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Research Article

Effects of different Sources of Organic Matter on Availability of Phosphorus in Wheat (*Triticum aestivum* L.) Crop at Quetta, Balochistan

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ABSTRACT

Wheat is one of the important staple food being grown worldwide. Less phosphorus (P) availability in upland areas of Balochistan is one of the major problems is achieving an optimum crop yield. An experiment was conducted to evaluate the response of different sources of organic matter on availability of phosphorus. The results were revealed that the soil with T1 was resulted moderate 0.26 dSm-1 electrical conductivity, pH 8.25, 0.51 organic matter, total phosphorus mg.kg-1 3.77 in soil and 0.88% phosphorus in wheat tissues, extractable phosphorus mg.kg-1 at 15.83 in soil, 0.041 total N% in soil and 2.30% in wheat tissues, total k mg.kg-1 172 in soil and 1.58% in wheat tissues, CaCO3 % 11.33 in soil. T2 was resulted minimum 0.23 dSm-1 electrical conductivity, pH 7.95, 0.59 organic matter, available phosphorus mg.kg-1 4.74 in soil and 1.05% phosphorus in wheat tissues, extractable phosphorus mg.kg-1 at 18.56 in soil, 0.048 total N% in soil and 2.77% in wheat tissues, total k mg.kg-1 191.33 and 1.91% in wheat tissues, CaCO3 % 13.33 in soil. T3 was resulted 0.31 dSm-1 electrical conductivity, pH 8.42, 0.38 organic matter, available phosphorus mg.kg-1 3.27 in soil and 0.37% phosphorus in wheat tissues, extractable phosphorus mg.kg-1 at 12.35 in soil, 0.031 total N% in soil and 1.75% in wheat tissues, total K mg.kg-1 134.33 in soil and 1.32% in wheat tissues, CaCO3 % 8.33 in soil. To control was resulted 0.333 dSm-1 electrical conductivity, pH 8.55, 0.37 organic matter, available phosphorus mg.kg-1 2.61 in soil and 0.14% phosphorus in wheat tissues, extractable phosphorus mg.kg-1 at 9.64 in soil, 0.021 total N% in soil and 1.26% in wheat tissues, total K mg.kg-1 88.66 in soil and 1.13% in wheat tissues, CaCO3 % 6.66 in soil. So, results concluded that organic amendments, particularly poultry waste, farmyard manure, and plant residues, positively impact soil properties and plant growth parameters.

Keywords: Organic Matter, Farm Yard Manure, Poultry Waste, Phosphorus, Wheat.

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INTRODUCTION

Wheat (*Triticum aestivum* L.), a member of the Poaceae family, holds significant importance as a staple crop in numerous countries worldwide, including Pakistan. Pakistan is among the top 10 wheat-producing nations in the world. Pakistan typically produces around 25 to 27 million metric tons of wheat annually, though this can fluctuate based on various factors like wheater condition, poor agricultural practices. Its historical role in the development of civilizations spans millennia, earning it the title of the "king of cereals.

Wheat grain serves as a direct or indirect component of human diets, while the straw finds application as animal feed. It constitutes a primary dietary source for many, providing approximately 73% of the calories and protein in the average diet (Bhanger et al., 2021).

Balochistan, Pakistan's largest province encompasses 44% of the nation's landmass, characterized by predominantly loose soil and a hyper-arid climate. Situated in the southwestern region within a desert belt, its global map location underscores its significance. Despite its vastness, Balochistan faces formidable challenges, particularly concerning environmental sustainability and food security. The barren highlands witness noticeable environmental impacts, leading to a decline in crop yields. Factors such as rapid population growth, recurrent droughts, climate fluctuations, land degradation, and desertification compound these challenges, posing significant hurdles to environmental stability and food production. Phosphorus (P) is crucial for plant growth and is a major growth-limiting nutrient despite its abundance in soils in both inorganic and organic forms Plants absorb phosphorus as orthophosphate (H_2PO_4 and HPO_4) (Hinsinger, 2001).

It is an essential structural component of various co-enzymes, phosphoproteins, phospholipids, and DNA. Phosphorus plays a vital role in energy transfer and storage, necessary for growth and reproduction. It is also important in several plant physiological processes, including photosynthesis, carbon metabolism, and membrane formation (Wu et al., 2005). Low phosphorus availability is a significant factor limiting crop production in acidic soils. The concentration of inorganic phosphorus in soil solution is generally very low because it tends to bind strongly to soil surfaces or form insoluble complexes with cations (Talboys et al., 2014).

Inorganic and organic phosphorus (P) occurs in soil in several forms, mainly slightly soluble and thus of low availability to plants. In calcareous soils, $CaCO_3$ surfaces specifically interact with phosphate an-ions although $CaCO_3$ also controls Ca concentration in soil solution and in the soil exchange complex (Kalayu, 2019). The removal of P from soil solution is mainly due to adsorption and precipitation processes. At low P solution concentrations, up to the millimolar range, adsorption processes predominate while precipitation reactions dominate at higher P concentrations (Jalali and Peikam, 2013). Keeping in view the facts that the application of different sources of organic matter will improve Phosphorus contents in soil and also promoted its availability to plant so the study was designed to evaluate their effects.

