimental design included three treatments: a control (T_0) without any fertilizer application, and three treatments involving the application of 25 tons per hectare of sheep dung (T1), cow manure (T2), or poultry manure (T3). Organic amendments were incorporated into the soil before broadcasting wheat seeds at 140 kg per hectare on December 2, 2023. Plants were watered twice a week till the end of the experiment to retain the moisture content. Regular field observations were conducted throughout the crop growth cycle. In adherence to organic farming principles, the application of synthetic chemical pesticides, fungicides and herbicides was strictly prohibited throughout the study period. Weed control measures were implemented through labour-intensive practices, commencing with manual removal of weeds and employing cultivation using a hand hoe. Notably, the crop demonstrated exceptional resistance to insect pests and fungal diseases, necessitating minimal intervention for pest management. Plant and soil properties were assessed within the central seven rows of each experimental plot to ensure data accuracy and consistency. Wheat maturity was reached on June 5, 2024, prompting manual harvesting. Grain yield data were standardized by adjusting moisture content to a uniform 15% to facilitate comparative analysis.

Assessment of organic matter

Determining soil's organic matter using the Walkley & Black method involves a procedure where organic carbon compounds reduce potassium dichromate ($K_2Cr_2O_7$), and the unreduced dichromate is then quantified through oxidation-reduction titration with ferrous ammonium sulphate. Reagents are prepared as follows: 1 N $K_2Cr_2O_7$ is made by drying $K_2Cr_2O_7$ at 105 °C in an oven for 2 hours, cooling and dissolving 49.04 g of it in deionized water to make a 1 L solution. Concentrated sulphuric acid (H_2SO_4, 98%) and orthophosphoric acid (H_3PO_4) are also prepared. The ferrous ammonium sulphate solution is made by dissolving 196 g of the compound in deionized water, adding 5 mL concentrated H_2SO_4, and bringing it to a 1 L volume. The procedure begins by placing 1 g of dried soil into a 500 mL beaker. Next, 10 mL of 1 N $K_2Cr_2O_7$ and 20 mL of concentrated H_2SO_4 were added, followed by constant stirring to thoroughly mix the suspension. After allowing the mixture to rest for 30 minutes, 10 mL of concentrated H_3PO_4 and 200 mL of distilled water were added, and the solution was allowed to cool. Magnetic stirring was then performed after adding a few drops of diphenylamine indicator. The solution was titrated with 0.5 M ferrous ammonium sulphate until its colour changed from violet-blue to green. For accuracy in determining the organic carbon content, two blanks were prepared without soil, containing all reagents and analysed in the same manner as the soil suspensions using Eq. (1).

$$M = \frac{10}{V_{Blank}}$$

$$\text{Oxidizable Organic C (\%)} = \frac{(V\ Blank - V\ Sample)\ x\ 0.3\ x\ M}{Wt} \quad (1)$$

$$\text{Total Organic C (\%)} = 1.334 \text{ x Oxidizable Organic C (\%)}$$

$$\text{Organic Matter} = 1.724 \text{ x Total Organic C (\%)}$$

Statistical analysis

Fischer's analysis of variance (ANOVA) method was used to analyse the recorded data. This methods described the significant differences among the means of all treatments. Least significant difference (LSD) test as used at probability level of 5% described by Steel et al. (1997). By using this statistical method we assess the efficiency of different treatments on wheat growth and yield ensuring that the observed differences were not due to random variation but were statistically significant.

Results and Discussion

Plant Height

Different treatment's effect on the height of plants were analysed and the study showed that T_3 depicted the significant results of plant height as compared to T_o, T_1 and T_2. Application of poultry manure T_3 resulted increase in 10.7% of plant height as compared to the control treatment showing that it has positive effects on plant growth and height. Poultry manure contains a lot of nutrients that provided essential nutrients that can help in increase in height of plant and plant growth during the whole duration of maturity. Similar outcomes were reported in the research of Rasool et al. (2023) and Hammad et al. (2020) they studied the addition of organic amendments such as manure for the growth and yield of wheat. Their

study showed that presence of vital nutrients that improves the crop's growth and yield parameters including the sustainable agricultural practices.

