

# Long Term Effect of Organic and Inorganic Manures on Rice Productivity and Major nutrient dynamics in 33 years old Rice- Rice Cropping System of Godavari Delta

## ABSTRACT:

**Aim:** To study the “Long Term Effect of Organic and Inorganic Manures on Rice Productivity and Major nutrient dynamics in 33 years old Rice- Rice Cropping System of Godavari Delta”.

**Place and duration of study:** A field experiment was carried out under *kharif* 2022 at Regional Agricultural Research Station, Maruteru, West Godavari district in the ongoing All India Coordinated Rice Improvement Project (AICRIP) on Long term soil fertility management in low land rice soils of Godavari delta under rice-rice cropping system.

**Study design and Methodology:** Treatments imposed in this study were T<sub>1</sub>: Control, T<sub>2</sub>: 50 % NPK, T<sub>3</sub>: 50% NPK + 50 % N-FYM, T<sub>4</sub>: 50 % NPK + 50% N-Green Manure, T<sub>5</sub>: 50 % NPK + 50 % N-*Azospirillum*, T<sub>6</sub>: FYM @ 10t/ha, T<sub>7</sub>: 100 % NPK+Zn+S, T<sub>8</sub>: 100 % NPK +Zn+S+FYM @ 5 t ha<sup>-1</sup>. All together were 8 treatments laid out in RBD with three Replications. The application of fertiliser was carried out in accordance with the treatments. The prescribed fertiliser dose (90:60:60) was administered in the following forms: urea (46% N), single superphosphate (16% P<sub>2</sub>O<sub>5</sub>), muriate of potash (60% K<sub>2</sub>O), and zinc sulphate (ZnSO<sub>4</sub>.7H<sub>2</sub>O) @ 40 kg ha<sup>-1</sup>. The total dosage of phosphorus, potassium, and zinc was used as a basal application. Three equally divided applications of nitrogen were made: one at the basal, one at the tillering stage, and one at the panicle initiation stage. Well decomposed farmyard manure (FYM) manure and *Pheltophorum* (green leaf manure) were applied one week before transplanting. Popular cultivar of Kharif rice MTU 1064 (Amara) was used for the study.

**Results:** Long-term application of organic and inorganic fertilizers and their combination didn't show any marked difference on physico-chemical properties of soil (pH and EC). Bulk density was recorded lowest in FYM @ 10 t ha<sup>-1</sup> and it was on par with (T<sub>8</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>). Organic carbon was observed highest in FYM @ 10 t ha<sup>-1</sup> and it was on par with (T<sub>8</sub> and T<sub>3</sub>). There was a significant impact of long-term application of organic and inorganic fertilizers and their combination on soil chemical properties, highest available N, P, K, S and Zn was observed highest in conjunctive treatment (T<sub>8</sub>) 100 % NPK + Zn + S + FYM @ 5 t ha<sup>-1</sup> whereas, lowest was recorded in control. There was a significant impact on grain and straw yields. Highest grain and straw yields were recorded in (T<sub>8</sub>) 100 % NPK + Zn + S +FYM @ 5 t ha<sup>-1</sup> and it was on par with (T<sub>7</sub>) 100 % NPK + Zn + S.

**Conclusions:** After the investigation, present study concludes that conjunctive and combined application of organics with inorganics improve soil physical, physico-chemical and chemical properties of the soil.

**Keywords:** Long term effect of manures – rice-rice cropping system- bulk density- organic carbon- nutrient dynamics-grain yield- straw yield