MATERIALS AND METHODS

Experimental area and Design

The experiment was conducted at the green house under Complete Randomize Design (CRD) at site, Balochistan, Agriculture College, Quetta (latitude 30.2674° N, longitude 66.9301° E) in the upland of Balochistan, Pakistan in 2022. The experiment layout was prepared for distributing the different sources of organic matter. The 4 treatment combinations of the experiment were assigned at random into 12 pots. Experimental details were as under;

Table 1. Some initial physicochemical properties of soil

Parameters	Units	Results	Remarks
pH		8.55	Alkaline
EC	dSm^{-1}	0.33	Low
Organic matter	%	0.42	Low
Total P	(mg. kg^{-1})	2.61	Low
Extractable P	(mg. kg^{-1})	9.46	Low
Total N	%	0.021	Low
Total k	(mg. kg^{-1})	88.61	Low
$CaCO_3$	%	6	Medium
Soil texture			Silty clay loam

Treatments Used

T_0 : without application of organic matter (Ct) + standard dose of NPK 50%

T_1 : 5 kg soil + 100 g pot^{-1} Farmyard Manure (FYM) + standard dose of NPK 50%

T_2 :5 kg soil + 100 g pot^{-1} Poultry Waste (PW) + standard dose of NPK 50%

T_3: 5 kg soil + 100 g pot^{-1} Plant Residues (PR) + standard dose of NPK 50%

Soil analysis

Before beginning the experiment, the soil was inspected using the (Bouyoucos, 1927) hydrometer method to determine the soil's texture. The EC and pH (1:2 soil water extract) were determined using digital EC and pH meters. Phosphorus determined by (Olsen, 1954). Organic matter was determined by (Walkley and Black, 1934). The total N was determined by Kjeldahl method (Nelson and Sommers, 1973), and P and K were extracted by AB-DTPA method (Ryan et al., 2001).

Plant analysis for macronutrients (N, P, and K)

The plant samples after harvest were oven dried at 70 ^{0}C for one week and then processed for N, P, and K analysis

Statistical Analysis

The collected data were statistically analyzed using two factorial analysis of variance (ANOVA) using Statix ver. 8.1 computer software.

RESULTS

Soil pH

The effect of sources of organic matter was applied in soil was investigated the result of pH of soil is given in (Figure. 1).The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on pH of soil. The pH values obtained from the experimental treatments provide valuable insights into the effect of different organic matter sources on soil acidity. In the control treatment (Ct) without organic matter, the mean pH was recorded at 8.55, indicating a slightly alkaline soil condition. Treatments involving the addition of organic matter showed variations in pH levels. T_3 5 kg soil + 100 g pot^{-1} plant residues (PR) was resulted in a slightly lower mean pH of 8.42, suggesting a potential influence of this organic material on reducing soil alkalinity. T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment demonstrated a further decrease in pH to 8.25, indicating a more pronounced effect on reducing soil alkalinity compared to both the control and PR treatments. Notably, the lowest mean pH value of 7.95 was observed in the T_2 5 kg soil + 100 g pot^{-1} poultry waste (PW) treatment, indicating a significant decrease in soil alkalinity with this organic input.

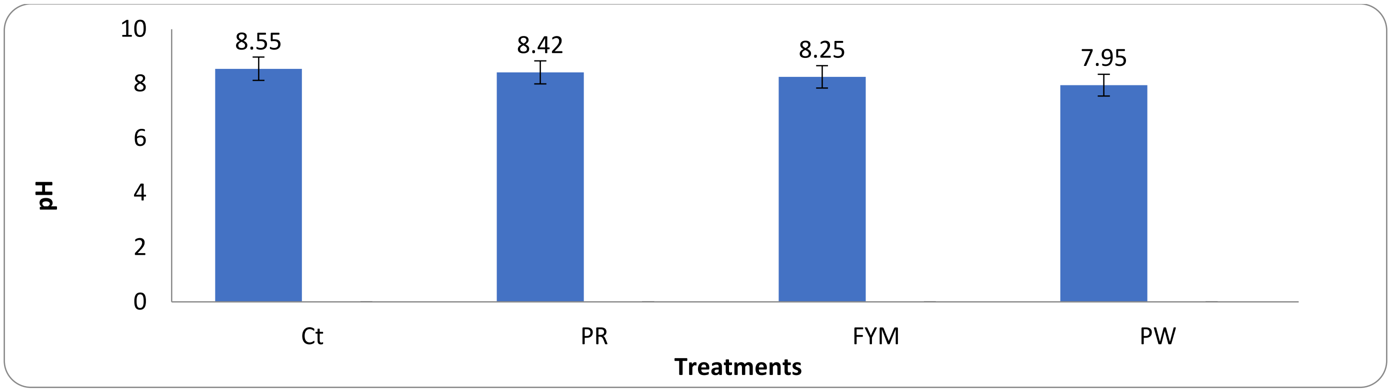

Figure 1. Effect of different level of organic matters on soil pH

Electrical conductivity (dSm^{-1})

The effect of sources of organic matter was applied in soil was investigated the result of electrical conductivity (dSm^{-1}) of soil is given in (Figure.2). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on electrical conductivity of soil. The results revealed that in the control Ct (without organic matter), the EC was 0.33, typical for regular soil. But when added different organic materials, the EC changed. T_3 5 kg soil + 100 g pot^{-1} plant residues (PR) made the EC slightly lower at 0.31, indicating a small impact on soil conductivity. T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) reduced the EC even more to 0.26, suggesting it might help soil conduct less electricity compared to the control and PR treatments. Adding T_2 5 kg soil + 100 g pot^{-1} poultry waste (PW) caused the EC to drop the most to 0.23, showing it might significantly reduce soil conductivity.

