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## Research Article

# Integrated Use of Organic Manures and Chemical Fertilizers on Yield, Nutrient Contents of Rice and Wheat Crops in Recently Reclaimed Saline Sodic Soil

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## ABSTRACT

A field study was carried out at the Soil Salinity Research Institute's research farm in Pindi Bhattian in 2020–21 to assess the effects of using chemical and organic fertilizers together on rice and wheat yields, as well as the nutrient contents and characteristics of recently reclaimed saline sodic soil. The original characteristics of the field were ECE 8.50 dS m<sup>-1</sup>, pHs 8.90 and gypsum requirement 4.12 tons acre<sup>-1</sup>. Using 100% of the required gypsum, this field was recovered. Application rates for six distinct organic manures were 20 t. ha<sup>-1</sup> + 75% R.D. of N P K. Merely 75% of the prescribed amount of NPK was administered in the control therapy. The manures that were used were wheat straw, sesbania green manure, press mud, FYM, poultry manure, and litter of eucalyptus leaves. The rice crop was treated with these manures one month prior to rice transplanting. Data showed that all of the manures enhanced rice yield in the paddy and straw compared to the control. Maximum yields of rice and straw were recorded in the applications of chicken manure, which was comparable to FYM and sesbania green manuring. This was followed by FYM, litter, press-mud, sesbania green manuring, wheat straw, and least in the control. All other manures remained non-significant with each other but significant over control, with the exception of P in poultry manure treated plots in straw, which stayed at par with press-mud treated plots. Maximum and considerably higher P contents were found in paddy and straw in press-mud treated plots. Plots treated with wheat straw had K levels that were both maximal and noticeably higher. Following rice crop harvest, soil tests showed that plots treated with poultry dung had lower maximum ECE. While press-mud sesbania treated plots showed a drop in maximum SAR, FYM remained at par with poultry manure. The press-mud treated plots had the highest P content in the soil, comparable to those treated with poultry manure, while the wheat straw treated plots showed the highest K content. The pH and total N levels were not statistically significant. In order to replicate the benefits of applied organic manures, wheat was grown in the same layout following the rice harvest. Wheat straw and grain yields were highest in residual poultry manure-applied plots; these yields were not significantly different from those of FYM-applied plots, which were followed by sesbania, wheat straw, and litter. Following wheat harvest, the soil's salinity and sodicity characteristics somewhat dropped while its fertility metrics slightly increased.

**Keywords:** Manures, Chemical Fertilizers, Rice, Wheat, Reclaimed Saline-Sodic Soil.

## INTRODUCTION

The reduction in rice crop yield from salt-affected lands varied between 36% and 69%,



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averaging 48% overall, which was greater than the yield losses seen in wheat (Murtaza, 2013). In Pakistan, salinity primarily resulted in a decrease of 25% in crop production (Zaman and Ahmad, 2009). In 2017, the waterlogging and salinity issues in Pakistan led to significant losses in crop yield, with concerns rising about potential monetary losses reaching Rs. 880 million (\$28.5 million), with a total annual economic damage estimate of \$300 million (Shahzad et al., 2017). Approximately 28000 to 40000 hectares of land are lost annually due to salinity, resulting in a revenue loss of around US\$ 230 million per year, mainly caused by reduced crop yields from high salinity and sodicity (Aslam, 2016). Rice and wheat are essential crops in Pakistan's irrigated agriculture. Hence, the rice-wheat cropping scheme holds significant importance, followed by maize and sugarcane. In this setup, rice is cultivated in a warm, sub-humid environment during monsoonal and summer months, while wheat is grown in a cooler, drier setting in the winter season. In the year 2020-21, the combined area dedicated to rice and wheat cultivation was 3.34 million hectares and 9.18 million hectares respectively. Research conducted across multiple sites in the Indus Basin in Pakistan on saline-sodic fields found that wheat grain yields were reduced by 20% to 43% on salt-affected lands, with an average loss of 32%.