## 1. INTRODUCTION

One of the most popular cereal food crops is Rice (*Oryza sativa* L.), which feeds roughly 40 nations and nearly two-thirds of the world's population. Rice cultivation is an essential aspect of the Asian economy; it accounts for more than 90% of the world's rice farming and consumption. In India, paddy is produced over an area of 45.07 million hectares, with a total yield of 122.7 million tonnes and a productivity of 2713 kg ha<sup>-1</sup>. ([Agricultural statistics at a glance, 2020-2021](#)). In Andhra Pradesh, during the *kharif* season, rice is grown over an area of 2.32 million hectares with an annual yield of 7.89 million tonnes and a productivity of 3395 kg ha<sup>-1</sup>. Due to intense rice monoculture, unbalanced fertilization, excessive irrigation water consumption, the Godavari delta's soil fertility and productivity are expected to be impacted. Continuous application of high quantities of chemical fertilisers had resulted in soil degradation issues, which were also detrimental to soil health. In India, long-term fertilizer studies revealed that, on average, during the wet season, rice removed 20.7 kg N, 5.17 kg P, and 35.5 kg K for every tonne of grain output ([Yoshida, 1981](#)). Some countries, such as India, have agricultural soils with very low levels of SOM, often falling below the critical limit of 2% in the root zone due to the widespread use of extractive farming practises, the application of small amounts of organic fertilisers and the prevalence of soil degradation due to erosion, salinization and other processes ([Lal, 2020](#)).

To increase and maintain production, it is required to apply fertilizer components, particularly N, P and K from both organic and inorganic sources in proper quantities. Numerous studies conducted at research institutes and on farmer fields have shown the value of organic manures and bio-fertilizers in completing the nutritional requirements of crops and ensuring production stability ([Sharma et al., 2008](#)). To maintain agricultural productivity, it is important to identify such systems or practises. The long-term fertilizer tests carried out by AICRIP demonstrated and revealed that the simultaneous application of fertilizers and manures would not only add sustainability to production and improve soil health, but would also improve use efficiency of applied nutrients.

## 2. MATERIAL AND METHODS:

Field experiment was conducted in Godavari medium black soil developed from alluvium at Regional Agricultural Research Station, Maruteru in West Godavari. Soil samples from 0 to 15 cm depth in each plot were collected and examined for different physical, physicochemical and chemical parameters of the soil using established procedures prior to preparatory cultivation of the experimental site. According to the preliminary soil analysis data, the experimental soil has a clay loam texture, slightly acidic in response, high in organic carbon, low in available nitrogen, medium in available phosphorus, and medium in potassium.

**Table 1. General characteristics of initial composite soil sample**

PARTICULARS	Value	Method of Analysis	References
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I. Mechanical analysis			
1. Sand (%)	<b>43</b>	Bouyoucos hydrometer method	<a href="#">Piper, 1966</a>
2. Silt (%)	<b>26</b>		
3. Clay (%)	<b>31</b>		
Textural class	<b>Clay loam</b>		
Bulk density ( $\text{Mg m}^{-3}$ )	<b>1.2</b>	Core sampler method	<a href="#">Black, 1965</a>
pH (1:2.5)	<b>6.3</b>	Glass electrode pH meter	<a href="#">Jackson, 1973</a>
EC ( $\text{dS m}^{-1}$ )	<b>0.65</b>	Conductivity meter	<a href="#">Jackson, 1967</a>
Organic carbon (%)	<b>1.21</b>	Wet digestion method	<a href="#">Walkley and Black, 1934</a>
Available N ( $\text{kg ha}^{-1}$ )	<b>180.7</b>	Alkaline potassium permanganate method	<a href="#">Subbiah and Asija, 1956</a>
Available $\text{P}_2\text{O}_5$ ( $\text{kg ha}^{-1}$ )	<b>47.2</b>	Olsen's method	<a href="#">Olsen et al., 1954</a>
Available $\text{K}_2\text{O}$ ( $\text{kg ha}^{-1}$ )	<b>271</b>	Flame photometry	<a href="#">Muir et al., 1965</a>
Available sulphur ( $\text{mg kg}^{-1}$ )	<b>31.25</b>	0.15% $\text{CaCl}_2$ extraction, Turbidimetry	<a href="#">Chesnin and yien (1951)</a>
Available Zinc ( $\text{mg kg}^{-1}$ )	<b>1.22</b>	DTPA extractable method	<a href="#">Lindsay and Norvell, 1978</a>

## 2.1 Experimental Details

### 2.1.1 Experimental design and layout

Field experiment was started in Godavari alluvial soil at Regional Agricultural Research Station, Maruteru in Andhra Pradesh during *kharif*, 1989. The experimental site has been under rice cultivation since *kharif*, 1989 onwards.