Organic matter

The effect of sources of organic matter was applied in soil was investigated the result of Organic Matter of soil is given in (Figure. 3). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter in soil. The results revealed that the control treatment (Ct) without organic matter, the average organic matter content was 0.37. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment had the highest average organic matter content at 0.59, indicating a significant contribution to soil fertility. Following closely, T_1 5 kg soil + 150 g pot^{-1}

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Farmyard Manure (FYM) treatment had an average organic matter content of 0.51, showing a substantial organic input to the soil. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment was yielded a slightly lower average organic matter content of 0.38.

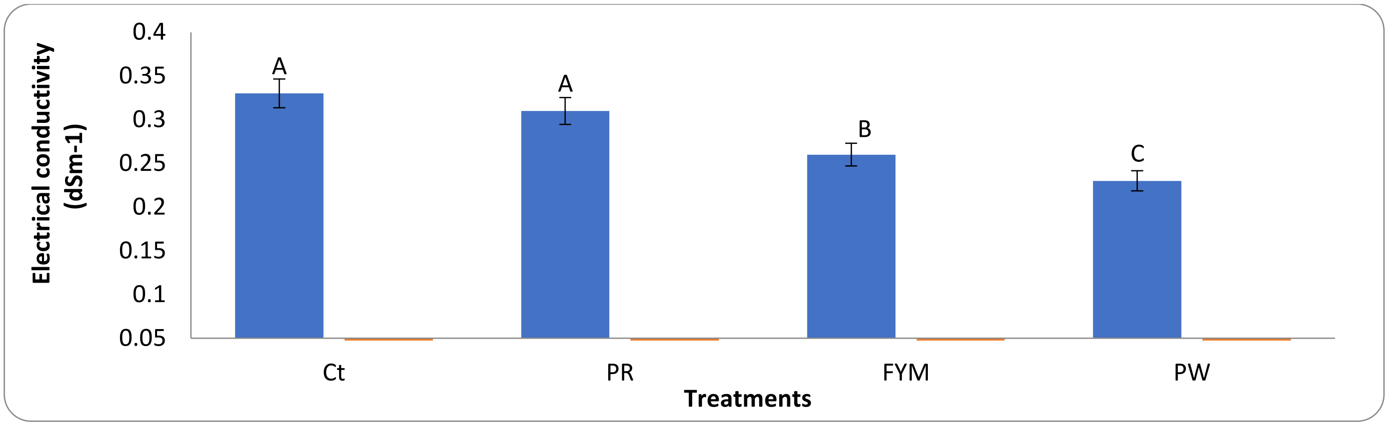

Figure 2. Effect of different level of organic matters on electrical conductivity (dSm-1)

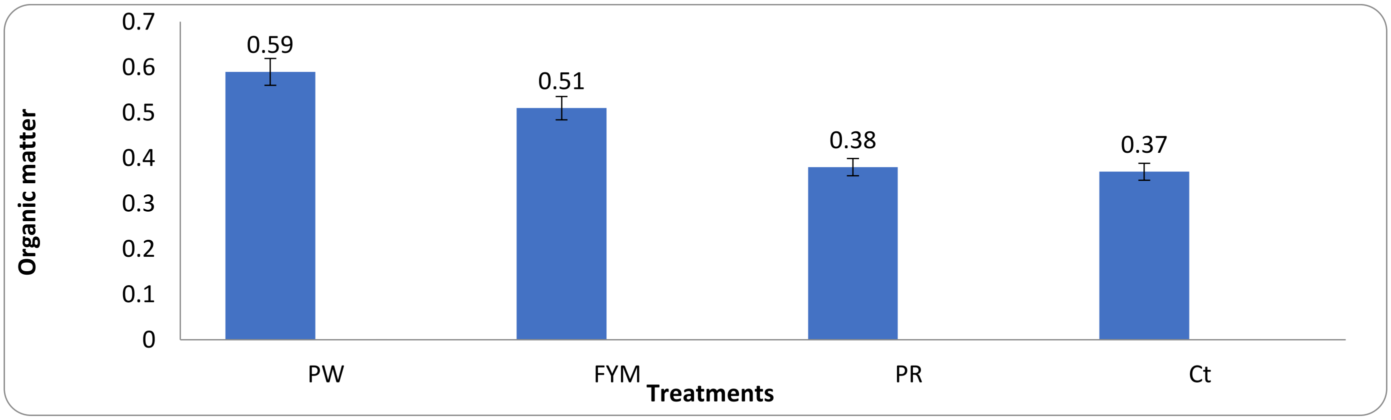

Figure 3. Effect of different level of organic matters

Total phosphorus

The effect of sources of organic matter was applied in soil was investigated the result of total p of soil is given in (Figure. 4). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on total p of soil. It can be observed that in the control treatment (Ct) without organic matter, the mean total phosphorus mg.kg^{-1} content was 2.616, representing the baseline level without any added organic material. Treatments involving organic matter additions exhibited variations in total phosphorus content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment was showed the highest mean total phosphorus mg.kg^{-1} content at 4.74, indicating a significant contribution of phosphorus to the soil from poultry waste. T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment followed with a mean total phosphorus mg.kg^{-1} content of 3.77, suggesting a substantial input of phosphorus to the soil from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower mean phosphorus mg.kg^{-1} content of 3.27.