Salt-affected soil has a significant impact on the accessibility of plant nutrients. The primary factors causing reduced soil fertility include: i) excessive levels of sodium, carbonates, and bicarbonate which hinder the accessibility of essential ions like calcium, phosphorous, potassium, zinc, manganese, iron, and boron. ii) a drop in phosphorus and micronutrient availability due to elevated soil pH (especially in sodic soils) iii) significant reduction in microbiological activity iv) leaching of salts during soil reclamation also results in leaching of nutrients v) limited water uptake by plants in salt-affected soils leads to reduced nutrient uptake due to physiological water unavailability. A fertile soil needs enough organic matter (Oldfield et al., 2018), yet salt-affected soils typically have less than 1% organic matter and necessitate additional organic inputs (Wood et al., 2018). Adding gypsum and manures to salty soils enhances the soil structure, soil health, and productivity. Farmers in dry and semi-dry areas with slightly salty and alkaline soils can improve their soil quality by using organic manure combined with gypsum, resulting in a potential increase in soil carbon storage up to 13.36 t ha<sup>-1</sup> as reported by Farooqi et al. (2023) through the joint use of gypsum and farmyard manure.

In the Indus plains, where saline sodic soils are dominant, the majority of the land reclaimed by using gypsum is used for rice-wheat rotation. The idea of combined nutrient management is particularly relevant for restoring saline sodic soils. Following the initial recovery of land, the main reason for unsustainable yields in a rice-wheat system has been the nutrient imbalance resulting from the consistent use of nitrogen without adequate levels of other nutrients like phosphorus and zinc (Singh and Singh, 2022; Swarup and Yaduvanshi, 2004). In this situation, the combination of organic manures and inorganic fertilizers is highly significant for sustainable production and preserving soil health. The results of an integrated nutrient management study for a rice-wheat cropping system in freshly recovered soil were published by Mehdi et al. (2011) where various combinations of green manure, FYM, and chemical fertilizer were used. For increasing rice paddy and straw yield, among various combinations, sesbania @20 t ha<sup>-1</sup> + 75% recommended dose of NPK proved to be the best combination, followed by sesbania @20 tons ha<sup>-1</sup> + 50% recommended dose of NPK (Shaheen Bas.). Organic manures provide both macro- and micro-nutrients and enhance the physical, chemical, and biological characteristics of recently reclaimed saline sodic soils.

With this in mind, the current research was planned to explore various organic sources to evaluate the effects of combined usage of chemical and organic fertilizers on rice and wheat yields, as well as the nutritional contents and characteristics of freshly reclaimed saline sodic soil.

## MATERIALS AND METHODS

In order to study the effects of integrated usage of various organic manures and chemical fertilizer on rice and wheat yield, their nutritional contents, and the qualities of recently reclaimed salty sodic soil, a field experiment was carried out at the research farm of the soil salinity research institution, Pindi Bhattian. The chosen field had a pH of 9.0, ECe of 13.5 dS m<sup>-1</sup>, and a gypsum demand of 4.12 t acre<sup>-1</sup>. It was a saline sodic field. The texture of the soil was sandy loam. The land was restored by applying gypsum @ 100% gypsum requirement of soil. The application of six distinct kinds of organic manures carried out thirty days prior to the rice crop's transplantation. Following their application to the rice crop, the manures were seen to have a lingering effect on the wheat crop. The treatments applied were as under:

- |                |  |
|----------------|--|
| T <sub>1</sub> | 75% Recommended dose (R.D.) of NPK                   |
| T <sub>2</sub> | Litter @ 20 t. ha <sup>-1</sup> + 75% R. D. of NPK   |
| T <sub>3</sub> | Sesbania @ 20 t. ha <sup>-1</sup> +75% R.D. of NPK   |
| T <sub>4</sub> | Press mud @ 20 t. ha <sup>-1</sup> + 75% R.D. of NPK |

- T<sub>5</sub> FYM @ 20 t. ha<sup>-1</sup> + 75% R.D. of NPK  
 T<sub>6</sub> Poultry manure @ 20 t. ha<sup>-1</sup> + 75% R.D. of NPK  
 T<sub>7</sub> Wheat Straw @ 20 t. ha<sup>-1</sup> + 75% R.D. of NPK