The experiment was laid out in a randomized block design with eight treatments replicated three times for rice crop (variety: MTU-1064 Amara) with spacing of 20x15 cm during *kharif* season. The organic manures were incorporated one week before rice transplanting in the treatments.

### 2.1.2. TREATMENTS:

- T<sub>1</sub> - Control
- T<sub>2</sub> - 50% NPK
- T<sub>3</sub> - 50% NPK + 50% FYM-N
- T<sub>4</sub> - 50% NPK + 50% GM-N
- T<sub>5</sub> - 50% NP K + *Azospirillum*
- T<sub>6</sub> - FYM@ 10 t ha<sup>-1</sup>
- T<sub>7</sub> - 100% NPK+Zn+S
- T<sub>8</sub> - 100% NPK+Zn+S + FYM @ 5t ha<sup>-1</sup>

RDF for *Kharif* rice: 90:60:60 (kg/ha)

## **2.2 Cultivation Details of Rice**

Organic manures used in different treatment combinations were Peltophorum (green leaf manure) with nutrient composition (1.6%, 0.3% and 0.45 % N, P and K) and farmyard manure (0.62%, 0.29% and 0.72 % N, P and K). These manures were applied one week before transplanting. The prescribed fertiliser dose (90:60:60) was administered in the following forms: urea (46% N), single superphosphate (16% P<sub>2</sub>O<sub>5</sub>), muriate of potash (60% K<sub>2</sub>O), and zinc sulphate (ZnSO<sub>4</sub>.7H<sub>2</sub>O) @ 40 kg ha<sup>-1</sup>. The total dosage of phosphorus, potassium, and zinc was used as a basal application. Three equally divided applications of nitrogen were made: one at the basal, one at the tillering stage, and one at the panicle initiation stage.

### **2.2.1 Land Preparation:**

The nursery area was properly ploughed and levelled. With a tractor-drawn disc plough, each field plot was tilled under dry conditions. Then, 15 days prior to transplantation, water was applied to each plot, and a power tiller was used to puddle the soil. Each plot was levelled with a wooden plank after the last puddling. The plots were set up according to the experimental design and the field was surrounded by irrigation and drainage systems.

## **2.3 SOIL ANALYSIS**

### **2.3.1 Collection and Processing of Soil Samples**

Soil samples were collected from each treatment plot after harvest. Soil samples were drawn from 0-15 cm depth for estimation of soil physical, physico-chemical and chemical properties. After properly mixing the soil, the quartering procedure was used to generate samples weighing approximately 1/2 kg. The samples were crushed, sieved through a 2 mm sieve, and kept in a neatly marked polythene bag for soil analysis using normal procedures after air drying in the shade. For the purpose of estimating the amount of organic carbon, these sieved samples were further run through a 0.2 mm sieve.

### **2.3.2 Statistical Analysis**

The data from the observations were statistically analysed using the analysis of variance for a randomised block design approach proposed by [Panse and Sukhatme \(1978\)](#). The statistical significance was examined using the F-test at a 5% level of probability, and if the "F" value was determined to be significant, the critical difference (CD) was calculated to test the significance

### **2.3.3 Yield Data:**

#### **Grain Yield**

Each net plot's harvested crop was bagged separately, left to dry in the sun, and then threshed using a paddy thresher according to each plot's harvest. Following threshing, the grain was cleaned, dried in the

sun to a consistent weight, and then weighed again to determine the final yield. Before expressing the total grain yield in  $\text{kg ha}^{-1}$ , grain yields from the labelled hills were added to those corresponding plot yields.

### Straw Yield

Each treatment's net plot straw was sun-dried to a consistent weight. Before expressing the total straw yield in  $\text{kg ha}^{-1}$ , the straw from the five marked hills was added to their respective net plot yields.