Extractable phosphorus

The effect of sources of organic matter was applied in soil was investigated the result of Extractable P of soil is given in (Figure. 5). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on Extractable P of soil. It can be observed that in the control treatment (Ct) without organic matter, the average extractable phosphorus mg.kg^{-1} content was 9.46. Treatments involving organic matter showed distinct variations in extractable phosphorus content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment displayed the highest average extractable phosphorus mg.kg^{-1} content at 18.56, indicating a substantial contribution of phosphorus availability from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment exhibited an average extractable phosphorus mg.kg^{-1} content of 15.83, suggesting a notable input of phosphorus availability from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average extractable phosphorus content of 12.35.

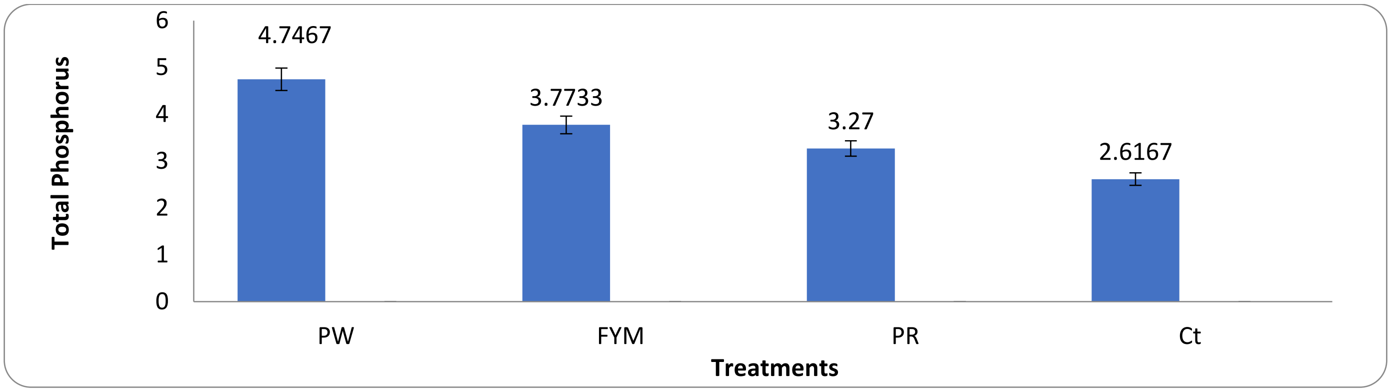

Figure 4. Effect of different level of organic matters on soil total P

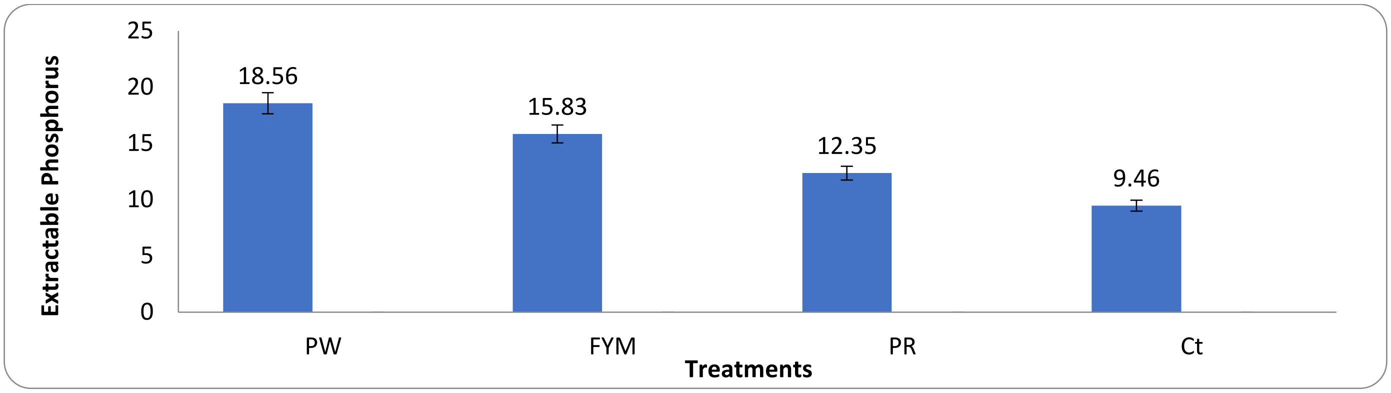

Figure 5. Effect of different level of organic matters on soil Extractable phosphorus

Total Nitrogen

The effect of sources of organic matter was applied in soil was investigated the result of Total N % of soil is given in (Figure. 6). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on Total N % of soil. The total nitrogen percentage was observed across the different treatments and it showed that in control treatment (Ct) without organic matter, the average total nitrogen percentage was 0.021. Treatments involving organic matter showed distinct variations in total nitrogen percentage. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment exhibited the highest average total nitrogen percentage at 0.048. T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment followed closely with an average total nitrogen percentage of 0.041. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average total nitrogen percentage of 0.031.

