***Original Research Article***

# Effect of paddy residue and nutrient management approaches on growth, yield and nutrient uptake by paddy in paddy-paddy cropping system


**ABSTRACT:**

An investigation on the efficacy of paddy residue and nutrient management approaches on growth, yield and nutrient uptake by paddy was conducted during *kharif* and *rabi-summer* seasons of 2019-20 and 2020-21 at Gabbur village, Raichur, Karnataka, India. The experiment was laid out in split plot design with three replications, which consisted of four residue management in main plots and five nutrient management approaches in sub plots.The treatment with residue incorporation + compost culture gave significantly taller plants (84.40 and 84.53 cm), higher number of tillers hill$^{-1}$ (20.06 and 20.09), grain yield (65.37 & 65.34 q ha$^{-1}$), straw yield (80.01 & 80.04 q ha$^{-1}$) and total N, P, K, S, Zn & Fe uptake over residue incorporation alone, residue burning and residue removal. Similarly, application of nutrients through SSNM targeted yield of 80 q ha$^{-1}$ gave significantly higher plant height (90.51 and 90.50 cm), higher number of tillers hill$^{-1}$ (23.02 and 22.95), grain yield (75.19 & 75.26q ha$^{-1}$), straw yield (92.17 & 92.14 q ha$^{-1}$) and total N, P, K, S, Zn & Fe uptake followed by STCR targeted yield of 80 q ha$^{-1}$ > STL method > recommended NPK > absolute control. Interaction effect showed that, residue incorporation + compost culture with SSNM targeted yield of 80 q ha$^{-1}$ recorded significantly higher plant height (95.95 and 96.13), number of tillers hill$^{-1}$ (25.50 and 25.56), grain yield (77.25 and 77.45 q ha$^{-1}$), straw yield (94.83 and95.32 q ha$^{-1}$) and nutrient uptake by paddy over other combinations.



**Keyword:** Paddy, Growth, Yield, Nutrient uptake


## 1. INTRODUCTION

Sustainability of natural resources such as soil and water for crop production is a major challenge with burgeoning population pressure. There is a need to balance between increasing crop production without compromising soil health and environmental sustainability**.** In Asia, rice is the principal staple crop where ~90 percent of the global rice being grown and consumed. In India, it occupies ~43.8 m ha of cultivable area with production of ~118.87 mt [1]. Intensive mono-cropped system of rice cultivation has commenced to show declining trend in rice yield, where imbalance nutrient management and decreasing soil organic matter are the major accountable factors for the declining the rice yield.

Crop residue is a kind of energy materials that is rich in carbon. Returning of crop residues in field has great significance in maintaining soil fertility and developing sustainable agriculture. After the green revolution, the introduction of high input technologies and high yielding varieties led to higher crop residue generation in India. Billions of tonns of crop residue now become trash due to the promotion of crop yield and the mechanical harvest. The disposal of such huge amount of residue is a major concern, particularly in the region where rice-rice/rice-wheat cropping system is extensively followed. Hence, the abundant

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**Comment [s3]:** Please don't use symbol, write 'and'

**Comment [s4]:** Please don't mention q as the unit, make it kg/ha or t/ha.

**Comment [s5]:** There is a need for improvement of Introduction part.
1.Some more recent references are to be added.
2.References of pervious research in the direction can be mentioned.
3.Nutrient dynamics of rice-rice or cereal-cereal cropping system should be written clearly.
4.Authors may look into the following recent researches:
(a) Hossain et al. 2021. https://doi.org/10.1007/978-981-16-0827-8_28
(b) Shankar et al. 2021. https:// doi.org/10.3390/plants10081622
(c) Zhang et al. 2021. https://doi.org/10.1016/j.cj.2020.11.007
(d) Sarkar et al., 2020. doi:10.3390/su12239808

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crop residues are often burnt by farmers in harvest seasons, resulting in not only awaste of organic fertilizer resource but also environmental pollutions and negative effects on soil ecosystem [2]. Crop residue contains considerable quantity of carbons (C), nitrogen (N), phosphorus (P), potassium (K) and other nutrients. In addition, crop residue can also improve soil properties and increase yield of crop.