## 3.RESULTS AND DISCUSSION:

### 3.1. Long-term effect of organic and inorganic fertilizers on soil physical, physico-chemical and chemical properties:

#### 3.1.1 Bulk Density

The highest bulk density (1.15) was recorded under the treatment control, whereas lowest bulk density (0.95) was recorded in the treatment  $T_6$  received FYM @  $10 \text{ t ha}^{-1}$  and it was on par with  $T_8$ :100 % NPK + Zn + S + FYM @  $5 \text{ t ha}^{-1}$  (0.98),  $T_3$ :50% NPK + 50% N-FYM (1.02),  $T_4$ :50% NPK + 50% N-Green Manure (1.01),  $T_5$ :50% NPK + 50% N-Azospirillum (1.04). There was a decrease in bulk density from initial soil sample to post harvest soil in all the treatment plots. The improved aggregation, higher porosity and improvement in soil structure brought about by the increase in soil organic matter are the causes of the reduction in bulk density of soil under integrated nutrition management. The findings made it very evident that combining organic sources with inorganic fertilisers lowers soil bulk density. These findings were similar to the findings reported by [Kharche et al. \(2013\)](#), reported that the integration of chemical fertilisers with organics resulted in a considerable reduction in bulk density from an initial value of  $1.32 \text{ Mg m}^{-3}$ , which was much lower than that of the control and solely chemical fertilisers. Numerous scientists have noted that the by-products of organic material decomposition typically aid in the granulation of soil particles and so enhance the soil's porosity, which naturally lowers the bulk density of the soil.

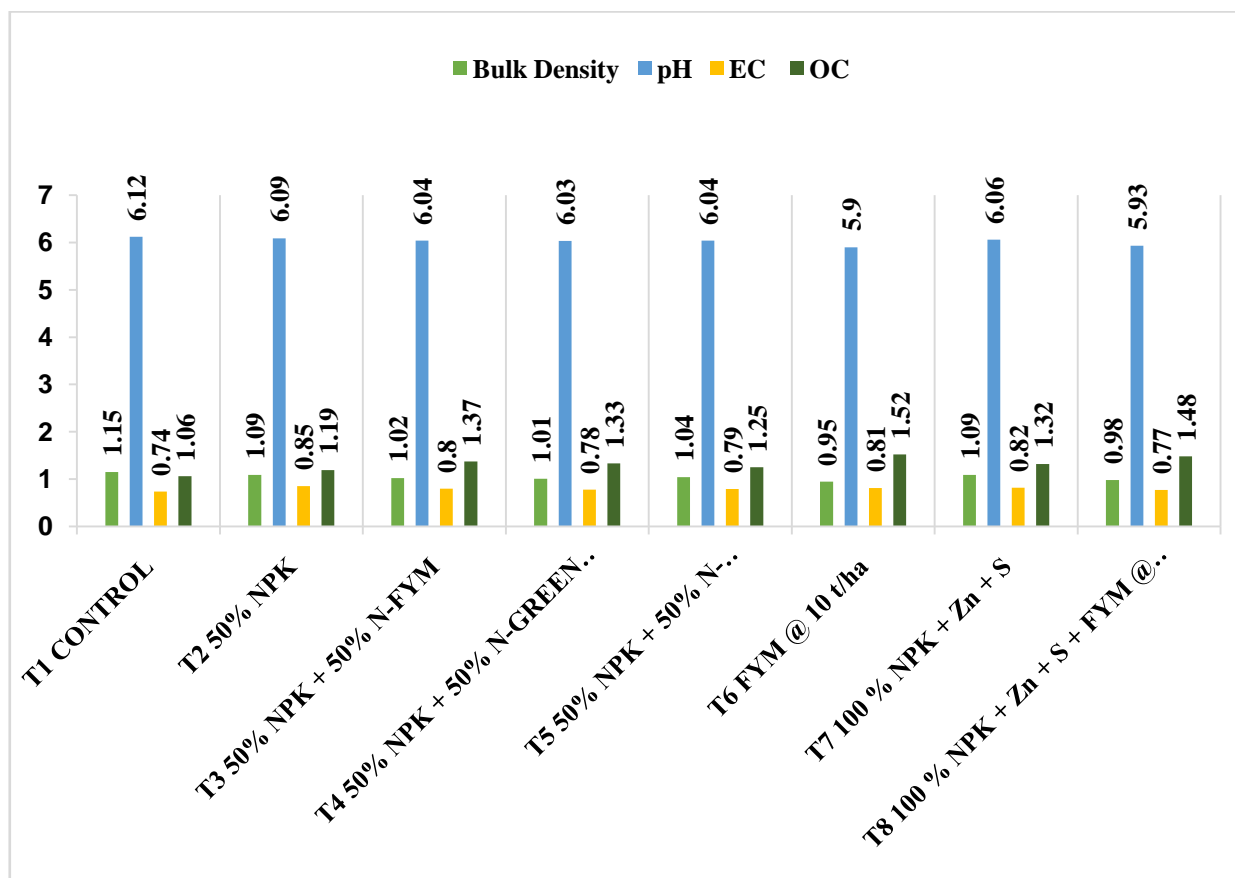
#### 3.1.2 pH & Electrical conductivity (EC)