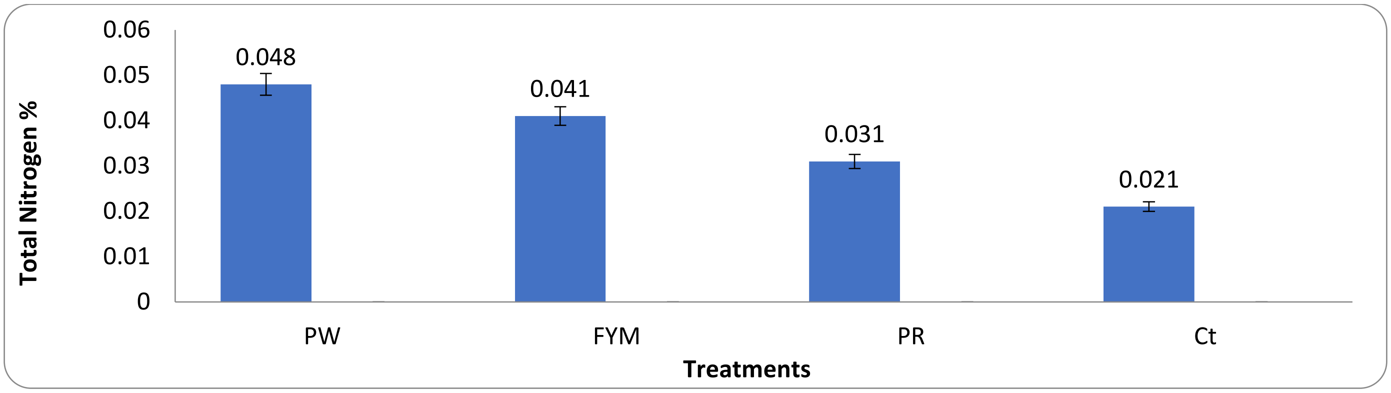

Figure. 6 Effect of different level of organic matters on soil Total Nitrogen %.

Total K

The effect of sources of organic matter was applied in soil was investigated the result of Total K (mg.kg^{-1}) of soil is given in (Figure. 7). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on Total K (mg.kg^{-1}) of soil. The results revealed that the control treatment (Ct), the average total potassium mg.kg^{-1} was 88.667, serving as the baseline without added organic material. Treatments involving organic matter showed distinct variations in total potassium content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment exhibited the highest average total potassium $mg.kg^{-1}$ at 191.33, indicating a significant contribution of potassium from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment showed an average total potassium $mg.kg^{-1}$ 172, suggesting a substantial input of potassium from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average total potassium $mg.kg^{-1}$ 134.33.

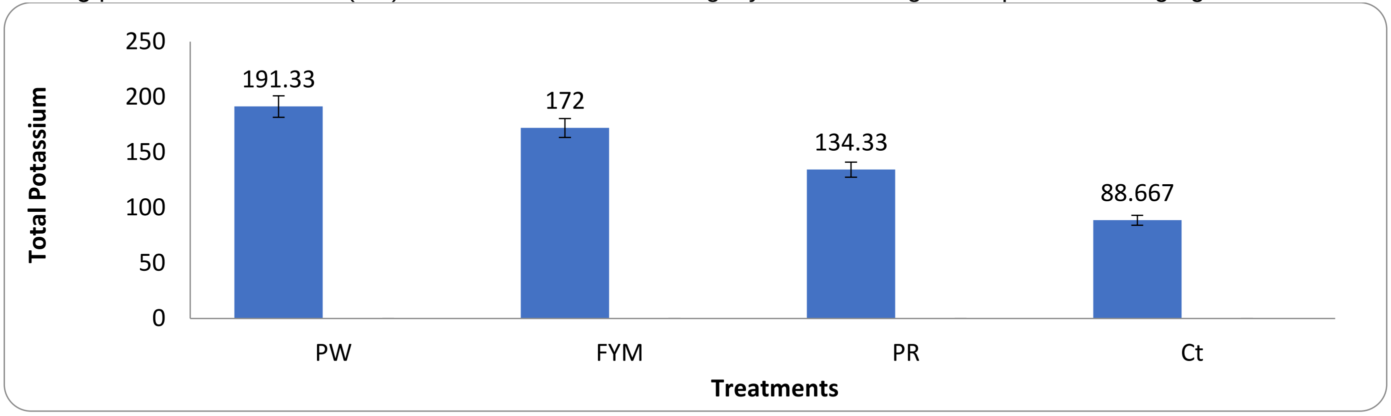

Figure 7. Effect of different level of organic matters on soil total K %.