Number of Tillers per Plant

Number of tillers per plant in all treatments was observed in detail in Table 3. Notable difference was observed among all treatments T_o and T_1, T_2 and T_3. Treatment with poultry manure T_3 exhibited a substantial 71.59% rise in tiller number compared to the control treatment. The results indicated that during the growth period of crop organic amendments are beneficial in promoting the tiller development. Increase in tillers in T_3 can be due to the nutrient rich composition of poultry manure that added the nutrients that are essential for the growth of tillers in wheat crop. These results are aligned with the research provided by Ibrahim et al. (2008) he described the positive effect of organic amendments on crop development and yield outcome. Ali et al. (2016) and Khan et al. (2019) have also highlighted the benefits of using organic inputs in enhancing the tiller production and crop yield.

Number of Grains per Spike

According to the conducted studies it has been revealed that among all treatments grain count has no significant difference. In this way, this study has contrasted results as compared to the studies provided by Koutroubas et al. (2016) he observed that by applying different organic fertilizers there is increase in grain per spike. These results can vary according to the organic amendments used, soil composition and climatic conditions. This indicates that use of organic fertilizers have potential to increase the number of grains per spike but it also depends on organic amendment nature and specific conditions of environment. The variation in number of grains per spike among all manure treatments could be due to several conditions like soil composition that is essential in nutrient availability that directly affect the grain production. Variations in soil fertility levels or nutrient content among the experimental plots may have influenced the grain count results. It has been observed that change in weather conditions like sunlight, temperature and rainfall can affect the plant growth processes and ultimately can affect the grain production. These different factors and their effect on plant growth and yield was studied by Koutroubas et al. (2016) and he observed that grain production may differ and can show contrasting outcomes of grain production per spike so there is need to study about the different mechanisms influencing grain production in wheat plants.

1000 Grain Weight (g)

The research findings depicted that there was no such notable difference among all the treatments on 1000 grain weight of wheat (Table 3). Various organic amendments such as sheep, cow and poultry manure did not show significant impact on wheat grain weight in comparison to control treatment. Results are close to the studies conducted by AlJanabi et al. (2019) he explained that addition of different doses of organic amendments can have positive impact on crop's 1000 grain weight. There could be difference according to the change in environmental conditions, experimental settings and techniques of application. This statement indicates that organic amendments application can potentially enhance the weight of grains, although their efficiency may differ based on the particular environmental and management circumstances.

Biological Yield

The biological yield of T_3 was the largest and significantly different from T_o, T_1, and T_2, similar to other features. The enhanced biological productivity associated with poultry manure can be due to its efficient supply of easily accessible nutrients such as NPK, compared to other types of fertilizers. Organic manures offer crops a diverse range of nutrients, although the specific composition and effectiveness may differ depending on the type and quality of the manure (Dhaliwal et al., 2021). Out of the many types of organic manure treatments, poultry manure was the most effective in enhancing plant traits, possibly because it undergoes quick mineralization. Although the majority of nitrogen in poultry manure is biological around 20 to 40 % exists in an inorganic state (Rasool et al., 2023). The findings of our study are quite related to the outcomes of Bhunia et al. (2019), he also observed that the increased biological production can be associated to the direct supply of nutrients from organic manures, specifically nitrogen, and their enhancement of the soil's water-stable aggregates.

Grain Yield

The wheat grain yield under various manure applications is displayed in Table 3. According to the results, poultry manure (T_3) showed a substantial difference contrasted to other recorded treatments with the grain yield of 6.755 t ha^{-1}, which was the greatest. The lowest output recorded was 5.426 t ha^{-1} for T_1. The increased quantity of N, P and K in poultry manure, relative to the other different treatments (Table 2), is responsible for the superior grain yield observed in T3. The outcomes support the results presented by Khalid et al. (2011) that, the application of farmyard (poultry) manure had a considerable positive impact on wheat grain production.