The results revealed that there was no significant difference in the pH and electrical conductivity values among all the treatments.

#### 3.1.3 Organic Carbon (%)

The highest soil organic carbon content was recorded in the organic treatment *i.e.*,  $T_6$  which received FYM @  $10 \text{ t ha}^{-1}$  (1.52 %). However, it was on par with treatments  $T_8$ - 100 % NPK + Zn + S + FYM @  $5 \text{ t ha}^{-1}$  (1.48 %),  $T_3$ -50% NPK + 50% N-FYM (1.37 %) and lowest soil organic content was observed in control (1.06 %). Increased OC content with integrated usage of chemical fertilisers and organic manure treatments might be attributable to direct synergistic effect of combined application of organics and inorganics resulted in improved root growth, and the addition of additional plant residues. Similar findings were obtained by [\(Sowmya et al., 2022\)](#) The FYM-treated plots had the highest levels of organic carbon due to the direct addition of organic matter to the soil and the stimulating effects of organics on boosting growth and the

activity of microorganisms. The direct incorporation of organic matter in the soil is attributed to the rise in soil organic carbon in the manure treatment combinations. Following the breakdown of these components, the soil's organic carbon content may have increased ([Dey et al., 2020](#); [Datta et al., 2022](#)).



**Fig. 1. Long-term effect of organic and inorganic fertilizers on soil Physical & Physico-chemical properties**

### 3.1.4 Available Nitrogen

Significantly higher available nitrogen ( $261 \text{ kg N ha}^{-1}$ ) was recorded in the treatment  $T_8$  i.e., (100 % NPK + Zn + S + FYM @  $5 \text{ t ha}^{-1}$ ) and it was on par with treatments that received 50 % NPK + *Azospirillum* ( $T_5$ - $249 \text{ kg ha}^{-1}$ ), 100 % NPK + Zn + S ( $T_7$ -  $249 \text{ kg ha}^{-1}$ ), 50 % NPK + 50 % GM-N ( $T_4$ -  $246 \text{ kg ha}^{-1}$ ), 50 % NPK + 50 % FYM-N ( $T_3$ -  $245 \text{ kg ha}^{-1}$ ). Lowest available nitrogen was recorded in Control ( $T_1$ -  $212 \text{ kg ha}^{-1}$ ). The maximum nitrogen concentration was found when organic and inorganic materials were applied together. This may be caused by the beneficial effects of manuring with inorganic fertilisers on soil nitrogen status, and it may also be brought about by the retention of nitrogen in the labile microbial pool due to shifting microbial flushes or by N mineralization from organic sources. Further, the wet soil conditions may have aided in the mineralization of soil nitrogen and increased soil microbial growth, which might have converted organically bound nitrogen into a form that was more easily available and resulted in the accumulation of more readily available nitrogen. The low nitrogen availability in FYM might be attributed to the fact that the nutrient releasing pattern of FYM is sluggish and the nutrient content is also low ([Balamurugan et al., 2020](#)).