$CaCO_3$

The effect of sources of organic matter was applied in soil was investigated the result of calcium carbonate ($CaCO_3$) of soil is given in (Figure. 8). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on calcium carbonate ($CaCO_3$) of soil. In the control treatment (Ct) without organic matter, the average calcium carbonate content was 6.6667. Treatments involving organic matter exhibited distinct differences in calcium carbonate content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment displayed the highest average calcium carbonate content at 13.333, indicating a significant contribution from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment showed an average calcium carbonate content of 11.333, suggesting a notable input of calcium carbonate from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average calcium carbonate content of 8.3333.

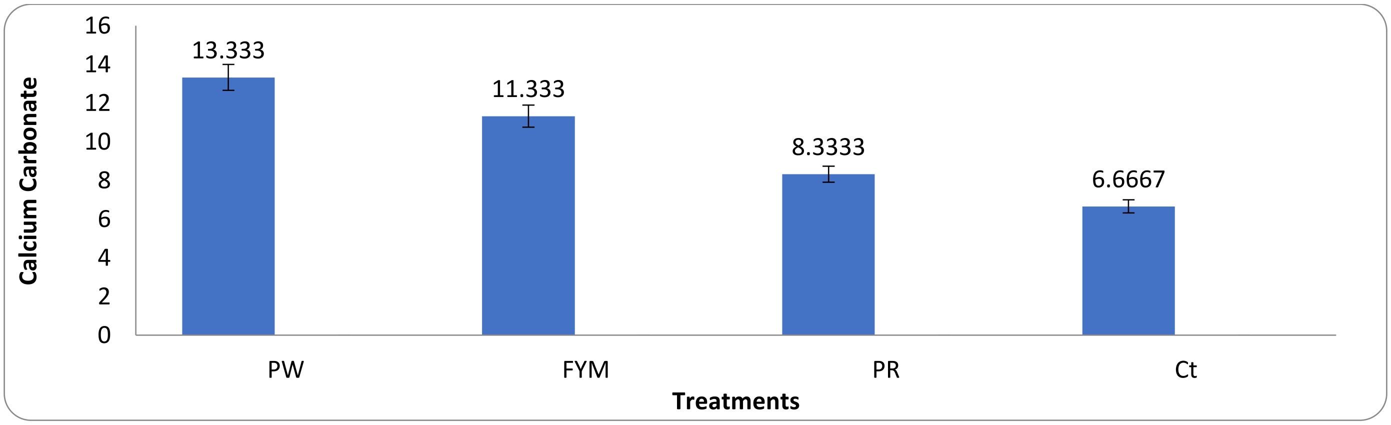

Figure 8. Effect of different level of organic matters on soil calcium carbonate %.

Plant parameters

Available Phosphorus % in Wheat

The effect of sources of organic matter was applied in soil was investigated the result of available P in wheat is given in (Figure. 9). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on available P of wheat. In the control treatment (Ct) without organic matter, the average available P content was 0.14%. Treatments involving organic matter exhibited distinct differences in available P %. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment displayed the highest average available P % at 1.05%, indicating a significant contribution from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment showed an average content of 0.88%, suggesting a notable input of available P from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average available P content of 0.37%.

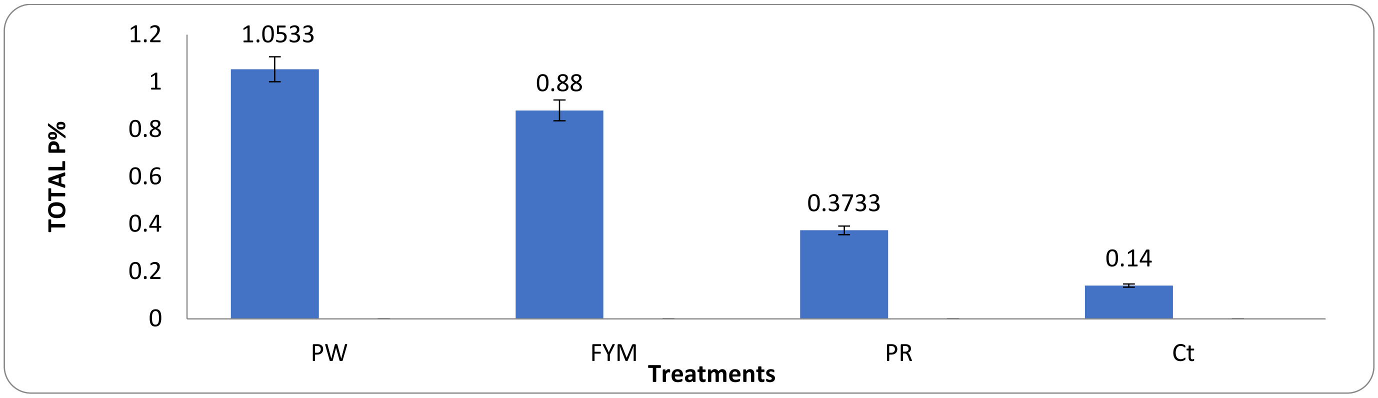

Figure 9. Effect of different level of organic matters on total P % in wheat tissues.