In nature, the bioconversion rate of paddy straw is slow and natural micro flora participates in degradation of the crop waste. Therefore, bio-augmentation of paddy straw with efficient microbes may improve and/or accelerate the decomposition process and fasten nutrient release by creating a suitable environment for degradation. Fungi are an important component of soil micro-biota in soil constituting more of the soil biomass than bacteria, depending on depth and nutrient conditions of soil. Fungi being filamentous in nature have an advantage in the decomposition of lignocellulosic waste as they possess ability to produce prolific spores that can quickly invade substrates. They play an important role in the degradation of rice straw. Moreover, mixed cultures can have greater influence on substrate colonization because of the higher production of enzymes and resistance to contaminant microbes compared to pure cultures. A compatible consortium of lignocellulolytic fungal might play an important role in the rapid degradation of paddy straw.

In recent years with the development of chemical fertilizer, use of the organic fertilizers has dramatically reduced. The effect of the incorporation of crop straws on the fertility of soil as well as yield response of the crop was well documented. However, the residue incorporation along with different nutrient management approaches *viz*., site specific nutrient management (SSNM), soil test and crop response (STCR), soil test laboratory method (STL) on yield and nutrient uptake has been rarely reported in paddy-paddy cropping system. Keeping in view of harmful effect of residue burning and excess fertilizer application rates, the present study was undertaken.

## 2. MATERIAL AND METHODS

### 2.1 Experimental site and soil

The field experiments were conducted during *kharif* and *rabi-summer* season of 2019-2020 and 2020-2021 in progressive farmer field at Gabbur village, Raichur situated in the North Eastern Dry Zone (Zone 2) of Karnataka at 16° 18'Nlatitude 77° 06' E longitude with an altitude of 393 m above mean sea level.

The soil of the experimental site was clay in texture with neutral pH (7.95), medium EC (1.13 dS $m^{-1}$) and high in OC (15.00 g $kg^{-1}$). The soil was low in available nitrogen (168.00kg $ha^{-1}$), high in available phosphorus (188.99 kg $ha^{-1}$) & potassium (520.12 kg $ha^{-1}$) and medium in available sulphur (16.30 mg $kg^{-1}$). The DTPA extractable Zn and Fe were in sufficient range with values 2.08 and 5.05, mg $kg^{-1}$, respectively.

### 2.2 Experimental details

The experiment was laid out in split plot design having four residue management (M) and five nutrient management approaches (T) with three replications as detailed in Table 1.

**Table 1: Treatment details**

| Main plot: Residue management | Subplot: Nutrient management |
|---|---|
| **$M_1$**: Residue removal<br>**$M_2$**: Residue incorporation (RI)<br>**$M_3$**: RI + Compost culture<br>**$M_4$**: Residue burning | **$T_1$**: Absolute control<br>**$T_2$**: Recommended NPK<br>**$T_3$**: Fertilizer based on STL<br>**$T_4$**: Fertilizer based on STCR for yield target of 80 q $ha^{-1}$<br>**$T_5$**: Fertilizer based on SSNM for yield target of 80 q $ha^{-1}$ |

During *kharif* 2019, the required amount of paddy residue of 94 q $ha^{-1}$ with nutrient composition of 0.42, 0.12 and 1.3 % of N, P and K, respectively was determined based on the straw generated in the farmer's field. In the subsequent seasons, immediately after harvest, above-ground residues from the individual plots were either completely removed/ retained/ retained & inoculated/ burnt and incorporated into about 15 cm depth using a tractor drawn rotovator. The fungal culture used in the study was "Compost culture" developed by Institute of Organic Farming, University of Agricultural Sciences Dharwad, Karnataka, India, which is a mixture of four microorganisms *i.e*., *Aspergillus*sps., *Trichoderma*sps., *Phaenerochaete*sps. and*Pleurotus*sps was applied @ 1 kg per tonne of paddy residue.