### 3.1.5 Available Phosphorus

The highest phosphorus content ( $55.5 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ ) recorded in the treatment  $T_8$  *i.e.*, (100 % NPK + Zn + S + FYM @  $5 \text{ t ha}^{-1}$ ) and it was on par with treatments that received 100 % NPK + Zn + S ( $T_7$ - $43 \text{ kg ha}^{-1}$ ), 50 % NPK + 50 % FYM-N ( $T_3$ -  $49.9 \text{ kg ha}^{-1}$ ), 50 % NPK + 50% GM-N ( $T_4$ -  $48.4 \text{ kg ha}^{-1}$ ), FYM @  $10 \text{ t ha}^{-1}$  ( $T_6$ -  $48.8 \text{ kg ha}^{-1}$ ). Lowest available Phosphorus was recorded in Control ( $T_1$ -  $25.6 \text{ kg ha}^{-1}$ ). In treatment  $T_8$ , additional usage of FYM, a direct source of phosphorus, contributed to the improvement in the status of available phosphorus. It might have also solubilized the native phosphorus in the soil by releasing several organic acids that have a chelating action decreased the fixation of phosphorus. Similar results agree with those of [Verma et al. \(2012\)](#). Increased available P status with FYM and green manure treatment might be attributed to P mobilisation in the soil. This rise in P might also be related to the breakdown of organic manures, which results in the release of significant amounts of  $\text{CO}_2$  and organic acids and these Organic manures provide a protective layer on sesquioxides, allowing the soil's phosphate-fixing ability to be reduced ([Sabeena et al., 2022](#); [Sharma et al., 2001](#)).

### 3.1.6 Available Potassium

The highest potassium content ( $411 \text{ kg K ha}^{-1}$ ) recorded in the treatment  $T_8$  *i.e.*, 100% NPK + Zn + S+ FYM @  $5 \text{ t ha}^{-1}$  ( $411 \text{ kg ha}^{-1}$ ) and it was on par with treatments that received 100 % NPK + Zn + S ( $T_7$ ,  $407 \text{ kg ha}^{-1}$ ). Lowest available Potassium was recorded in Control ( $T_1$ ,  $337 \text{ kg ha}^{-1}$ ). Numerous researches have noted that organic manure has a favourable impact on the amount of K that is accessible ([Das et al., 2021](#); [Biswas et al., 2023](#)). The findings of the experiment revealed that the highest accessible nutrient status was seen in the combination of organic and inorganic treatments. Long-term use of chemical fertilisers in combination with organic manures boosts the soil potassium content. The higher ability of organic colloids to retain K ions on the exchange sites may be responsible for this ([Rajashekarappa et al., 2014](#)). [Verma et al. \(2002\)](#) also observed that continual usage of FYM and green manures improved the soil potassium status. The favourable effect of green leaf manuring and FYM on available potassium might be attributed to a decrease in potassium fixation, solubilization and release as a result of organic matter interaction with clay, in addition to direct potassium addition to the soil potassium pool.

### 3.1.7 Available Sulphur

The highest available sulphur was recorded in the treatment  $T_8$  *i.e.*, (100 % NPK + Zn + S + FYM @  $5 \text{ t ha}^{-1}$ ) and it was on par with  $T_7$ -(100 % NPK + Zn + S),  $T_6$ - FYM @  $10 \text{ t ha}^{-1}$ . Lowest was recorded in  $T_1$ -Control. Because of the continuous cropping and manuring for 33 years, the soil nutrient status in terms of S increased in all plots treated with FYM and fertilisers. This was reportedly attributable to the provision of S from organic sources as well as that delivered in fertilisers. [Mengyu et al. \(2017\)](#) observed that a long-term application of organic fertilization combined with chemical fertilization can enhance total sulphur and valid sulphur.

### 3.1.8 Available Zinc

Highest zinc content in the soil was recorded in the treatment T<sub>8</sub>-100 % NPK + Zn + S + FYM @ 5 t ha<sup>-1</sup> (1.71 mg kg<sup>-1</sup>), it was on par with T<sub>7</sub>-100 % NPK + Zn + S (1.59 mg kg<sup>-1</sup>) & T- FYM @ 10 t ha<sup>-1</sup> (1.54 mg kg<sup>-1</sup>) and lowest was observed in Control (0.79 mg kg<sup>-1</sup>). An increase in DTPA extractable zinc in inorganic treatment T<sub>7</sub> might be due to synergistic effect between nitrogen and zinc. The zinc-enriched treatments (T<sub>7</sub>, T<sub>8</sub>) showed increased Zn content in the soil, which was attributed to the enrichment of organic manure with the application of fertilizer zinc, which might have supplied additional Zn to the soil pool. This was in accordance with the findings of [Sabeena et al. \(2022\)](#). The rise in Zn availability owing to the use of FYM in conjunction with NPK may be attributed to Mineralization of organically bound forms of Zn complexation in FYM ([Shambhavi et al., 2018](#)). This may be an impact of the synthesis of organic chelates, which reduced the susceptibility of Zn adsorption, fixing, and precipitation, increasing its availability in soil ([Sabeena et al., 2022](#); [Babu et al., 2007](#)).