For rice, an NPK dosage of 110–90–60 kg ha<sup>-1</sup> was advised. Three replications of a randomized complete block design made up the system of layout. The plot measured 6 by 4 meters. Shaheen Basmati rice was the kind tested. When rice was transplanted, the entire NPK was applied. Urea, SSP, and SOP were the sources of NPK. Ten days following the transplanting of rice, 12.5 kg ha<sup>-1</sup> of zinc sulfate (33% zinc) was applied. For the crop to mature satisfactorily, all cultural methods were used. Data on straw and paddy yields were gathered. Samples of paddy and straw were oven dried to a constant weight at 65 degrees Celsius before being analyzed to determine NPK levels. Following the harvest of the rice crop, soil samples were taken and tested for salt and fertility indices. Following the rice crop harvest, wheat was grown in the same layout with a 75% recommended dose of nitrogen fertilizer (recommended dose: 140-110-70 kg ha<sup>-1</sup>). At the time of sowing, the entire P, K, and one-third of the N were applied; the remaining N was applied in two splits during the first and second irrigations. Urea, SSP, and SOP were the sources of NPK. Water from canal was used for irrigation. When the crop reached maturity, data on grain and straw yields were collected. After being oven dried to a constant weight at 65 degrees Celsius, the grain and straw samples were examined for determination of NPK nutrients. All soil physico-chemical properties were determined using the methods given in Hand book No. 60 (Staff., 1954) with the exception of total nitrogen in soil and plants which was determined by adopting method used by Jackson (1958). Total nitrogen (N) of soil and plant samples was determined using the Kjeldahl apparatus (Nelson and Sommers, 1980) whereas to analyze P and K, one gram of finely ground plant samples was digested in di-acid mixture (HNO<sub>3</sub>: HClO<sub>4</sub> 4:1 v/v) and the diluted digests were examined for P and K using the methods explained by Tandon (2005): the vanado-molybdate yellow color method and flame photometry. Potassium (K<sup>+</sup>) in soil was analyzed using the method described by Norman (1965). The available phosphorus in soil was determined by using method of Watanabe and Olsen (1965) whereas soil texture was determined by using method of (Moodie et al., 1951). Procedures outlined by Tandon (2005) were followed for oven drying and analysing nutrient contents (NPK) of organic manures. The least significant differences (LSD) test was used to compare treatment means after all data were statistically analyzed using randomized complete block design (Steel and Torrie, 1985)

## RESULTS AND DISCUSSION

### Impact of various organic manures on paddy and straw yield:

A saline-sodic soil with ECe of 13.5 dS m<sup>-1</sup>, pH of 9.0, and a gypsum requirement of 4.12 t acre<sup>-1</sup> was chosen. By applying gypsum at 100% of the soil's gypsum needs, the field was restored. Following reclamation, 20 t. ha<sup>-1</sup> of six different organic manures were applied: press mud, poultry manure, wheat straw, fresh eucalyptus leaves (litter), sesbania green manure, FYM, and FYM. After applying manures for a month, rice was transplanted and 75% of the suggested NPK dosage was administered. The Chemical analysis of different organic manures is given in Table 1. According to table (2)'s paddy yield data, poultry manure produced the highest yield (4.35 t. ha<sup>-1</sup>) compared to FYM (4.21 t. ha<sup>-1</sup>) and sesbania (4.17 T. ha<sup>-1</sup>). Press mud (3.75 t. ha<sup>-1</sup>) was the next highest yield, surpassing both wheat straw and fresh eucalyptus leaves (litter). Eucalyptus leaves and wheat straw performed equally well and continued to outperform the control group, which received only 75% of the necessary dosage of NPK. These findings agree with Yaduvanshi (2001), Ahmad et al. (2001), and Singh (1984). According to data on straw yield, rice straw produced by poultry manure was considerably higher (12.10 t ha<sup>-1</sup>), followed by FYM, Press mud, sesbania, wheat straw, litter, and least in control. Wheat straw remained superior to eucalyptus leaves which remained superior to control for producing paddy yield. Ahmad et al. (2001) and (Yaduvanshi, 2001) both reported similar results. Poultry manure produced the highest paddy and straw yield. The reason might be that it contained highest N contents, which result in more production of paddy and straw yield over all the other manures. FYM and sesbania green manure both remained at par indicating that the nutrient supplying power of these two manures was almost equal but both of these contains less N than the poultry manure that resulted in low yield than poultry manure. Available press mud was not in well decomposed form and it decomposed slowly to supply nutrient. Wheat straw and eucalyptus leaves also decomposed slowly due to wide C:N ratio resulting in less supply of N and resulted in low yield.