### 2.3 Fertilizer calculations

The quantity of fertilizer dose for soil test laboratory (STL) method was calculated on the basis of low, medium and high fertility ratings for N, $P_2O_5$ and $K_2O$. Furthermore, the quantity of fertilizers for STCR treatment was calculated by using standardized equation developed for *Vertisols* of Siruguppa for rice cultivation [3] as detailed below;

FN = 3.45 T - 0.29 SN (KMnO$_4$ - N)
F$P_2O_5$ = 2.82 T - 1.70 S$P_2O_5$ (Olsen's - $P_2O_5$)
F$K_2O$ = 2.00 T - 0.09 S$K_2O$ ($NH_4$OAC - $K_2O$)

Where,

T = Targeted yield (q $ha^{-1}$)
FN = Nitrogen supplied through fertilizer (kg $ha^{-1}$)
F$P_2O_5$ = Phosphorus supplied through fertilizer (kg $ha^{-1}$)
F$K_2O$ = Potassium supplied through fertilizer (kg $ha^{-1}$)

Similarly, for SSNM, the quantity of N, $P_2O_5$ and $K_2O$ required were calculated based on the nutrient removal by paddy crop per tonne. In the first season, the average nutrient removal of N, $P_2O_5$ and $K_2O$ by rice crop per tonne grain production considered was 17.81, 16.67 and 25.86 kg $ha^{-1}$ [4]. In the subsequent seasons nutrient removal of N, P and K considered was on the basis of previous crop results.

### 2.4 Growth and yield measurements

The plant height and number of tillers $hill^{-1}$of paddy in each season was recorded at crop harvest. In each season, the above ground biomass of all plants was manually harvested separately from the net plot, threshed and dried in sun. The grains were cleaned and weight was recorded in quintals hectare (q $ha^{-1}$).

### 2.5 Nutrient uptake by paddy

The collected plant samples (grain and straw ) at the time of harvest from each plot were thoroughly washed with deionized water and oven dried at 60 °C to obtain constant weight, cut to pieces, powdered and used for analysis of total N, P, K, S and micronutrients using standard procedures and workout for total uptake.

### 2.6 Statistical analysis

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The experimental data were subjected to statistical scrutiny to find out the influence of treatments on growth, yield and nutrient uptake by paddy. Further the effects were tested at 5% level of significance [5].

## 3 RESULT AND DISCUSSION

The data on growth, yield and nutrient uptake paddy are furnished inTable 2 to 7. There was a slight difference in these parameters during both *kharif* and *rabi-summer* experiments, but the pattern of response were similar. Hence, only pooled data of the two years are used to emphasize the results.

### 3.1 Growth attributes of paddy

Pooled results showed that, among the residue management options, RI + compost culture registered significantly higher plant height (84.40 and 84.53 cm) and number of tillers hill$^{-1}$ (20.06 and 20.09) over residue incorporation alone, residue burning & residue removal during *kharif* and *rabi-summer* season, respectively (Table 2). The results obtained in performances probably due to better decomposition of the paddy straw by added microbial inoculants, which led to enhanced nutrients availability and good soil condition to the crop growth resulted in quantitative increase in growth attributes with increased cell division, cell enlargement, photosynthesis and protein synthesis. The beneficial role of microbial inoculants on plant height was also reported by Singh *et al*. [6] in rice crop.

During *kharif* and *rabi-summer* season, application of fertilizers based on SSNM targeted yield of 80 q ha$^{-1}$ ($T_5$) recorded significantly higher plant height (90.51 and 90.50 cm) and number of tillers hill$^{-1}$ (23.02 and 22.95) followed by SSNM targeted yield of 80 q ha$^{-1}$ > STL method > recommended NPK > absolute control (Table 2). Improved plant height and number of tillers hill$^{-1}$ under SSNM targeted yield of 80 q ha$^{-1}$ was accrued due to sufficient nutrients supply as per crop demand and indigenous soil nutrient supplying capacity as compared to STL method, recommended NPK and absolute control. The results are also in conformity with the findings of Raghavendra *et al*. [7], who reported higher plant height of 72.8 cm with the application of site specific nutrients (150: 43: 115 kg NPK kg ha$^{-1}$) in dry-DSR. A similar result for plant height was also noticed in rice [8].

