# Agronomics of wheat (*Triticum aestivum* L.)) under phosphorus doses, organic amendments, and tillage practices across the years

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***Abstract-***

## Abstract

Wheat is an important cereal crop and consumed as staple food across the globe. Stagnant yield of wheat is major challenge to fulfil human requirements and there is a dire need to pragmatic solution. Hence the experiment was performed to enhance grain yield, phosphorus use efficiency, benefit cost ratio and net returns. A two-year study (2017-18 & 2018-19) was arranged under three factors i.e., tillage practices (shallow 15 cm & deep 30 cm), organic manures (poultry manure, green manure, mung bean residues & sugarcane residues) and phosphorus regimes (0, 60, 90 & 120 kg ha$^{-1}$). Experiment was executed under randomized complete block design with split pot arrangement and replicated thrice. Data collection regarding grains per spike, grain yield, phosphorus content in soil, grain and straw, phosphorus use efficiency, benefit cost ratio and net returns were assessed. Results of this study exposed that the maximum grain yield (3614 kg ha$^{-1}$), benefit cost ratio (BCR) (3.24) and net returns (168067 PKR) obtained under deep tillage practices during both years. Poultry manure had produced the highest grain yield (3664 kg ha$^{-1}$), BCR (3.24) and net return (171629 PKR) followed by cattle manure. Phosphorus (P) application @90 kg P ha$^{-1}$ produced the highest grain yield (4068 kg ha$^{-1}$) 60 kg P ha$^{-1}$ enhanced BCR and phosphorus use efficiency (PUE), followed by 90 kg P ha$^{-1}$. From the results it was concluded that most of the agronomic and quality parameters of wheat were higher with integrated use of 120 kg P ha$^{-1}$ and poultry manure under deep tillage system. Therefore, it is recommended that application of 120 kg P ha$^{-1}$ along with poultry manure and deep tillage system could increase wheat productivity and profitability under semi-arid climate of Peshawar.

**Keywords:** benefit cost ratio, net return, phosphorus use efficiency, wheat, yield

## I. INTRODUCTION

Wheat is one of the most important food crops in the world, providing approximately 20% of the calories consumed by humans globally. Wheat is grown on over 225 million hectares of land in more than 100 countries, making it the second most widely grown crop after maize. Over the past few decades, improvements in agronomic practices, including the use of high-yielding varieties, have contributed to an increase in wheat yields. As a result, the global average yield of wheat has increased from 2.5 tonnes per hectare in the 1960s to around 3.5 tonnes per hectare in recent years. This has helped to meet the growing demand for wheat, which is expected to continue to increase as the global population grows.

Despite the increase in yield, however, the total area of land under wheat cultivation has remained relatively stable over the past two decades. This is due in part to the limited availability of arable land and water resources, as well as competition from other crops. The global wheat trade is estimated to be worth around US $50 billion, with the largest exporters being the United States, Canada, Australia, Russia, and Ukraine. Wheat is consumed in approximately 89 countries around the world, with the largest consumers being China, India, and the European Union. (Kiss, 2011). Furthermore, although wheat accounts for more than 36.3 percent of Pakistan's total cultivated land, this is still below the average proportion of wheat cultivation in other developing countries Manzoor et al. (2013) and adequate and balanced supply of nutrients is crucial for maximizing the production of wheat crops. A crucial factor in enhancing the productivity of wheat crops is ensuring that they have access to an appropriate quantity and balance of nutrients (Jamal et al., 2018, Amanullah, 2019). However, right amount and amount of nutrients for wheat crops is very important for them to grow at their best Tariq et al. (2017). Soil with a lot of calcium makes it hard for the P ions in wheat to fall apart and get stuck together, which makes it hard for wheat to get the nutrients it needs.

Phosphate compounds that provide a lot of energy for plant biochemical reactions include adenosine triphosphate (ATP) and adenosine diphosphate (ADP). Nucleic acid (DNA, RNA), nucleotides, phospholipids (lipids), and phosphoproteins are all parts of living things that are not possible without P. Pakistan's soils are alkaline in reaction and calcareous in nature, so when chemical P fertilizers are added to the soil, it quickly adsorbs a lot of P. This P isn't available to plants because the soils quickly adsorption (Jamal et al., 2018). Ahmad and Jalil (1992) reported that majority of soils in Pakistan (approximately 93%) are deficient in available P due to their calcareous nature, which is characterized by a lack of parent material containing P minerals. Additionally, soils with less than 10 mg $P_2O_5$ $kg^{-1}$ tend to have limited availability of P.

The lower plant availability of applied P, as well as low levels of P fertilizer use due to rising prices (Ahmad et al., 1992; Amalluah et al., 2018) make it necessary to come up with new ways to increase the efficiency of P use in agriculture. Many ways have been suggested to make sure plants use as much P as possible (Alam et al., 2005; Amanullah et al., 2019, Kosar et al., 2003, Hinsinger, 1998). The practice of tillage can have an impact on both the chemical and physical properties of soil, as well as the breakdown and availability of organic matter (OM). This is due to the fact that tillage stimulates microbial and enzymatic activity within the soil, which can facilitate the decomposition of OM and improve the uptake of nutrients by plants (Redel et al., 2011). Maize growth and productivity can be enhanced by implementing deep ploughing practices and applying phosphorus (P), which can promote faster growth and the development of components that contribute to its overall productivity (Jan et al., 2016).

Organic manure plays a crucial role in both soil and crop productivity by serving a variety of functions within the agroecosystem (Weil and Magdoff, 2004). In general, the use of organic inputs can have a positive impact on the health of the agri-environment (Defra, 2002). The proper management and storage of organic waste is a critical challenge that must be addressed in organic farming (Petricet al., 2009). Poultry manure (PM) is a low-cost source of macro-nutrients (N, P, K, Ca, Mg, S) and micro-nutrients (Zn, Cu, Fe, Mn, B) that can boost soil C and N content, porosity, and microbial activity. Poultry manure is an economical source of both macro-nutrients (N, P, K, Ca, Mg, S) and micro-nutrients (Zn, Cu, Fe, Mn, B) that can significantly enhance the content of soil C and N, as well as promote porosity and microbial activity (Ghosh et al., 2004). Poultry dung can be used as an organic amendment to help soils that have become nutrient-depleted recover (Sanchez- Monedero et al., 2004). Böhme and Böhme (2006) found that adding organic manures to the soil over time improves physical and chemical conditions by creating a more favorable soil structure, increasing soil cation exchange capacity, increasing nutrients available and providing a substrate for microbial activity.

Despite the potential for animal manures and crop residues to significantly increase crop output with their high levels of nitrogen, phosphorus, potassium, and other nutrients, their utilization is often limited due to inadequate storage and application techniques (Fageria, 2009). The use of manure can provide long-term benefits to crop productivity and soil quality, although nutrient release can be a slow and gradual process in many cases. Manure can be a viable alternative to chemical fertilizers, as it can deliver yields that are comparable to, or even better than, those obtained from inorganic fertilizers. Taking all of the aforementioned factors into consideration, this study focused on the effects of phosphorus doses, organic amendments, and tillage techniques on wheat yield and yield components, with a particular emphasis on phosphorus use efficiency.

## MATERIALS AND METHODS

### Material and methods

Two years i.e. 2017-18 and 2018-19 was executed at Agronomy Research Farm University of Agriculture Peshawar (34027'12.46" N and 71027'56.4"). Field study was arranged by employing three factors i. Tillage methods (shallow 15 cm & deep 30 cm), ii. Organic manures (poultry manure, green manure, mungbean residues & sugarcane residues) iii. phosphorus regimes (0, 60, 90 & 120 kg ha$^{-1}$). Experiment was laid out under randomized complete block design having split plot arrangement by keeping three replications. Tillage treatments were kept in main plot whereas, organic manures and phosphorus regimes were allocated in sub plots. Field preparation for shallow (15 cm) and deep tillage (30 cm) was done through rotavator and mold bold plough respectively. Sowing was done having net plot size 3m x 5m with 10 rows and 140 kg nitrogen ha$^{-1}$ was applied in three equal splits. Before 30 days of planting subjected organic manures were incorporated into the soil. The concentration of NPK in organic manures is given in Table 1. Soil sampling was done using standard procedure and soil analysis report given in Table.2. Moreover, weather traits were noted during both years field experimentation (Figure 1).