### Impact of various organic manures on NPK concentrations in rice

Concentration of N, P and K in paddy and straw is presented in table 3. Data depicted that poultry manure treated plot paddy samples contained significantly higher N contents (2.50%) and it was followed by FYM (2.46%) , litter

(2.33%) , press mud(2.29%) , sesbania (2.26%) , wheat straw(2.20%) and least in control(2.08%) treatment. As for as Nitrogen concentration in rice straw samples is concerned maximum N concentration (1.91%) was observed in poultry manure treated plots which was followed by FYM treated plots(1.74%), press mud treated plots (1.73%) and sesbania treated plots (1.70%) which remained non-significant with each other. Wheat straw remained superior to litter and least N concentration in rice straw was observed in control plot. Poultry manure treated plots contained maximum N contents both in paddy and straw. The reason might be that poultry manure contained maximum nitrogen (2.14 % N) and on its decomposition, nitrogen availability to plants was improved. FYM, sesbania, press mud contained relatively less nitrogen than poultry manure; hence their respective plots contained less nitrogen in paddy and straw samples. Litter and wheat straw contained less nitrogen content compared all the other tested manures. Hence, N availability to plants in these treatments is less than other manures. Moreover, these two manures took more time for decomposition than the other manure and release nutrients.

Table 01. Total NPK contents of organic manures.

Organic manure	Total N (%)	Total P (%)	Total K (%)
Litter (Eucalyptus leaves)	0.34	0.09	0.29
Sesbania	0.68	0.21	0.39
Press mud	1.86	0.94	0.30
FYM	1.09	0.28	0.73
Poultry manure	2.14	0.98	1.02
Wheat straw	0.45	0.13	1.36

Table 2. Impact of various organic manures on rice paddy and straw yield.

Treatments	Paddy yield (t. ha <sup>-1</sup> )	Straw yield (t. ha <sup>-1</sup> )
T <sub>1</sub> 75% R.D	2.17 D	5.00G
T <sub>2</sub> Litter (20 t. ha <sup>-1</sup> ) + 75% R.D.	3.21C	7.37F
T <sub>3</sub> Sesbania (20 t. ha <sup>-1</sup> ) + 75% R.D.	4.17A	11.25C
T <sub>4</sub> press mud (20 t. ha <sup>-1</sup> ) + 75% R.D.	3.75B	10.33D
T <sub>5</sub> FYM (20 t. ha <sup>-1</sup> ) + 75% R.D.	4.21A	11.60B
T <sub>6</sub> Poultry manure (20 t. ha <sup>-1</sup> ) +75% R.D.	4.35A	12.10A
T <sub>7</sub> Wheat straw(20 t. ha <sup>-1</sup> ) +75% R.D.	3.27C	8.37E
LSD	0.1725	0.1336

Table3. Impact of various organic manures on the concentrations of NPK in rice straw and rice grain.

Treatments	Rice grain			Rice straw		
	Total N(%)	Total P(%)	Total K(%)	Total N(%)	Total P(%)	Total K(%)
T <sub>1</sub> 75% R.D	2.08G	0.156 D	0.156E	1.56E	0.06C	1.077D
T <sub>2</sub> Litter (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.33C	0.163 CD	0.173DE	1.59D	0.077BC	1.093D
T <sub>3</sub> Sesbania (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.26E	0.173 BC	0.190CD	1.70B	0.083B	1.237C
T <sub>4</sub> press mud (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.29D	0.203 A	0.213AB	1.73B	0.103A	1.263B
T <sub>5</sub> FYM (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.46B	0.176BC	0.213AB	1.74B	0.080B	1.237C
T <sub>6</sub> Poultry manure (20 t. ha <sup>-1</sup> ) +75% R.D.	2.50A	0.180 B	0.203DC	1.91A	0.086AB	1.260B
T <sub>7</sub> Wheat straw (20 t. ha <sup>-1</sup> ) +75% R.D.	2.20F	0.163 CD	0.230A	1.58C	0.073BC	1.323A
LSD	0.0178	0.0157	0.0178	0.0178	0.0178	0.0178