Significantly higher plant height of 95.95 & 96.13 cm and number of tillers hill$^{-1}$ of 25.50 & 25.56 was noticed under RI + compost culture with SSNM targeted yield of 80 q ha$^{-1}$ ($M_3T_5$; Table 2) in comparison to other combinations which might be due to enhanced availability of both macro and micro nutrients besides improvement in soil microbial activity.The enhanced uptake of these nutrients might have resulted in increased vegetative growth of plant. In parallel, Vijayaprabhakar *et al*. [9] reported that the incorporation of harvested rice residue with 25 kg additional N ha$^{-1}$ as basal + bio-mineralizer (2 kg t$^{-1}$ of rice residue) and cow dung slurry (5 %) recorded higher plant height and number of tillers hill$^{-1}$over incorporation of straw alone and removal of straw.

### 3.2 Yield of paddy

Among the different residue managements, RI + compost culture ($M_3$) registered significantly higher grain yield of 65.37 & 65.34 q ha$^{-1}$ and straw yield of 80.01 & 80.04 q ha$^{-1}$ during both *kharif* and *rabi-summer* season, respectively over residue incorporation alone, residue burning and residue removal (Table 3).The impact of straw application on crop yield varies dependingon straw application timing, straw incorporation method, theamount of crop residue, soil characteristics and the amount of fertilizer applied [10]. Crop residues upon decomposition releases essential nutrients slowly throughout the growth period, which will result in better plant growth and yield as noticed in our study. While the incorporation of paddy straw with compost culture enhanced this process and resulted in higher grain & straw yield when compared to straw incorporation alone, residue burning and residue removal, possibly due to microbial load, which can accelerate the decomposition of crop straws. These findings were in support of Jayadeva *et al*. [11].