Nitrogen % in Wheat Tissues

The effect of sources of organic matter was applied in soil was investigated the result of nitrogen % in wheat tissues is given in (Figure. 10). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on nitrogen % in wheat tissues. In the control treatment (Ct) without organic matter, the average nitrogen %c was 1.26%. Treatments involving organic matter exhibited distinct differences in nitrogen content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment displayed the highest average nitrogen % at 2.77%, indicating a significant contribution from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment showed an average nitrogen % of 2.30%, suggesting a notable input of nitrogen from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average nitrogen % of 1.75%.

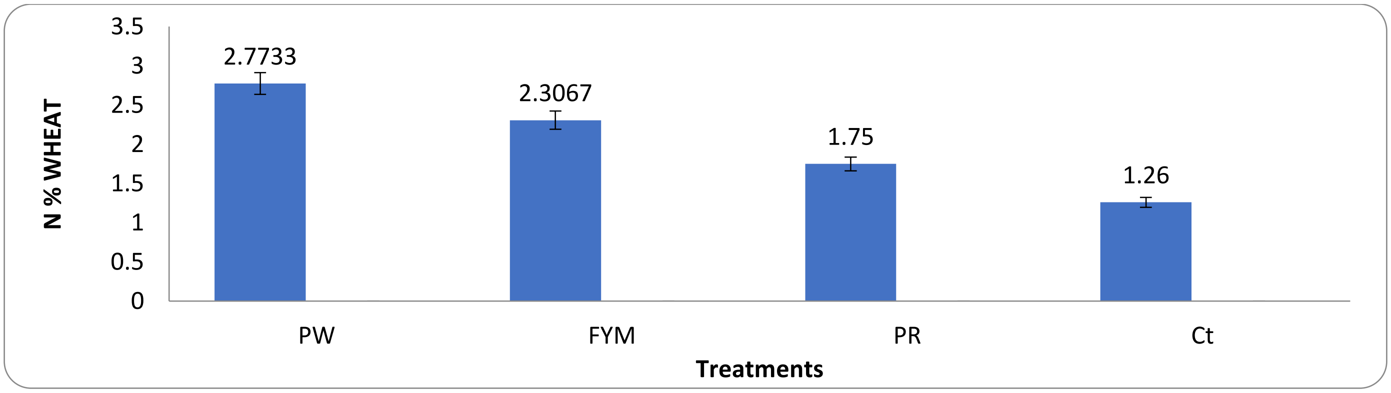

Figure 10. Effect of different level of organic matters on Total N % in wheat tissues.

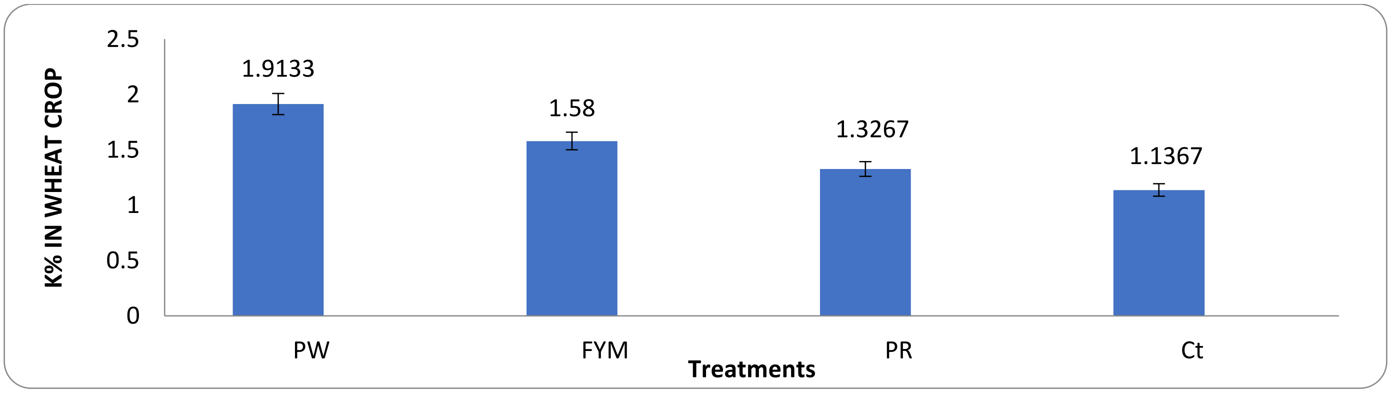

Figure 11. K% effect of different level of organic matters on Total K % in wheat tissues.

Potassium% in wheat Tissues

The effect of sources of organic matter was applied in soil was investigated the result of potassium % in wheat is given in (Figure.11). The analysis of variance illustrated significant ($P<0.05$) effect of different source of organic matter on potassium % in wheat. In the control treatment (Ct) without organic matter, the average potassium content was 1.13%. Treatments involving organic matter exhibited distinct differences in potassium content. T_2 5 kg soil + 100 g pot^{-1} Poultry Waste (PW) treatment displayed the highest average potassium content at 1.91%, indicating a significant contribution from poultry waste. Following closely, T_1 5 kg soil + 150 g pot^{-1} Farmyard Manure (FYM) treatment showed average potassium content of 1.58%, suggesting a notable input of potassium from farmyard manure. T_3 5 kg soil + 100 g pot^{-1} Plant Residues (PR) treatment resulted in a slightly lower average potassium content of 1.32%.