Similarly, paddy samples in press mud treated plots contained maximum total P (0.203%) that was followed by poultry manure treated plot paddy samples (0.180%), then FYM treated plot paddy samples (0.176%) and least in control treatment (0.156%). Phosphorus concentration in rice straw samples was maximum in press mud treated plot(0.103%) which remained non –significant with poultry manure treated plot (0.086%) and was followed by FYM

and sesbania which remained non-significant with each other. Wheat straw and litter remained non-significant with each other with respect to P concentration of rice straw. Minimum P concentration was noted in control treatment. The reason might be that press mud contained higher P contents and, on its decomposition, more P became available to plants than the other manures treated plots. Poultry manure, press mud, FYM and sesbania contained less P than press mud but more P than wheat straw and litter. Hence plots treated with these manures contained less P than press mud but more P than wheat straw and litter. Moreover, litter and wheat straw took more time for decomposition than the FYM, poultry manure and sesbania green manuring. As for as potassium concentration of paddy samples is concerned, maximum K concentration was observed in wheat straw (0.230%) applied plots which was followed by FYM (0.213%) applied plots followed by poultry manure (0.203%) sesbania (0.190%) and least K concentration in paddy samples was observed in control treatment(0.156%) where only 75% recommended dose of NPK was applied. Potassium concentration in rice straw was maximum in wheat straw applied plots (1.323%) followed by press mud (1.263%), poultry manure (1.260%). K concentration of rice straw in FYM applied plots and sesbania applied plot was non-significant followed by litter and minimum K concentration in rice straw was noted in control treatment where only 75% recommended dose of NPK was applied. Wheat straw treated plots contained the higher contents of K in paddy and straw of rice samples than other manures treated plots. The reason might be that wheat straw contained more K than any other tested manure. Although its decomposition occurred slowly than other tested manures yet K uptake by plants from soil remained in progress till maturity. Hence more K was noted in wheat straw treated plots. Litter contained less K than all other tested manures. Hence litter treated contained less K both in paddy and straw than all other tested manures. Similar findings were reported by Sen and Bandyopadhyay (2001) and Ahmad et al. (2001). When chemical fertilizers, manures, and sesbania are applied in tandem with rice paddy and straw, Sarwar (2005) found that the concentration of NPK was higher than when chemical fertilizers and manures were applied separately. Tiwari et al. (2001) found that using chemical fertilizers in addition to organic manures resulted in a higher rate of nutrient utilization and a faster rate of mineralization. The outcomes also support the conclusions made by Yaduvanshi (2001) and Tabasam et al. (2002).

#### Impact of various organic manures on soil sodicity/salinity and soil fertility after rice harvest

Table 4 presents the results of soil analysis following rice harvest. It indicates that the integrated use of organic manures and chemical fertilizer led to a decrease in salinity/sodicity parameters (pH<sub>s</sub>, EC<sub>e</sub>, and SAR) of the soil after rice harvest. Maximum values of salinity/sodicity parameters were detected in the control treatment, where only 75% of the authorized amount of chemical fertilizer was administered. Minimum values of pH<sub>s</sub>, EC<sub>e</sub>, and SAR were discovered where a mixture of poultry manure and chemical fertilizer was applied after the rice harvest.

Table 4. Analysis of the Soil following Rice Harvest.

Treatments	pH <sub>s</sub>	EC <sub>e</sub> (dS m <sup>-1</sup> )	SAR (m mmol L <sup>-1</sup> ) <sup>1/2</sup>	Total N(%)	Av. P (mg kg <sup>-1</sup> )	Ext.K (mg kg <sup>-1</sup> )
T <sub>1</sub> 75% R.D	8.36 NS	3.66 B	19.50 A	0.027 D	5.93 E	117.33 A
T <sub>2</sub> Litter (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.35	3.63 AB	19.67 A	0.031 CD	6.42 D	127.67 D
T <sub>3</sub> Sesbania (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.37	3.31 B	18.43 C	0.035 BC	6.68 BCD	131.33 C
T <sub>4</sub> press mud (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.32	3.29 B	18.54 BC	0.031 AB	7.06 A	130.33 C
T <sub>5</sub> FYM (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.33	3.33 B	19.30 AB	0.040 A	6.87 AB	130.33 C
T <sub>6</sub> Poultry manure (20 t. ha <sup>-1</sup> ) +75% R.D.	8.32	3.24B	18.43 C	0.040 A	6.80 ABC	135.0 B
T <sub>7</sub> Wheat straw(20 t. ha <sup>-1</sup> ) +75% R.D.	8.32	3.85 A	19.57 A	0.029 D	6.53 CD	140.67 A
LSD	0.0467	0.5111	0.8246	0.0046	0.3075	2.4958