### Traits measurement

Data regarding yield and yield components were collected using standard procedures. Moreover, benefit cost ratio and net returns were also studied as well as phosphorus determination in grains and phosphorus use efficiency was assessed using proposed procedures. Phosphorus in soil before and after wheat crop and in wheat plant (grains and straw) at physiological maturity stage in each-treatment was determine according to the standard procedures used by Soltanpour (1985). Moreover, phosphorus agronomic use efficiency (the ratio of the increase in grain yield over P-control plots to the applied rate of P) was determine according to Amanullah (2012). In addition, benefit cost ratio was found according to Amanullah et al. (2010). Divide the present value of benefits by the present value of costs is called benefit cost ratio. Net returns (value of the increased yield produce as a result of P-fertilizer application with comparison of plots receiving zero P) was determine according to the procedures described by Amanullah et al. (2010).

### Statistical Analysis

Collected of studied trial was analyzed through analysis of variance (Gomez and Gomez, 1984) by using MSTATC statistical software. Treatment means comparison were differentiated by employing LSD test at $P \leq 0.05$ (Jan et al., 2009).

### Results

### Plant height (cm)

Year, tillage depth, organic sources and P levels had imposed a significant impact on plant height (cm) (Table 3). All interactive effects were found significant ($P \leq 0.05$) except, T x OM, Y x T and Y x P x OM. Interactive effect of all factors showed that the highest (106 cm) plant length was measured under shallow tillage by employing 90 kg ha$^{-1}$ phosphorus (P) along with cattle manure followed by poultry manure and the shortest length (86 cm) was recorded under 0 kg ha$^{-1}$ P by using sugarcane residues (Fig. 2). Moreover, deep tillage practices had significantly increased plant length (109 cm) under poultry manure along with 120 kg ha$^{-1}$ P that is resulted similar length by using 90 kg ha$^{-1}$ whereas, the least plant length (91 cm) with sugarcane residues application (Fig. 2).

### No. of grains spike$^{-1}$

A significant variation was observed in grains spike$^{-1}$ as affected by year, tillage depth, organic manures and different phosphorus regimes (Table 4), while all the interactions were found not significant except T x P. Deep tillage produced more grains spike$^{-1}$(39) than shallow tillage (37). Mean data of organic manure revealed that poultry manure application produced higher grain spike$^{-1}$(39), followed by cattle manure (38) and the lowest No. of grains spike was counted in sugarcane residues (37). Moreover, P application at the rate of 120 kg ha$^{-1}$produced maximum grains spike$^{-1}$ (40) while the lowest grains spike$^{-1}$(34) was recorded in control. Additionally, higher grains pike$^{-1}$ were counted in $Y_2$ (39) than in $Y_1$ (37). Interactive effect of T x P showed that increasing rate of P up to 90 kg ha$^{-1}$ enhanced number of grains spike$^{-1}$ under deep tillage as compared to shallow tillage (Fig. 3).

### Grain yield (kg ha$^{-1}$)

Grain yield (GY) was significantly ($P \leq 0.05$) affected by year, tillage depth, organic manures and P regimes (Table 5). Interactions P x OM, Y x P, Y x T x P and Y x P x OM were found significant. Deep tillage produced significantly higher GY as compared to shallow tillage. Among organic manure, poultry manure application considerably enhanced GY (3664 kg ha$^{-1}$) followed by cattle manure (3594 kg ha$^{-1}$) and the lowest GY (3492 kg ha$^{-1}$) was achieved by incorporation of mungbean residues. P application of 120 kg ha$^{-1}$produced the maximum GY (3928 kg ha$^{-1}$) followed by 90 kg ha$^{-1}$ (3785 kg ha$^{-1}$) and 60 kg ha$^{-1}$ (3785 kg ha$^{-1}$) while the minimum GY was gathered in control (2658 kg ha$^{-1}$). Higher GY was recorded in year 2 ($Y_2$) as compared to year 1 ($Y_1$). Increasing P rate up to 60 kg ha$^{-1}$enhanced GY of wheat under all organic manures, however further increase in P rate had not significantly increased GY (Fig. 4). 90 kg P ha$^{-1}$ along with poultry manure increased GY in $Y_2$ as compared to $Y_1$.

### Phosphorus contents in grains (mg kg$^{-1}$)

Phosphorus grains P content was significantly ($P \leq 0.05$) influenced by tillage depth, organic manures and P regimes. Deep tillage significantly increased P grain content as compared to shallow tillage (Table 6). Among organic manures, poultry manure significantly increased P content (0.352 mg kg$^{-1}$), followed by cattle manure (0.333 mg kg$^{-1}$) while lower P content (0.314 mg kg$^{-1}$) was determined by using sugarcane residues. P content was significantly enhanced by increase P rate and the maximum P content (0.366 mg kg$^{-1}$) was recorded under 120 kg P ha$^{-1}$, followed by 90 kg P ha$^{-1}$ (0.362), while the minimum P content was found in control treatment (0.276 mg kg$^{-1}$). However, year effect was significantly contributed to P content during $Y_2$ as compared to $Y_1$. Among interactions, T x P, P x OS, T x P x OS, Y x P, Y x T x OS and Y x T x P content as assessed significant. P content was increased with an increase in the rate of P up to 90 kg ha$^{-1}$under both tillage depths (Fig. 5). OM x P interaction showed that increasing P rate improved P content up to 90 kg ha$^{-1}$ along by using poultry manure and further increase had not significantly increased P content in grains (Fig. 6). P application up to 90 kg P ha$^{-1}$ increased P grain content by growing wheat under deep tillage during both years study.

### Phosphorus content in straw (mg kg$^{-1}$)

P concentration in straw was considerably influenced by year, tillage depth, organic manures, and P regimes (Table 7). Interactive effect of T x P x OM, Y x T x P, Y x P x OM, Y x P, T x P, and P x OM were shown significant ($P \leq 0.05$). Deep tillage considerably increases P content in straw (0.152 mg kg$^{-1}$) as compared to shallow tillage (0.149 mg kg$^{-1}$). Higher P content (0.160 mg kg$^{-1}$) was assessed under poultry manure, followed by cattle manure (0.152 mg kg$^{-1}$), and lower content (0.146 mg kg$^{-1}$) was reported by using Mungbean residues. In terms of P rates, the highest P content (0.188 mg kg$^{-1}$) was obtained at 120 kg P ha$^{-1}$ and the lowest content was determined in control (0.091 mg kg$^{-1}$). Furthermore, P content of straw was higher in $Y_2$ than $Y_1$. Straw P content significantly increased P up to 120 kg $ha^{-1}$. Increasing rate of P that linearly improved straw P content by using poultry manure under a deep tillage (Fig. 7). Straw P contents increases linearly increased by increasing P rate under both tillage depths (Fig. 8).