Harvest Index%

The study showed substantial variations in the harvest index (HI) among treatments, particularly between the control (T_0) and poultry manure treatments (T_2 and T_3). T_0 presented the highest HI at 49.32%, while T_3 had the lowest HI at 43.12%. In T_3 lower HI would be because poultry manure may promote vegetative growth as compared to reproductive growth and thus leading to lower biomass. These results aligns with Smith et al. (2015) who found out that application of nitrogen fertilizers can enhance the vegetative growth of crop as compared to grain yield. Additionally, it has been observed that poultry manure application has raises the nutrients level and protein in wheat as seen in Table 4, it is more likely due to the slow release nitrogen effect that was described by Jones et al. (2017). However, this increase in nutrients leads towards unfavourable conditions in HI. This emphasize the need of manure management for balanced vegetative and reproductive growth.

Table 3: Effect of manure application on growth parameters of wheat plant

Treatments	Plant height (cm)	No. of tillers plant $^{-1}$	No. of grains Spike^{-1}	1000-grain weight	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest Index %
T_o	76.50 ^{c}	3.252 ^{c}	50.00 ^{a}	45.472 ^{a}	11.290 ^{b}	5.472 ^{b}	49.32 ^{a}

T_1	79.55 ^{bc}	4.273 ^{bc}	53.00 ^{a}	46.852 ^{a}	11.665 ^{b}	5.426 ^{b}	46.50 ^{ab}
T_2	82.05 ^{b}	5.876 ^{b}	54.00 ^{a}	42.659 ^{a}	12. 794 ^{b}	5.618 ^{b}	43.91 ^{bc}
T_3	83.90 ^{a}	6.251 ^{a}	49.00 ^{a}	45.452 ^{a}	15.667 ^{a}	6.755 ^{a}	43.12 ^{c}

Table 4: Nitrogen (N) content%, phosphorus (P) and potassium (K) concentrations of grain wheat under different manure application

Treatments	Grain Protein content%	N Con. (%)	P Con. (ppm)	K Con. (ppm)
T_o	11.476 ^{b}	1.994^{b}	41.425 ^{a}	2882.00 ^{a}
T_1	12.405 ^{b}	1.982^{b}	43.910 ^{a}	2688.00 ^{a}
T_2	13.106 ^{ab}	2.098^{ab}	38.060 ^{a}	2688.00 ^{a}
T_3	14.958 ^{a}	2.391^{a}	41.252 ^{a}	2664.25 ^{a}

Grain Protein Content%

The data regarding the grain protein content showed significant variations between T_3 and both T_o and T_1 that is due to different manure application. The data depicted that wheat grain protein content varied between 13.475% and 15.95%. It has been observed that application of poultry manure has showed substantial increase in grain protein content. This can be a result because of high concentrations of nutrients like N, P and K present in poultry manure that favours the grain protein content. These findings are similar with (Moniruzzaman et al., 2022) who described that application of organic amendments like compost can affect the water and nutrient absorption by seeds, he observed the highest grain protein with the compost treatment where the application rate was 60 Mg ha^{-1}.

Grain Nitrogen, Phosphorus, and Potassium Content

It has been observed that T_3 treatment showed significant raise in nitrogen content (%) as contrast to both the control (T_0) and T_1 treatments because poultry manure contains high levels of nitrogen and enhance its uptake by plants. In contrast, among all treatments there were no substantial differences in phosphate and potassium levels. This suggests that manure application has no effect on the availability of phosphate and potassium. Similar findings were found in the research by Ahmed et al. (2018) according to his studies manure application can enhance the nitrogen levels but have no or minimal impact on potassium and phosphate when their soil concentrations are already present in appropriate amount. The results also indicate that within each nutrient category, means charted by the same letters are not statistically significant at the probability level of 5%, whereas means with different letters are statistically significant.

Conclusion

Based on this study conducted on the comparative analysis of different organic amendments on the progression and production of wheat crop, it has been concluded that poultry manure showed the best results regarding the wheat growth and yield among all treatments. As

compared to all other tested treatments, poultry manure significantly increased the grain yield, grain protein and biological yield. It is rich in nutrients and greatly contributes in agricultural productivity but it is also important to consider its potential environmental impacts such as slow or gradual release of nitrogen in soil and potassium and phosphate accumulation in soil. This can gradually lead towards the soil nutrient imbalance over time that is why careful application and management of manure is required to maximize the crop yield with sustainable agriculture.

Authors' contributions

All authors made significant contributions towards the successful writing of this work and also permitted it for publication.

Competing interest

The authors' disclose that they have no competing interests.

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