Mean sharing similar letter(s) do not differ significantly at p= 0.05

When organic manures are combined with fertilizer application treatments, the soil's pH decreased after rice harvest. This could be caused by the increased production of CO<sub>2</sub> and organic acids during the decomposition of the manures. On the other hand, the soil's EC and SAR decrease because the native CaCO<sub>3</sub> was activated by the

organic acids generated during the decomposition of the manures, converting it into  $\text{CaSO}_4$ , which reclaimed the soil. During reclamation, salts were leached down during flooding, which resulted in decreased pHs, ECe, and SAR of the soil. Patrick Jr et al. (1985) obtained comparable results. The maximum total N and available P was observed when a combination of FYM and chemical fertilizer was used, and it remained non-significant when a combination of poultry manure and chemical fertilizer was used, according to data regarding the total N, available P, and extractable K contents of the soil following rice harvest. The mineralization of organic manures may be the cause of the increased nitrogen content in the soil in the integrated treatments. Zia (1992) reported similar results, stating that wheat straw, FYM, and sesbania green manure had the maximum residual N fertility. The mineralization of organic P and the resulting generation of organic acids may be the cause of the increase in soil P availability. The treatment that included chemical fertilizer and wheat straw application yielded the highest value of accessible K, and it was succeeded by the application of sesbania, chicken manure, and FYM. In the control treatment, when only 75% of the authorized amount of NPK was administered, the minimum value of extractable K was reported. The solubilizing activity of organic acids created during the decomposition of organic manures and their ability to hold K in available form may have contributed to the additional K applied in the integrated treatments, which may have increased the amount of available K.

### Residual effect of organic manures on grain and straw yield of wheat

Table 5 presents the residual effect of various organic manures applied to rice on the grain and straw yield of the following wheat crop. It indicates that the treatment with poultry manures ( $20 \text{ t. ha}^{-1} + 75 \text{ R.D.}$ ) produced the maximum wheat grain yield ( $2.69 \text{ t ha}^{-1}$ ), which was comparable to the treatments with press mud @  $20 \text{ t. ha}^{-1}$  and FYM  $20 \text{ t. ha}^{-1}$ , yielding  $2.65 \text{ t ha}^{-1}$  and  $2.66 \text{ t ha}^{-1}$ , respectively. Sesbania ( $20 \text{ t. ha}^{-1}$ ) produced the next highest yield ( $2.52 \text{ t ha}^{-1}$ ), while the lowest grain yield ( $2.06 \text{ t ha}^{-1}$ ) was achieved with only 75% recommended dose of NPK fertilizer applied. Regarding the straw yield, the treatment that applied chicken manure @  $20 \text{ t. ha}^{-1} + 75\%$  of the authorized dose of fertilizer yielded the highest straw yield ( $3.62 \text{ t ha}^{-1}$ ). This was followed by the application of FYM @  $20 \text{ t. ha}^{-1}$ , which produced a  $3.51 \text{ t ha}^{-1}$  wheat straw yield. Following press mud and sesbania, the residual effect of chicken manure and FYM continued to be superior for increasing wheat's grain and straw yield, while the control treatment's minimal wheat grain and straw yield was recorded. The explanation could be that these organic manures increased the soil's fertility, which in turn increased crop productivity. The findings corroborate those of Ahmad et al. (2001), (Mehdi et al., 2011), (Dang and Verma, 1996), and Tiwari et al. (2001).

Table 5. Residual effect organic manures on grain and straw yield of wheat.