**Table 2: Plant height and number of tillers hill$^{-1}$of paddy as influenced by residue and nutrient management**

| Treatment | Plant height (cm) | | | | | | Number of tiller hill$^{-1}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Kharif* | | | *Rabi-summer* | | | *Kharif* | | | *Rabi-summer* | | |
| | **2019** | **2020** | **Pooled** | **2019-20** | **2020-21** | **Pooled** | **2019** | **2020** | **Pooled** | **2019-20** | **2020-21** | **Pooled** |
| **Residue management (M)** | | | | | | | | | | | | |
| $M_1$: Residue removal | 77.86 | 78.10 | 77.98 | 76.39 | 77.58 | 76.98 | 16.75 | 17.22 | 16.98 | 16.22 | 16.88 | 16.55 |
| $M_2$: Residue incorporation (RI) | 80.28 | 81.80 | 81.04 | 80.76 | 80.99 | 80.88 | 18.26 | 19.18 | 18.72 | 18.59 | 18.85 | 18.72 |
| $M_3$: RI + Compost culture | 83.31 | 85.50 | 84.40 | 84.40 | 84.66 | 84.53 | 19.44 | 20.68 | 20.06 | 19.89 | 20.29 | 20.09 |
| $M_4$: Residue burning | 78.16 | 78.69 | 78.42 | 76.78 | 77.92 | 77.35 | 16.93 | 17.58 | 17.25 | 16.51 | 17.21 | 16.86 |
| **S.Em.±** | **0.49** | **0.64** | **0.40** | **0.42** | **0.44** | **0.33** | **0.20** | **0.25** | **0.15** | **0.17** | **0.16** | **0.11** |
| **C.D. at 5%** | **1.69** | **2.20** | **1.40** | **1.44** | **1.52** | **1.16** | **0.70** | **0.87** | **0.52** | **0.59** | **0.56** | **0.39** |
| **Nutrient management (T)** | | | | | | | | | | | | |
| $T_1$: Absolute control | 66.43 | 64.23 | 65.33 | 64.52 | 63.91 | 64.21 | 11.48 | 11.06 | 11.27 | 11.09 | 10.91 | 11.00 |
| $T_2$: Recommended NPK | 77.32 | 79.14 | 78.23 | 77.12 | 78.37 | 77.74 | 16.67 | 17.57 | 17.12 | 16.68 | 17.27 | 16.97 |
| $T_3$: STL | 81.08 | 83.11 | 82.09 | 81.05 | 82.19 | 81.62 | 17.98 | 18.98 | 18.48 | 17.87 | 18.64 | 18.26 |
| $T_4$: STCR of 80 q ha$^{-1}$ | 85.20 | 87.10 | 86.15 | 84.96 | 86.24 | 85.60 | 20.73 | 22.03 | 21.38 | 20.63 | 21.57 | 21.10 |
| $T_5$: SSNM of 80 q ha$^{-1}$ | 89.50 | 91.52 | 90.51 | 90.27 | 90.73 | 90.50 | 22.36 | 23.67 | 23.02 | 22.74 | 23.16 | 22.95 |
| **S.Em.±** | **0.43** | **0.59** | **0.39** | **0.40** | **0.43** | **0.33** | **0.19** | **0.21** | **0.13** | **0.16** | **0.19** | **0.13** |
| **C.D. at 5%** | **1.24** | **1.69** | **1.13** | **1.14** | **1.23** | **0.95** | **0.55** | **0.60** | **0.38** | **0.47** | **0.56** | **0.39** |
| **Interaction (M × T)** | | | | | | | | | | | | |
| $M_1T_1$ | 65.99 | 63.79 | 64.89 | 63.87 | 63.45 | 63.66 | 11.22 | 10.61 | 10.91 | 10.67 | 10.51 | 10.59 |
| $M_1T_2$ | 75.15 | 75.85 | 75.50 | 73.26 | 75.40 | 74.33 | 15.60 | 16.15 | 15.87 | 14.99 | 15.82 | 15.41 |
| $M_1T_3$ | 78.78 | 79.66 | 79.22 | 77.11 | 79.07 | 78.09 | 16.74 | 17.53 | 17.13 | 16.00 | 17.17 | 16.58 |
| $M_1T_4$ | 82.67 | 83.62 | 83.14 | 80.82 | 82.83 | 81.83 | 19.29 | 20.16 | 19.73 | 18.51 | 19.69 | 19.10 |
| $M_1T_5$ | 86.72 | 87.57 | 87.15 | 86.88 | 87.16 | 87.02 | 20.89 | 21.65 | 21.27 | 20.93 | 21.20 | 21.07 |
| $M_2T_1$ | 66.66 | 64.37 | 65.51 | 64.85 | 64.15 | 64.50 | 11.69 | 11.36 | 11.53 | 11.40 | 11.17 | 11.29 |
| $M_2T_2$ | 77.78 | 80.11 | 78.95 | 78.76 | 79.20 | 78.98 | 16.97 | 18.06 | 17.52 | 17.63 | 17.80 | 17.72 |
| $M_2T_3$ | 81.44 | 84.05 | 82.74 | 82.73 | 82.90 | 82.81 | 18.46 | 19.44 | 18.95 | 18.81 | 19.14 | 18.98 |
| $M_2T_4$ | 85.63 | 87.92 | 86.77 | 86.50 | 87.03 | 86.76 | 21.30 | 22.71 | 22.00 | 21.72 | 22.30 | 22.01 |
| $M_2T_5$ | 89.90 | 92.54 | 91.22 | 90.97 | 91.65 | 91.31 | 22.86 | 24.31 | 23.58 | 23.40 | 23.86 | 23.63 |
| $M_3T_1$ | 66.83 | 64.71 | 65.77 | 65.38 | 64.44 | 64.91 | 11.75 | 11.60 | 11.67 | 11.56 | 11.36 | 11.46 |
| $M_3T_2$ | 80.85 | 84.14 | 82.50 | 82.72 | 83.22 | 82.97 | 18.34 | 19.61 | 18.98 | 18.84 | 19.36 | 19.10 |
| $M_3T_3$ | 85.04 | 88.38 | 86.71 | 86.87 | 87.40 | 87.14 | 19.77 | 21.07 | 20.42 | 20.33 | 20.74 | 20.54 |
| $M_3T_4$ | 89.56 | 92.61 | 91.09 | 91.19 | 91.83 | 91.51 | 22.76 | 24.70 | 23.73 | 23.46 | 24.14 | 23.80 |
| $M_3T_5$ | 94.25 | 97.65 | 95.95 | 95.84 | 96.41 | 96.13 | 24.56 | 26.44 | 25.50 | 25.25 | 25.86 | 25.56 |
| $M_4T_1$ | 66.22 | 64.04 | 65.13 | 63.98 | 63.58 | 63.78 | 11.25 | 10.69 | 10.97 | 10.73 | 10.62 | 10.68 |
| $M_4T_2$ | 75.49 | 76.45 | 75.97 | 73.72 | 75.67 | 74.69 | 15.76 | 16.46 | 16.11 | 15.24 | 16.09 | 15.67 |
| $M_4T_3$ | 79.05 | 80.36 | 79.70 | 77.49 | 79.40 | 78.45 | 16.96 | 17.88 | 17.42 | 16.33 | 17.52 | 16.93 |
| $M_4T_4$ | 82.94 | 84.26 | 83.60 | 81.31 | 83.28 | 82.30 | 19.56 | 20.56 | 20.06 | 18.85 | 20.13 | 19.49 |
| $M_4T_5$ | 87.11 | 88.33 | 87.72 | 87.40 | 87.68 | 87.54 | 21.13 | 22.29 | 21.71 | 21.41 | 21.71 | 21.56 |
| **S.Em.±** | **0.86** | **1.18** | **0.78** | **0.79** | **0.85** | **0.66** | **0.38** | **0.42** | **0.26** | **0.33** | **0.39** | **0.27** |
| **C.D. at 5%** | **2.48** | **3.39** | **2.25** | **2.29** | **2.46** | **1.90** | **1.11** | **1.20** | **0.76** | **0.95** | **1.11** | **0.77** |