### Soil P contents (mg $ha^{-1}$)

Soil P content was significantly affected by year, tillage depth, organic manures and P regimes (Table 8). Interactive effect of Y x T, Y x OM, T x P, Y x P, Y x T x P and Y x P x OM were shown significant ($P \leq 0.05$). Deep tillage enhanced soil P content (4.68 mg $kg^{-1}$) as compared to shallow tillage (4.51 mg $kg^{-1}$). Among organic manure, poultry manure significantly enhanced soil P contents (4.70 mg $kg^{-1}$), followed by cattle manure (4.57 mg $kg^{-1}$) while the lowest soil P content (4.52 mg $kg^{-1}$) was determined with sugarcane residues. In case of P regimes, soil P content was increased with increasing P rate from 0 to 120 kg P $ha^{-1}$, and the maximum soil P contents (4.96 mg $kg^{-1}$) were recorded at 120 kg $ha^{-1}$ followed by 90 (4.90 mg $kg^{-1}$) while the minimum grain P content was recorded in control (3.97 mg $kg^{-1}$). Moreover, soil P contents were increased with an increase in P levels under a deep tillage (Fig. 9).

### P use efficiency (PUE)

Data concerning PUE of wheat as affected by year, tillage depth, organic manures and P regimes (Table 9). Interactive effects i.e. T x OM, T x P, P x OM, P x T x OM, Y x P, Y x T x P and Y x P x OM were found significant ($P \leq 0.05$). Effect of tillage depth was found non-significant, however under shallow tillage depth higher PUE (17.3 %) was recorded. The maximum PUE was observed in poultry manure (18.7%) and the minimum PUE (17.5%) was recorded each in sugarcane and mungbean residues. Moreover, the maximum PUE (18.7%) was obtained when 60 kg $ha^{-1}$ P was applied followed by 90 kg $ha^{-1}$ and the minimum (15.5%) PUE was recorded 120 kg P $ha^{-1}$. Interactive effect of P x OM the PUE was calculated at 60 kg P $ha^{-1}$ and the value was found under sugarcane residues by employing 120 kg P $ha^{-1}$ (Fig 10). Interaction effect of T x P revealed that at 60 kg P $ha^{-1}$ shallow tillage had the highest PUE and the least efficiency was recorded at 120 kg P $ha^{-1}$ by employing deep tillage (Fig. 11). In addition, interactive effect of T x OM the highest PUE was determined under poultry manure be keeping shallow tillage and the least value reflected under sugarcane residues by deep tillage practice (Fig. 12).

### Benefit cost ratio

Benefits cost ratio was significantly affected by year, tillage depth, organic manures and P regimes (Table 10). Interactive effects T x P, P x OM, Y x P and Y x T x P were resulted significant ($P \leq 0.05$). The findings showed that deep tillage (3.24) was cheaper than shallow tillage (3.12). 60 kg P $ha^{-1}$ application was the most economical (3.31), followed by 90 kg P $ha^{-1}$ (3.19), but increasing the P rate decreased the BCR. $Y_2$ also had a greater BCR than $Y_1$. Interactive effect of P x T the deep tillage had the highest BCR by employing 60 kg P $ha^{-1}$ and the least BCR was calculated under shallow tillage where no phosphorus was used (Fig. 13). The interaction of OM x P revealed that at 60 kg P $ha^{-1}$ under poultry manure had the highest BCR whereas, the least BCR was assured under 120 kg P $ha^{-1}$ by using sugarcane residues (Fig. 14).

### Net return (PKR)

The data showed that tillage depth, organic manures, P regimes and year significantly influenced net return of wheat and interactive effects T x P, P x OM, Y x P and Y x T x P were resulted significant ($P \leq 0.05$). Deep tillage had the highest net return (PKR 168067) as compared to shallow tillage (PKR 162447). For organic manures, poultry manure, cattle manure, mungbean residues and sugarcane residues had achieved net returns of (PKR 171629), (PKR 166348), (PKR 161857) and (PKR 161194) respectively. However, P regimes had the highest net return (PKR 174468) at 90 kg P ha$^{-1}$, whereas the lowest (PKR 139655) was recorded at control. Moreover, 2018-19 had the highest net return than 2017-18. Interactive effect of P x T the maximum net return was achieved at 90 kg P ha$^{-1}$ by employing deep tillage and the net return was earned under no application of P (Fig. 15). Moreover, OM x T showed that the highest net returns was attained under poultry manure with deep tillage operation and the least return was got from sugarcane residues by performing shallow tillage practice (Fig. 16).

## Discussion

Increased tillage depth was observed to result in taller plants than shallow tillage depth. This could be attributed to the benefits of proper tillage depth, which can improve soil structure and increase aggregate decomposition and disintegration. These improvements enhance soil and root contact, leading to increased nutrient availability and ultimately promoting plant growth. Our findings are consistent with those of He et al. (2019), who found that plants that were cultivated using a deep tillage system were observed to have a greater height than those grown in a shallow tillage system. The findings are consistent with Kaur et al. (2016), who reported that the use of deep tillage was found to result in taller plants compared to shallow tillage, and when organic manures were applied, poultry manure resulted in the highest plant height. This increase in plant growth can be attributed to the readily available nutrients in poultry manure, which is in contrast to the slow release of nutrients from crop wastes Tahir et al. (2011) and Sarwar et al. (2007) reported similar results, claiming that application of poultry manure resulted in a 10% increase in plant height, indicating its positive impact on plant growth. Furthermore, the use of poultry manure also contributed to an increase in plant height according to Iqtidar et al. (2006). According to Gowda et al., 2010, poultry manure applied at a rate of 2.45 t ha$^{-1}$ resulted in significantly greater plant height (86.30 cm). Wheat crop plant height grew linearly as P was increased from 0 kg ha$^{-1}$ to 120 kg ha$^{-1}$. It could be due to the use of P, which improves early growth, root development, and response to mineral fertilizer application, allowing more nutrients and water to be absorbed, speeding up cell division and development and increasing plant height (Kursat et al., 2010). Amanullah et al. (2015) found similar results, claiming that applying greater P levels (120 and 160 kg ha1) boosted plant height.

Deep tillage resulted in a higher number of grains per spike than shallow tillage. This suggests that deep tillage is beneficial for soil management and improves the physical qualities of the soil, as compared to shallow tillage (Ali et al., 2018). According to Khan et al. (2010), maize cultivation with deep tillage resulted in a higher grain yield compared to maize grown with shallow tillage. This is likely due to the fact that deep tillage loosens the top layer of subsoil, which promotes the growth of a deeper and wider root system that can collect water and nutrients from deeper soil layers, as well as increase soil volume (Sen, 2003).

The organic sources showed different effects on the number of grain spikes produced. Poultry manure resulted in the highest number of grain spikes per plant, followed by cattle manure, while mungbean residues resulted in the lowest number of grain spikes. The increase in grain weight may be attributed to the nutrients provided by poultry manure, such as nitrogen, phosphorus, and potassium, which improved soil physical qualities, especially in dense clay soils, resulting in more grain production (Jan et al., 2018). Because poultry excrement is an excellent source of plant macronutrients, wheat yield components increased (Khaliq et al., 2011). The application of phosphorus at rates of 90 and 120 kg ha$^{-1}$ resulted in a significant increase in the number of grains per spike. This could be attributed to the improved development of the root system as a result of phosphorus application, as well as the increased uptake of water and nutrients that are easily transported to the developing sink. Our findings are supported by Kaleem et al. (2009), who reported that phosphorus application significantly improved the number of grains per spike.

Deep tillage was found to significantly increase wheat grain yield compared to shallow tillage, which may be attributed to the loosening of the upper layer of the subsoil that allows for deeper and wider root system development. This enables the roots to collect more water and nutrients from deeper soil layers and a larger soil volume, ultimately enhancing wheat growth and photosynthetic efficiency (Sen, 2003). The results are in agreement with the findings of Ali et al. (2012), who observed a significant increase in plant weight and grain yield with deep tillage. Similarly, Khan et al. (2010) reported that deep tillage resulted in higher grain yield in maize compared to standard or zero tillage practices.