Treatments	Grain yield ( $\text{t. ha}^{-1}$ )	Straw yield ( $\text{t. ha}^{-1}$ )
T <sub>1</sub> 75% R.D	2.06DE	2.64E
T <sub>2</sub> Litter ( $20 \text{ t. ha}^{-1}$ ) + 75% R.D.	2.22CD	2.91D
T <sub>3</sub> Sesbania ( $20 \text{ t. ha}^{-1}$ ) + 75% R.D.	2.52B	3.18C
T <sub>4</sub> press mud ( $20 \text{ t. ha}^{-1}$ ) + 75% R.D.	2.65A	3.32BC
T <sub>5</sub> FYM ( $20 \text{ t. ha}^{-1}$ ) + 75% R.D.	2.66A	3.51AB
T <sub>6</sub> Poultry manure ( $20 \text{ t. ha}^{-1}$ ) +75% R.D.	2.69A	3.62A
T <sub>7</sub> Wheat straw( $20 \text{ t. ha}^{-1}$ ) +75% R.D.	2.41CDC	3.24E
LSD	0.1052	0.1948

Mean sharing similar letter(s) do not differ significantly at  $p= 0.05$

### Residual impact of organic manures on the concentrations of NPK in wheat

Table 6 provides information on the NPK content of wheat grain and straw as influenced by the residual effects of various organic manures combined with chemical fertilizer. It notes that the highest N concentration (2.55%) in wheat grain was found in T<sub>6</sub>, which was followed by T<sub>4</sub>, T<sub>7</sub>, and T<sub>2</sub>. The lowest Nitrogen concentration (2.13%) in wheat grain was found in control treatment T<sub>1</sub>. Regarding P concentration in wheat grain, T<sub>6</sub> showed the highest P concentration (0.34%), which remained non-significant when compared to T<sub>5</sub>. T<sub>3</sub>, T<sub>4</sub>, and T<sub>6</sub> were the next highest concentrations. Regarding the P content of wheat grain, treatments T<sub>2</sub> and T<sub>7</sub> continued to be non-significant, while the control treatment had the lowest P content (0.21%). T<sub>7</sub> had the highest K concentration in wheat grain, and it was followed by T<sub>5</sub> and T<sub>2</sub>. It remained non-significant with T<sub>6</sub>, T<sub>4</sub>, and T<sub>3</sub>. The wheat grain with the lowest K content was discovered in treatment T1, the control. Regarding the nitrogen content of wheat straw, the plot treated with poultry manure had the highest nitrogen concentration (0.52%), whereas the plot treated with press mud, sesbania, FYM wheat straw, and litter applied plots showed no significant differences in nitrogen content. Maximum P

concentration of P in wheat straw was observed in poultry manure treated plot (0.19%) which remained non-significant with press mud applied plot followed by sesbania, wheat straw and litter, while Minimum P concentration was found in control treatment. As for as K concentration in wheat straw is concerned maximum K concentration was noted in wheat straw applied plot which remained non-significant with Poultry manure, press mud and FYM applied plot followed by litter applied and control treatment. The explanation could be that the addition of Sesbania and FYM to rice crops along with chemical fertilizer enhanced the soil's organic matter content, which in turn enhanced the soil's aeration, permeability, aggregation, water-holding capacity, and biological qualities. As a result, wheat absorbed more NPK and chemical fertilizer was more effectively administered to the crop. The results are corroborated by Dixit and Gupta (2000) findings.

Table6. The residual impact of organic manures on the concentrations of NPK in grain and wheat straw.

Treatments	Total N (%)	Total P (%)	Total K (%)	Total N (%)	Total P (%)	Total K (%)
	Grain			Wheat straw		
T <sub>1</sub> 75% R. D	2.13D	0.21C	0.28 D	0.40 C	0.10 D	2.12 C
T <sub>2</sub> Litter (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.31 C	0.23 C	0.31 CD	0.42 C	0.12 CD	2.24 BC
T <sub>3</sub> Sesbania (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.42 ABC	0.27 BC	0.35 ABC	0.46 B	0.14 BC	2.34 AB
T <sub>4</sub> press mud (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.34 BC	0.25 BC	0.38 A	0.49 AB	0.17 A	2.42 A
T <sub>5</sub> FYM (20 t. ha <sup>-1</sup> ) + 75% R.D.	2.51AB	0.31 AB	0.32 BCD	0.42 C	0.15 B	2.38 AB
T <sub>6</sub> Poultry manure (20 t. ha <sup>-1</sup> ) +75% R.D.	2.55A	0.34 A	0.36 AB	0.52 A	0.19A	2.46 A
T <sub>7</sub> Wheat straw (20 t. ha <sup>-1</sup> ) +75% R.D.	2.25CD	0.22 C	0.39 A	0.40 C	0.13BC	2.49 A
LSD	0.1714	0.0686	0.0461	0.0356	0.0293	0.1565