### **3.2. Long-term effect of organic and inorganic fertilizers on yield data**

**3.2.1 Grain yield:** Results of the present investigation revealed that combined application of organic and inorganic manures recorded higher grain yields when compared to organic and inorganic manures applied alone. The grain yield of rice ranged from 2780 to 6115 kg ha<sup>-1</sup>. Significantly higher grain yield was recorded in treatment T<sub>8</sub> and it was on par with T<sub>7</sub>, whereas lowest was observed under Control.

The increase in production in integrated applied plots may be attributed to greater and continuous access to nutrients for plants, which eventually boosted grain output ([Farhad et al., 2009](#)). In addition to increasing N availability, manures also provide micronutrients that promote P and K usage efficiency, leading to better growth and production characteristics. The benefits of green manuring and FYM were equivalent and enhanced rice grain production considerably above the control ([Ram et al., 2011](#)). Increased root biomass may have enhanced nutrient absorption by using more soil, which would have improved physiology and metabolism within the plant, leading to increased yields ([Rao et al., 2014](#); [Srinivas et al., 2015](#)).

### **3.2.2 Straw Yield:**

The straw yield of rice ranged from 4795 to 8887 kg ha<sup>-1</sup>. It was observed that there was a significant difference in straw yields among the treatments. Significantly highest straw yield was recorded in the treatment T<sub>8</sub> (8887 kg ha<sup>-1</sup>) which received 100 % NPK + Zn + S + FYM @ 5 t ha<sup>-1</sup>, but it was on par with treatment T<sub>7</sub> (8592 kg ha<sup>-1</sup>)-100 % NPK + Zn + S whereas lowest was observed under Control (4792 kg ha<sup>-1</sup>). The data revealed that there was an improvement in straw yield in all the treatments except control. This might be due to improved nutrient availability and, as a result, higher nutrient absorption by plants. Rice straw yields were shown to improve when FYM and inorganic fertilisers were applied together, according to [Naing et al. \(2010\)](#). This suggests that farmers might use less inorganic fertiliser while still boosting the yield of their straw by mixing FYM and inorganic fertilisers. According to [Bodruzzaman et al. \(2010\)](#), plots treated with 10 t ha<sup>-1</sup> FYM with 75% NPKZn yielded as much rice straw as or more than plots treated with 100% NPKZn.

Treatments	N (kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	K (kg ha <sup>-1</sup> )	S (kg ha <sup>-1</sup> )	Zn (kg ha <sup>-1</sup> )	Grain Yield (kg ha <sup>-1</sup> )	Straw Yield (kg ha <sup>-1</sup> )
T <sub>1</sub>	212	25.6	337	29.25	0.79	2780	4795
T <sub>2</sub>	231	41.2	354	30.57	1.03	3995	6399
T <sub>3</sub>	245	49.9	360	32.96	1.35	4652	7592
T <sub>4</sub>	246	48.4	373	31.34	1.22	4660	7387
T <sub>5</sub>	249	43	355	31.22	1.31	4077	7248
T <sub>6</sub>	224	48.8	365	35.63	1.54	4327	7427
T <sub>7</sub>	249	52.5	407	37.28	1.59	5370	8592
T <sub>8</sub>	261	55.5	411	38.69	1.71	6115	8887
<b>SEm ±</b>	9	2.75	12.82	1.16	0.07	257	370
<b>CD @ 0.05</b>	27.3	8.35	38.9	3.52	0.20	779	1122
<b>CV (%)</b>	6.5	10.47	6.01	6.02	8.76	9.89	8.79