Compared to other organic sources, the use of poultry manure resulted in a substantial increase in grain yield. According to Jan et al. (2018), poultry manure has been found to have high nutritional value for crop production in comparison to farmyard manure and other research studies. Our results are consistent with Patil and Bhilare (2000), who reported that the use of poultry manure led to an increase in wheat grain yield. This increase in yield may be attributed to the readily available nutrients, such as nitrogen, provided by poultry manure to the plants (Channabasanagowda et al., 2008). Bodruzzaman et al. (2010) found that applying poultry manure increased grain yield. It has been claimed that the effect of organic manures in increasing crop output is related to the continual mineralization of all vital nutrients (Abbas et al., 2012). Our findings were consistent with previous research, which found that poultry manures have a considerable impact on wheat crop yield (Zafar et al., 2011). Pedro et al. (2011) observed that the application of poultry manure and phosphorus resulted in a higher number of grains and increased grain weight, which led to an overall increase in wheat grain yield. Furthermore, the study found that the highest grain yield was achieved with a phosphorus application rate of 120 kg ha$^{-1}$. Our findings are consistent with Mumtaz et al., (2014), who found that applying P at a rate of 120 kg ha$^{-1}$ enhanced wheat grain production considerably. Rehim et al. (2012) found results similar to ours, indicating that increasing levels of phosphorus resulted in higher wheat grain yield compared to the control. This could be attributed to the development of a larger canopy, which could absorb and utilize more radiant energy as phosphorus levels increased, leading to increased accumulation of dry matter by crop plants. The higher uptake of phosphorus could be explained by the higher doses and content of phosphorus, which led to higher yields of both grain and straw (Mumtaz et al., 2014).

The application of organic manures, specifically poultry manure, resulted in a significant increase in the phosphorus content of both grain and straw, as well as an increase in phosphorus use efficiency (PUE) for wheat. Similarly, Aziz et al. (2010) observed a significant increase in nutritional concentrations in plant leaves when 20 t ha-1 of poultry manure was applied compared to the control. According to Ghosh et al. (2004), poultry manure has approximately one-third of the nutrients found in bovine manure. However, poultry manure can enhance microbial populations, resulting in the release of acids into the rhizosphere, which can enhance the solubility of phosphorus and improve plant availability of nutrients (Wickramatilake et al., 2010; Schefe and Tymms, 2013). The results of this study, which show that adding poultry manure to soil increased the concentrations of soil organic carbon, nitrogen, phosphorus, potassium, calcium, and magnesium, are consistent with previous studies that have found similar improvements in soil properties with the addition of poultry manure (Ali et al.,2009).

Supplying phosphorus @120 kg ha$^{-1}$ significantly increased the phosphorus content of grain and straw. Our findings also suggest that the use of phosphorus fertilizer increased the total phosphorus accumulation in wheat grain. This could be attributed to increased activity of phosphatase and wheat roots, which can improve soil phosphorus availability and wheat phosphorus uptake. (Yu et al. 2013). Phosphorus fertilizer increased both the amount of phosphorus stored and the efficiency with which phosphorus was used for grain and dry matter.

The results of this study showed that the phosphorus use efficiency increased up to a rate of 60 kg ha$^{-1}$, but then decreased as the phosphorus rate was increased further. (Zhang et al. 2008). Insufficient P availability in soil can limit wheat growth and development, while increased phosphorus availability can enhance adventitious root development, tillering, photosynthesis, and ultimately grain yield. The application of phosphorus fertilizer initially improves nitrogen and phosphorus uptake, leading to faster wheat plant growth and ultimately increasing phosphorus use efficiency (Yu et al. 2013).

## Conclusion

In conclusion, the results of this study indicate that the measured traits were significantly affected by the different treatments. Deep tillage in both years resulted in a significant increase in the number of grains per spike, grain yield, grain and straw phosphorus content, soil phosphorus content, benefit cost ratio, and net returns. Poultry manure application resulted in significantly higher grain yield, grain and straw phosphorus content, soil phosphorus content, benefit cost ratio, and net return, followed by cattle manure. However, the highest grain yield, grain P content, and soil P content were obtained with the application of 90 kg P ha$^{-1}$. Additionally, the application of 60 kg P ha-1 improved benefit cost ratio and P use efficiency, followed by 90 kg P ha$^{-1}$. Therefore, it can be concluded that the combination of deep tillage, 120 kg P ha$^{-1}$, and poultry manure application contributed significantly to the agronomic and quality parameters of wheat crop.

## APPENDIX

**Appendixes, if needed, appear before the acknowledgment.**

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| Poultry manure | | |
|---|---|---|
| Name | Value | Unit |
| N | 2.28 | % |
| P | 1.93 | % |
| K | 1.61 | % |
| Cattle manure | | |
| N | 0.84 | % |
| P | 0.37 | % |
| K | 0.59 | % |

**Table 1.** Composition of NPK of organic manures solublizing bacteria on growth, yield, protein content and P uptake in maize. *Advances in Agriculture & Botanics*, *3*(1), 46-58

| | Mungbean residues | |
|---|---|---|
| N | 0.84 | % |
| P | 0.33 | % |
| K | 1.5 | % |
| | Sugarcane residues | |
| N | 0.92 | % |
| P | 0.21 | % |
| K | 1.7 | % |

**Table 2.** Soil analysis of experimental site of 2017-18 and 2018-19

| 2017-18 | | |
|---|---|---|
| **Measurements** | **Value** | **Unit** |
| Soil Texture | Clay loam | - |
| Organic matter | 0.87 | % |
| Phosphorus | 6.24 | mg $kg^{-1}$ |
| Potassium | 121.2 | mg $kg^{-1}$ |
| pH | 8.2 | - |
| EC | 1.8 | $dSm^{-1}$ |
| 2018-19 | | |
| Soil Texture | Clay loam | - |
| Organic matter | 0.90 | % |
| Phosphorus | 6.98 | mg $kg^{-1}$ |
| Potassium | 119.3 | mg $kg^{-1}$ |
| pH | 8.0 | - |
| EC | 2.0 | $dSm^{-1}$ |