Mean sharing similar letter(s) do not differ significantly at p= 0.05

**Residual impact of organic manures on soil fertility and sodicity/salinity**

Table 7 presents the results of soil analysis following wheat harvest. It indicates that the integrated use of organic manures and chemical fertilizer led to a decrease in salinity/sodicity parameters (SAR) of the soil after wheat harvest.

Table 7. Soil Analysis after wheat harvest.

Treatments	pH <sub>s</sub>	EC <sub>e</sub> (dS m <sup>-1</sup> )	SAR (m mmol L <sup>-1</sup> ) <sup>1/2</sup>	Total N(%)	Av. P(mg kg <sup>-1</sup> )	Ext.K(mg kg <sup>-1</sup> )
T <sub>1</sub> 75% R.D	8.34NS	3.55 NS	17.60	0.031	6.30	125
T <sub>2</sub> Litter (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.33	3.42	17.40	0.034	7.36	140
T <sub>3</sub> Sesbania (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.35	3.28	16.60	0.038	7.42	142
T <sub>4</sub> press mud (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.30	3.27	16.54	0.034	7.46	144
T <sub>5</sub> FYM (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.30	3.29	16.42	0.046	7.36	142
T <sub>6</sub> Poultry manure (20 t. ha <sup>-1</sup> ) + 75% R.D.	8.30	3.22	15.50	0.052	7.80	146
T <sub>7</sub> Wheat straw(20 t. ha <sup>-1</sup> ) +75% R.D.	8.31	3.45	17.10	0.036	7.60	148
LSD	0.0467	0.498	0.8013	0.0039	0.2895	2.759

Maximum value of SAR was detected in the control treatment, where only 75% of the authorized amount of chemical

fertilizer was administered.

Minimum value of SAR was found where a mixture of poultry manure and chemical fertilizer was applied. This could be caused by the increased production of CO<sub>2</sub> and organic acids during the decomposition of the manures and the native CaCO<sub>3</sub> was activated by the organic acids generated during the decomposition of the manures, converting it into CaSO<sub>4</sub>, which reclaimed the soil. During reclamation, salts were leached down during irrigation, which resulted in decreased SAR of the soil. Patrick Jr et al. (1985) obtained comparable results. The maximum total N and available P was observed when a combination of poultry manure and chemical fertilizer was used, and it remained non-significant regarding total nitrogen when litter and press mud was used as organic source, according to data regarding the total N of the soil following wheat harvest. The mineralization of organic manures may be the cause of the increased nitrogen content in the soil in the integrated treatments. Zia (1992) reported similar results, stating that wheat straw, FYM, and sesbania green manure had the maximum residual N fertility. The mineralization of organic P and the resulting generation of organic acids may be the cause of the increase in soil P availability. The treatment that included chemical fertilizer and wheat straw application yielded the highest value of accessible K, and it was succeeded by the application of chicken manure and press mud. In the control treatment, when only 75% of the authorized amount of NPK was administered, the minimum value of extractable K was reported.

## CONCLUSION

Incorporation of six organic matter sources (Poultry manure, FYM, litter, press-mud, sesbania green manuring and wheat straw) in combination along with NPK fertilizers could enhance and maintain sustainable rice yields as well as soil fertility in the reclaimed saline sodic soils. Moreover, application of all organic matter sources along with NPK fertilizers has significant residual impact regarding enhanced wheat yield and improved the soil's salinity and sodicity characteristics somewhat of the soil compared to the chemical fertilizers alone.

## AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

## COMPETING OF INTEREST

The authors declare no competing interests.

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