DISCUSSION

Laboratory incubation experiment on impact of various organic residues on phosphorus (P) fractions and available P in soil. The results unveiled that the mean Al–P content in soil exhibited an increase with higher levels of P application. However, as the levels of organic residue increased during the incubation period, the mean Al–P content decreased. Additionally, there was a significant interaction observed between added P and organic residue, influencing the Al–P content in the soil. Furthermore, the data indicated a notable increase in Al–P contents in soil with an increasing time interval from 6 to 12 months. These findings underscore the dynamic nature of P fractions in soil and the intricate interplay between P application, organic residues, and incubation time, highlighting the complexities involved in soil P dynamics under varying environmental conditions (Dotaniya and Datta, 2014). Similar effect of organic matter were observed in the current research.

The study examined that the P status and distribution across various parts of wheat (*Triticum aestivum*) plants, alongside the root and shoot growth response in a split-root soil culture, The findings unveiled substantial enhancements in growth parameters, with plant biomass soaring by up to 80% compared to the control P application. Concurrently, P uptake by wheat seedlings surged by over 8 times in comparison to the control. However, no notable varietal discrepancies emerged across growth and P uptake metrics in wheat seedlings. Furthermore, heightened P concentrations in the shoot facilitated increased shoot unloading of P and P assimilation in control roots, consequently elevating P concentrations in wheat plant roots, indicative of P translocation within the roots. These results underscored the efficacy of added soluble P in augmenting nutrient absorption under acidic soil conditions. (Shabnam et al., 2018) similar results observed in this study.

the crucial role of phosphorus as a key nutrient essential for various stages of crop growth, including root initiation, elongation, dispersion, nodulation, and nitrogen fixation. The absence of sufficient phosphorus can severely limit plant growth, productivity, and seed setting. To address this limitation, the application of organic, along with beneficial microbes, has been found to enhance phosphorus availability in the soil and promote its uptake in plants. The integration of organic, inorganic, and microbial fertilizers is believed to replenish soil nutrients, prevent soil decline and degradation, sustain soil functions, and increase nutrient availability. Imran's findings confirmed the significant impact of organic sources such as biochar, compost, and residues on phosphate reactivity in soil. Moreover, the extensive use of organic matter in combination with chemical and biological fertilizers has been shown to improve grain yield, as well as the chemical quality of both plants and soil. This integrated approach not only enhances agricultural productivity but also optimizes economic returns for farmers (Olsen, 1954). The application of organic, along with beneficial microbes, has been found to enhance phosphorus availability in the soil and promote its uptake in crop observed similarly in the research.

Field experiment findings suggest that organic manure application plays a significant role in mobilizing soil P and increasing P availability. The study further indicates that soil dissolved organic matter (DOM) characteristics are influenced by manure application, thereby facilitating soil P availability. These insights provide valuable evidence for guiding sustainable phosphorus management and manure application strategies in agro ecosystems. By leveraging the benefits of organic manure in conjunction with chemical fertilization, farmers can optimize P utilization, maintain soil fertility, and ensure sustainable crop production over the long term (Li et al., 2022) similar with current findings.

Keeping in view the challenge of lower wheat productivity in calcareous soils research was conducted and findings revealed that among the organic sources, farmyard manure (FYM) out performed others across all tested traits. Furthermore, integrating inorganic P sources with organic manures resulted in further enhancements in crop performance and post-harvest soil P content. Based on their study results, the researchers recommended a specific strategy to ensure optimal wheat productivity in calcareous soils. They suggested incorporating 10 tons of FYM per hectare alongside single super phosphate (SSP) or 100% acidulated rock phosphate (RP) at the rate of 90 kg P_2O_5 per hectare. This integrated approach offers a promising solution to address the challenge of low wheat productivity in calcareous soils, providing practical insights for improved nutrient management practices in agricultural systems

(Ahmad et al., 2022). The inadequate nutrient management, particularly phosphorus (P) was observed as emerging issue. To address this issue, conducted the research and similar results of organic manures were observed by enhancements in crop performance.

CONCLUSION

It is concluded that among the treatments, the poultry waste amendment resulted in the highest decrease in EC, suggesting its effectiveness in availability of P. The addition of organic amendments resulted in higher levels of extractable phosphorus compared to the control, indicating improved phosphorus availability for plant uptake. Poultry waste and farmyard manure treatments particularly enhanced phosphorus availability, with poultry waste showing the highest extractable phosphorus content. All organic treatments increased soil organic matter content compared to the control. This is beneficial for enhancing soil structure, water retention, and nutrient cycling, with poultry waste again demonstrating the highest organic matter content among the treatments. This is advantageous for optimizing nutrient availability and microbial activity in the soil.

AUTHOR CONTRIBUTIONS

Allah Dina Umrani: Research conducted, draft preparation; Aurang Zaib and Muhammad Waris: Writing-review and final editing; Muhammad Sharif: Supervision, Atta Ullah, Shafiq Ur Rehman: Methodology and Project administration; Saduddin, Zaffarullah did Validation, Muhammad Saddam and Muhammad Affan:Data Curation, Software, Formal analysis

COMPETING OF INTEREST

The authors declare no competing interests.

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