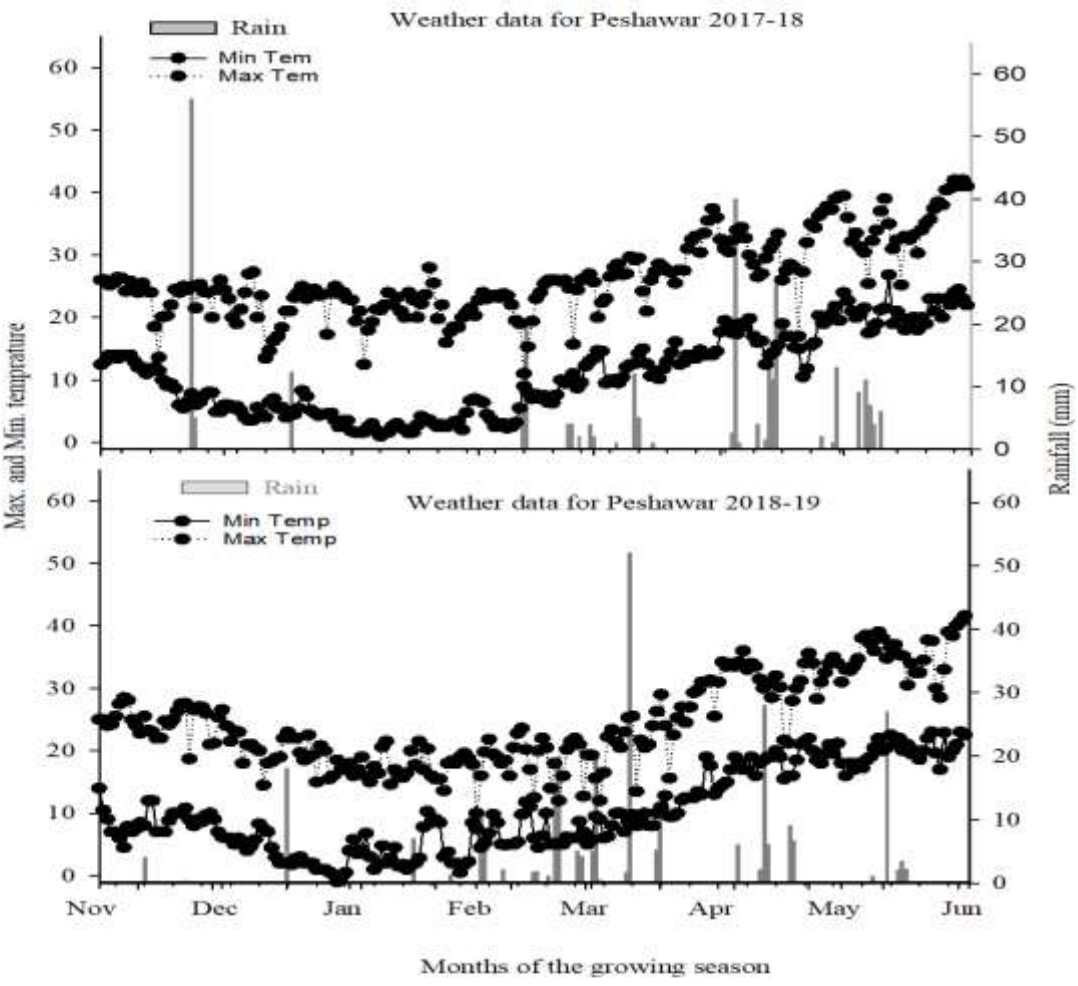

Fig. 1. Mean monthly maximum and minimum temperature and rainfall data of the experimental site during growing season 2017-18 and 2018-19.

**Table 3**. Effect of phosphorus, organic manures, and tillage depths on plant height (cm) of wheat.

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 97.1 | 99.9 | 98.5b |
| T2 (30 cm) | 100.8 | 103.1 | 101.9a |
| LSD $_{(0.05)}$ | 2.3 | 1.3 | 0.9 |
| Organic manures (OM) | | | |
| Poultry manure | 100.8 | 104.5 | 102.6a |
| Cattle manure | 99.5 | 103.6 | 101.6a |
| Mungbean residues | 98.8 | 100.6 | 99.7b |
| Sugar cane residues | 96.6 | 97.3 | 97.0c |
| LSD $_{(0.05)}$ | 1.9 | 1.9 | 1.3 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 91.2 | 98.0 | 94.6d |
| $P_1 = 60$ | 100.2 | 100.7 | 100.5c |
| $P_2 = 90$ | 101.6 | 102.7 | 102.1b |
| $P_3 = 120$ | 102.8 | 104.6 | 103.7a |
| LSD $_{(0.05)}$ | 1.9 | 1.9 | 1.3 |
| Year | | | |
| 2017-18 | | | 98.9b |
| 2018-19 | | | 101.5a |
| Significance | | | ** |
| Interaction | Significance | Interaction | Significance |
| T x OM | Ns | T x P x OM | * |
| Y x T | Ns | Y x P | ** |
| Y x OM | * | Y x T x P | ** |
| Y x T x OM | * | Y x P x OM | ns |
| T x P | * | Y x T x P x OM | ** |
| P x OM | ** | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

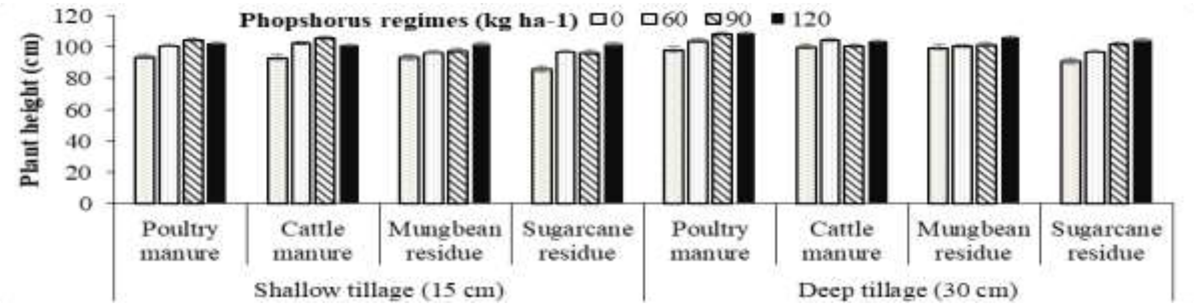

*Fig. 2. Effect of organic manures, phosphorus regimes and tillage on plant height*

**Table 4**. Effect of phosphorus, organic manures, and tillage depths on no. of grain per spike of wheat.

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 37 | 38 | 37 |
| T2 (30 cm) | 38 | 40 | 39 |
| LSD $_{(0.05)}$ | 0.7 | 0.6 | 0.4 |
| Organic manures (OM) | | | |
| Poultry manure | 38 | 40 | 39 |
| Cattle manure | 37 | 39 | 38 |
| Mungbean residues | 37 | 39 | 38 |
| Sugar cane residues | 36 | 39 | 37 |
| LSD $_{(0.05)}$ | 0.9 | 0.8 | 0.6 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 33 | 34 | 34 |
| $P_1 = 60$ | 37 | 39 | 38 |
| $P_2 = 90$ | 39 | 40 | 40 |
| $P_3 = 120$ | 39 | 42 | 40 |
| LSD $_{(0.05)}$ | 1.6 | 0.8 | 0.9 |
| Year | | | |
| 2017-18 | | | 37 |
| 2018-19 | | | 39 |
| Significance | | | ** |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OS | ns |
| Y x T | ns | Y x P | ns |
| Y x OM | ns | Y x T x P | ns |
| Y x T x OM | ns | Y x P x OS | ns |
| T x P | * | Y x T x P x OS | ns |
| P x OM | ns | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively.

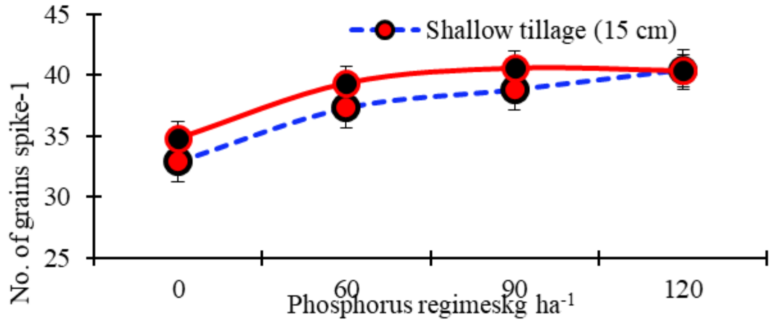

*Fig. 3.* Interactive effect of tillage depths and phosphorus regimes on *grains spike$^{-1}$*

Table 5. Effect of phosphorus, organic manures, and tillage depths on grain yield (kg $ha^{-1}$).