**Table. 2. Long-term effect of organic and inorganic fertilizers on soil Chemical properties and Rice Grain & Straw yield**

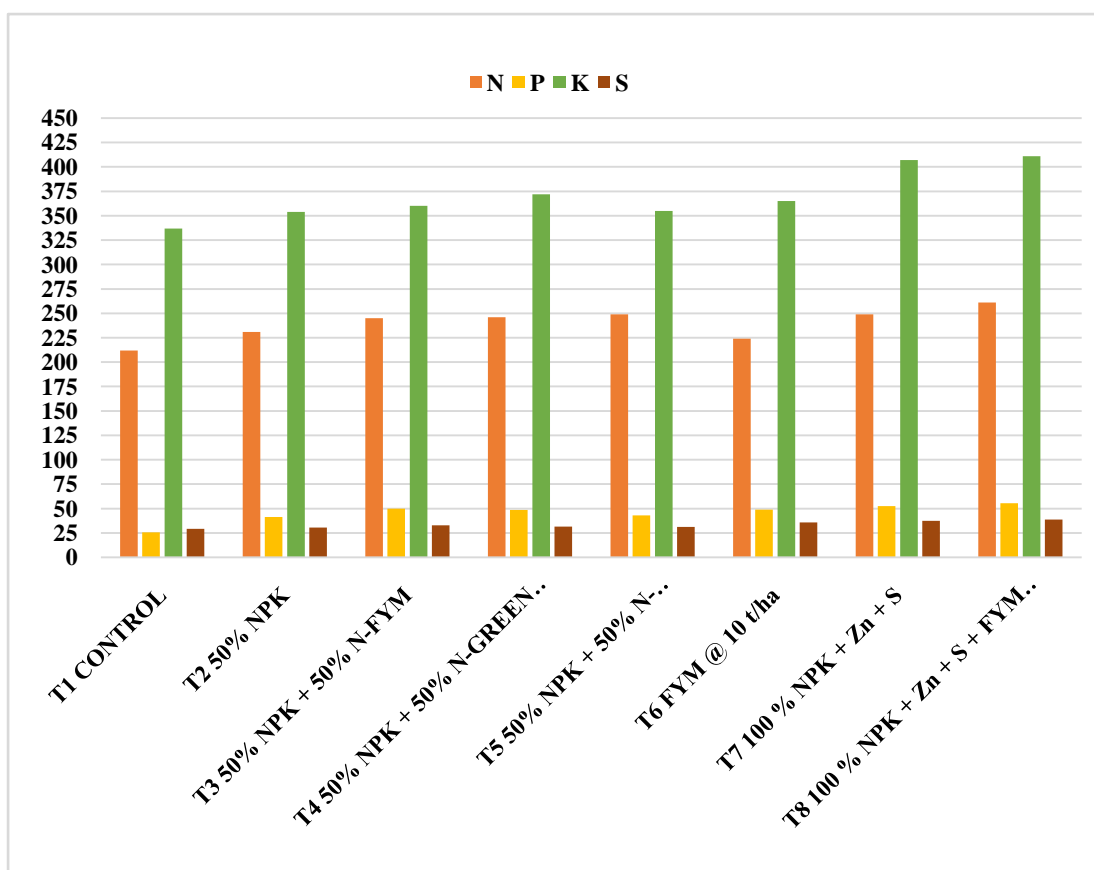


Fig. 2. Long-term effect of organic and inorganic fertilizers on soil chemical properties.

#### 4. CONCLUSION:

Continuous fertiliser and manure application affects the soil physical, physicochemical and chemical properties. After the investigation, present study concludes that conjunctive and combined application of organics with inorganics improve soil physical, physico-chemical and chemical properties of the soil. As a result, FYM may be utilised as an alternative source to minimise the consumption of inorganic fertiliser. This long-term study concludes that applying 100% RDF + Zn + S + FYM @ 5 t ha<sup>-1</sup> is a superior alternative in terms of yield components, supplementing inorganics with organics is the optimal strategy for preserving soil quality and crop production.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exists.

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