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 3419 | 3610 | 3515 b |
| T2 (30 cm) | 3552 | 3675 | 3614 a |
| LSD $_{(0.05)}$ | 48 | 48 | 34 |
| Organic manures (OM) | | | |
| Poultry manure | 3593 | 3735 | 3664 a |
| Cattle manure | 3503 | 3686 | 3594 b |
| Mungbean residues | 3445 | 3539 | 3492 c |
| Sugar cane residues | 3403 | 3611 | 3507 c |
| LSD $_{(0.05)}$ | 76 | 68 | 48 |
| P regimes (kg $ha^{-1}$) | | | |
| $P_0 = 0$ | 2700 | 2617 | 2658 d |
| $P_1 = 60$ | 3747 | 3824 | 3785 c |
| $P_2 = 90$ | 3702 | 4068 | 3885 b |
| $P_3 = 120$ | 3794 | 4063 | 3928 a |
| LSD $_{(0.05)}$ | 77 | 50 | 45 |
| Year | | | |
| 2017-18 | | | 3486 b |
| 2018-19 | | | 3643 a |
| Significance | | | ** |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OS | Ns |
| Y x T | ns | Y x P | ** |
| Y x OM | ns | Y x T x P | * |
| Y x T x OM | ns | Y x P x OS | ** |
| T x P | ns | Y x T x P x OS | Ns |
| P x OM | ** | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

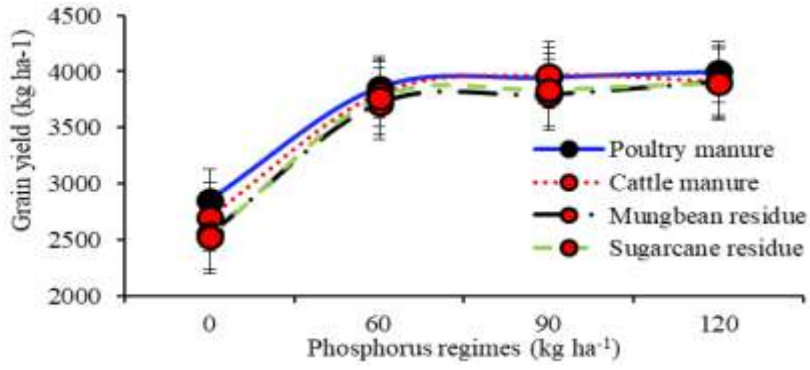

Fig. 4. Interactive effect of organic manures and phosphorus regimes on grain yield.

Table 6. Effect of phosphorus, organic manures, and tillage depths on phosphorus content in grains.

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 0.324 | 0.327 | 0.325 b |
| T2 (30 cm) | 0.332 | 0.340 | 0.336 a |
| LSD $_{(0.05)}$ | 0.004 | 0.004 | 0.002 |
| Organic manures (OM) | | | |
| Poultry manure | 0.347 | 0.356 | 0.352 a |
| Cattle manure | 0.331 | 0.336 | 0.333 b |
| Mungbean residues | 0.321 | 0.326 | 0.323 c |
| Sugar cane residues | 0.312 | 0.316 | 0.314 d |
| LSD $_{(0.05)}$ | 0.005 | 0.005 | 0.003 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 0.274 | 0.279 | 0.276 d |
| $P_1 = 60$ | 0.315 | 0.320 | 0.318 c |
| $P_2 = 90$ | 0.353 | 0.371 | 0.362 b |
| $P_3 = 120$ | 0.368 | 0.364 | 0.366 a |
| LSD $_{(0.05)}$ | 0.004 | 0.004 | 0.003 |
| Year | | | |
| 2017-18 | | | 0.328 b |
| 2018-19 | | | 0.333 a |
| Significance | | | * |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OM | ** |
| Y x T | ns | Y x P | ** |
| Y x OM | ns | Y x T x P | ** |
| Y x T x OM | * | Y x P x OM | Ns |
| T x P | ** | Y x T x P x OM | Ns |
| P x OM | ** | | |

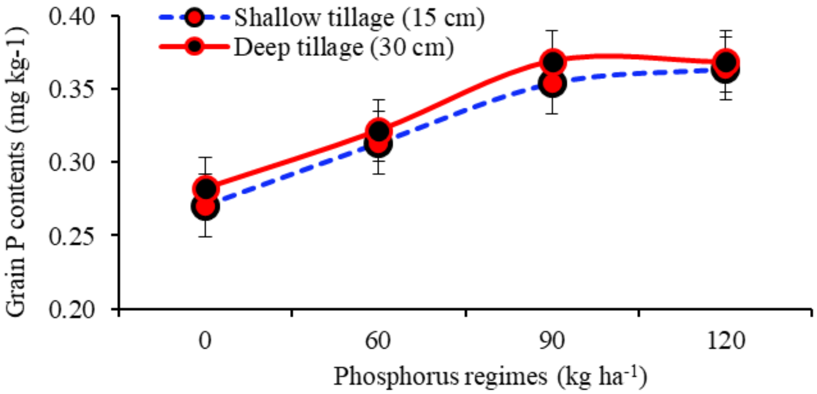

Fig. 5. Interactive effect of tillage depths and phosphorus regimes on grain P contents.

Table 7. Effect of phosphorus, organic manures, and tillage depths on phosphorus content in straw.

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 0.149 | 0.150 | 0.149 b |
| T2 (30 cm) | 0.150 | 0.153 | 0.152 a |
| LSD $_{(0.05)}$ | ns | 0.003 | 0.002 |
| Organic manures (OM) | | | |
| Poultry manure | 0.160 | 0.160 | 0.160 a |
| Cattle manure | 0.151 | 0.153 | 0.152 b |
| Mungbean residues | 0.144 | 0.149 | 0.146 c |
| Sugar cane residues | 0.144 | 0.144 | 0.144 c |
| LSD $_{(0.05)}$ | 0.002 | 0.005 | 0.003 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 0.088 | 0.094 | 0.091 d |
| $P_1 = 60$ | 0.151 | 0.151 | 0.151 c |
| $P_2 = 90$ | 0.175 | 0.168 | 0.171 b |
| $P_3 = 120$ | 0.184 | 0.193 | 0.188 a |
| LSD $_{(0.05)}$ | 0.003 | 0.003 | 0.002 |
| Year | | | |
| 2017-18 | | | 0.149 b |
| 2018-19 | | | 0.151 a |
| Significance | | | * |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OS | ** |
| Y x T | ns | Y x P | ** |
| Y x OM | ns | Y x T x P | ** |
| Y x T x OM | ns | Y x P x OS | * |
| T x P | ** | Y x T x P x OS | ns |
| P x OM | ** | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

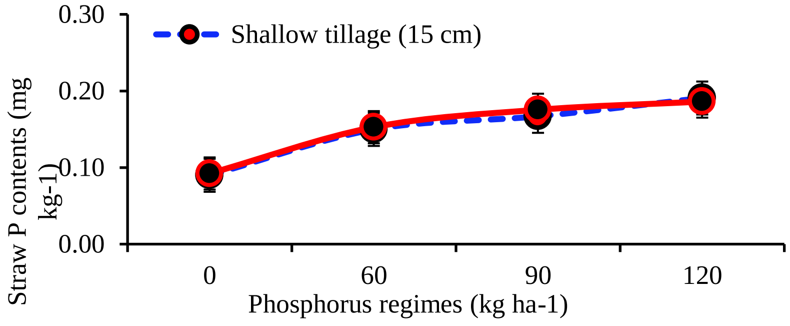

Fig. 7. Interactive effect of organic manures and phosphorus regimes on straw P contents

Table 8. Effect of phosphorus, organic manures, and tillage depths on phosphorus content in soil

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 4.45 | 4.57 | 4.51 a |
| T2 (30 cm) | 4.58 | 4.77 | 4.68 b |
| LSD $_{(0.05)}$ | 0.03 | 0.03 | 0.02 |
| Organic manures (OM) | | | |
| Poultry manure | 4.63 | 4.78 | 4.70 a |
| Cattle manure | 4.52 | 4.62 | 4.57 b |
| Mungbean residues | 4.46 | 4.68 | 4.57 b |
| Sugar cane residues | 4.43 | 4.61 | 4.52 c |
| LSD $_{(0.05)}$ | 0.06 | 0.04 | 0.03 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 3.89 | 4.05 | 3.97 d |
| $P_1 = 60$ | 4.47 | 4.59 | 4.53 c |
| $P_2 = 90$ | 4.70 | 5.09 | 4.90 b |
| $P_3 = 120$ | 4.98 | 4.95 | 4.96 a |
| LSD $_{(0.05)}$ | 0.05 | 0.05 | 0.04 |
| Year | | | |
| 2017-18 | | | 4.51 b |
| 2018-19 | | | 4.67 a |
| Significance | | | ** |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OM | Ns |
| Y x T | ** | Y x P | ** |
| Y x OM | * | Y x T x P | ** |
| Y x T x OM | ns | Y x P x OM | ** |
| T x P | ** | Y x T x P x OM | Ns |
| P x OM | ns | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

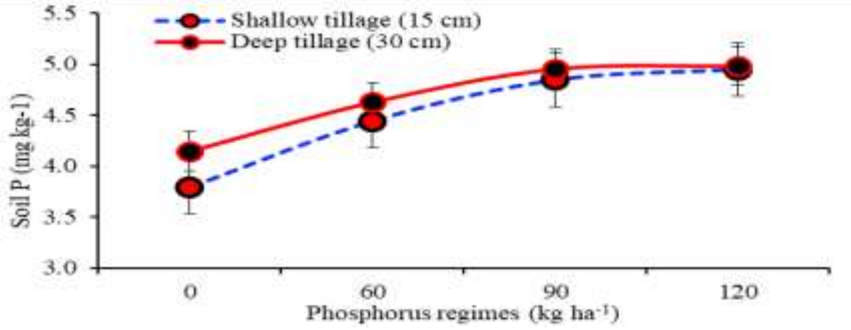

Fig. 9. Interactive effect of tillage depths and phosphorus regimes on soil P contents

Table 9. Effect of phosphorus, organic manures, and tillage depths on phosphorus use efficiency

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 17.0 | 17.5 | 17.3 |
| T2 (30 cm) | 17.0 | 17.0 | 17.0 |
| LSD $_{(0.05)}$ | ns | ns | Ns |
| Organic manures (OM) | | | |
| Poultry manure | 17.9 | 18.4 | 18.1 a |
| Cattle manure | 17.2 | 18.0 | 17.6 a |
| Mungbean residues | 16.9 | 16.4 | 16.6 c |
| Sugar cane residues | 16.1 | 16.3 | 16.2 c |
| LSD $_{(0.05)}$ | 0.8 | 0.5 | 0.7 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 18.8 | 18.5 | 18.7 a |
| $P_1 = 60$ | 17.0 | 17.5 | 17.2 b |
| $P_2 = 90$ | 15.2 | 15.8 | 15.5 c |
| $P_3 = 120$ | 0.6 | 0.4 | 0.4 |
| LSD $_{(0.05)}$ | | | |
| Year | | | 12.8 |
| 2017-18 | | | 13.0 |
| 2018-19 | | | NS |
| Significance | Significance | Interaction | Significance |
| Interaction | ** | T x P x OS | * |
| T x OM | ns | Y x P | * |
| Y x T | ns | Y x T x P | ** |
| Y x OM | ns | Y x P x OS | ** |
| Y x T x OM | ** | Y x T x P x OS | Ns |
| T x P | * | | |
| P x OM | 18.8 | 18.5 | 18.7 a |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

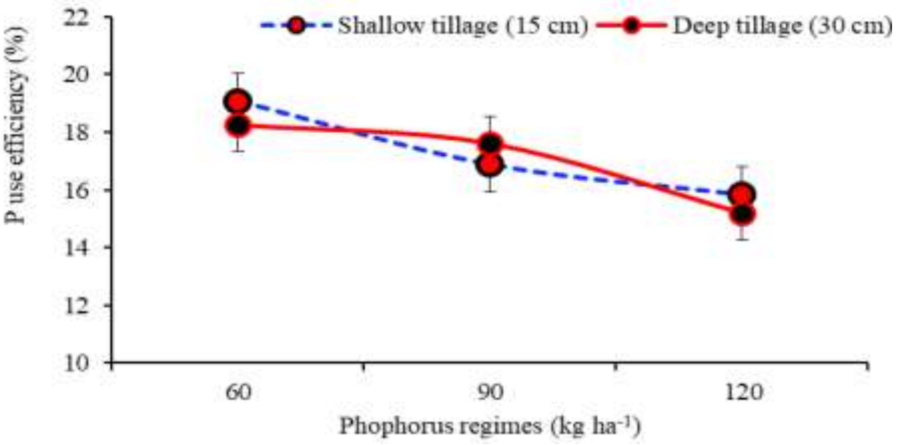

*Fig. 10. Interactive effect of organic manures and phosphorus levels on P use efficiency (%)*

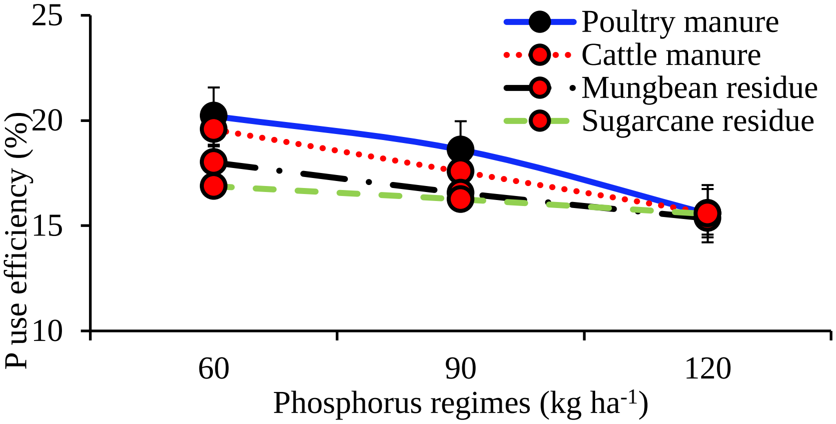

*Fig.11. Interactive effect of tillage depths and phosphorus regimes on P use efficiency (%)*

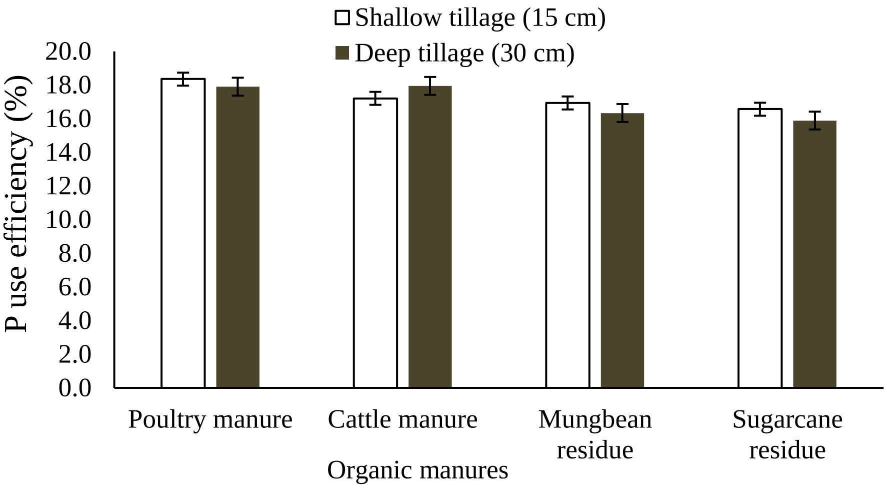

*Fig. 12. Interactive effect of organic manures and tillage depths on P use efficiency (%)*

Table 10. Effect of phosphorus, organic manures, and tillage depths on benefit cost ratio

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 3.09 | 3.14 | 3.12 b |
| T2 (30 cm) | 3.22 | 3.25 | 3.24 a |
| LSD $_{(0.05)}$ | 0.02 | 0.02 | 0.02 |
| Organic manures (OM) | | | |
| Poultry manure | 3.19 | 3.26 | 3.22 a |
| Cattle manure | 3.14 | 3.16 | 3.15 c |
| Mungbean residues | 3.16 | 3.19 | 3.18 b |
| Sugar cane residues | 3.14 | 3.19 | 3.17 bc |
| LSD $_{(0.05)}$ | NS | 0.03 | 0.03 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0$ = 0 | 3.13 | 3.16 | 3.14 c |
| $P_1$ = 60 | 3.34 | 3.31 | 3.32 a |
| $P_2$ = 90 | 3.13 | 3.25 | 3.19 b |
| $P_3$ = 120 | 3.02 | 3.08 | 3.05 d |
| LSD $_{(0.05)}$ | 0.04 | 0.03 | 0.03 |
| Year | | | |
| 2017-18 | | | 3.16 b |
| 2018-19 | | | 3.20 a |
| Significance | | | * |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | T x P x OS | Ns |
| Y x T | ns | Y x P | ** |
| Y x OM | ns | Y x T x P | * |
| Y x T x OM | ns | Y x P x OS | Ns |
| T x P | ** | Y x T x P x OS | Ns |
| P x OM | ** | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

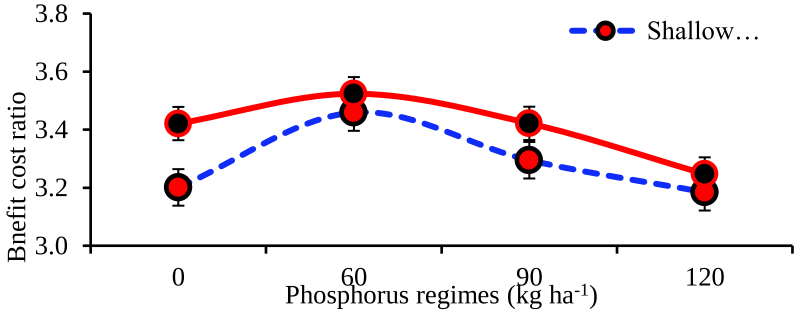

*Fig. 13. Interactive effect of tillage depths and phosphorus regimes on benefit cost ratio*

Table 11. Effect of phosphorus, organic manures and tillage depths on net returns

| Tillage depths | Year (Y) | | Mean |
|---|---|---|---|
| | 2017-18 | 2018-19 | |
| T1 (15 cm) | 160397 | 164497 | 162447 b |
| T2 (30 cm) | 166705 | 169429 | 168067 a |
| LSD $_{(0.05)}$ | 1883 | 1883 | 1393 |
| Organic manures (OM) | | | |
| Poultry manure | 168827 | 174430 | 171629 a |
| Cattle manure | 165246 | 167449 | 166348 b |
| Mungbean residues | 160897 | 162817 | 161857 c |
| Sugar cane residues | 159232 | 163156 | 161194 d |
| LSD $_{(0.05)}$ | 3150 | 2663 | 1970 |
| P regimes (kg ha$^{-1}$) | | | |
| $P_0 = 0$ | 138819 | 140491 | 139655 b |
| $P_1 = 60$ | 174992 | 172781 | 173887 a |
| $P_2 = 90$ | 169776 | 179161 | 174468 a |
| $P_3 = 120$ | 170615 | 175420 | 173018 a |
| LSD $_{(0.05)}$ | 2923 | 2628 | 1940 |
| Year | | | |
| 2017-18 | | | 163551 b |
| 2018-19 | | | 166963 a |
| Significance | | | * |
| Interaction | Significance | Interaction | Significance |
| T x OM | ns | P x T x OS | ns |
| Y x T | ns | Y x P | ** |
| Y x OM | ns | Y x P x T | * |
| Y x T x OM | ns | Y x P x OS | ns |
| T x P | ** | Y x P x T x OS | ns |
| P x OM | ** | | |

ns, *, and ** denote non-significant, significant at a probability of 5 & 1%, respectively

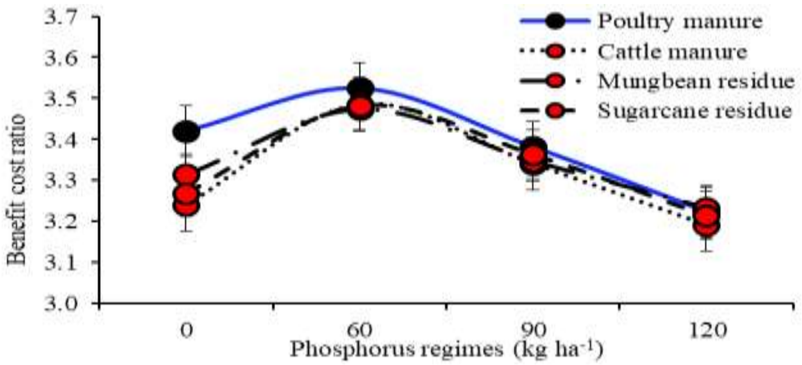

*Fig. 14. Interactive effect of organic manures and phosphorus regimes on benefit cost ratio*

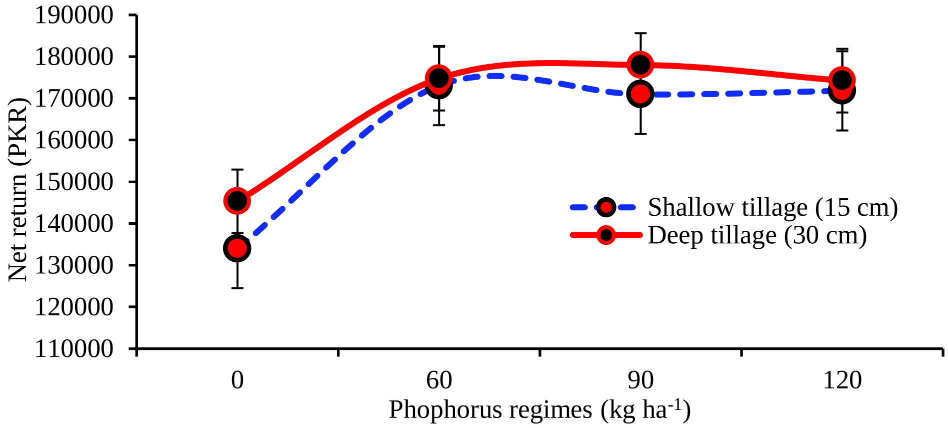

Fig. 15. Interactive effect of organic manures and tillage depths on net return (PKR)

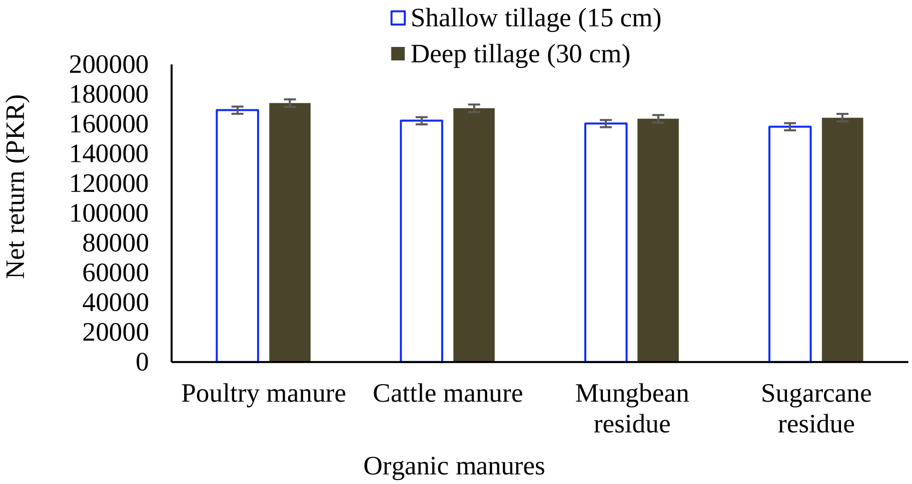

Fig. 16. Interactive effect of organic manures and tillage depths on net return (PKR)

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