**Table 3: Grain and straw yieldof paddy as influenced by residue and nutrient management**

| Treatment | Grain yield (q ha$^{-1}$) | | | | | | Straw yield (q ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Kharif*** | | | ***Rabi-summer*** | | | ***Kharif*** | | | ***Rabi-summer*** | | |
| | **2019** | **2020** | **Pooled** | **2019-20** | **2020-21** | **Pooled** | **2019** | **2020** | **Pooled** | **2019-20** | **2020-21** | **Pooled** |
| **Residue management (M)** | | | | | | | | | | | | |
| $M_1$: Residue removal | 62.88 | 63.01 | 62.94 | 62.57 | 62.61 | 62.59 | 76.88 | 77.05 | 76.97 | 76.52 | 76.51 | 76.51 |
| $M_2$: Residue incorporation (RI) | 64.01 | 64.41 | 64.21 | 64.16 | 63.79 | 63.98 | 78.41 | 78.76 | 78.58 | 78.53 | 78.06 | 78.30 |
| $M_3$: RI + Compost culture | 64.86 | 65.88 | 65.37 | 65.43 | 65.25 | 65.34 | 79.22 | 80.79 | 80.01 | 80.32 | 79.75 | 80.04 |
| $M_4$: Residue burning | 63.03 | 63.30 | 63.17 | 62.77 | 62.96 | 62.86 | 77.00 | 77.38 | 77.19 | 76.71 | 76.89 | 76.80 |
| **S.Em.±** | **0.14** | **0.21** | **0.12** | **0.17** | **0.18** | **0.14** | **0.17** | **0.25** | **0.19** | **0.30** | **0.28** | **0.25** |
| **C.D. at 5%** | **0.49** | **0.73** | **0.40** | **0.59** | **0.62** | **0.48** | **0.60** | **0.88** | **0.66** | **1.03** | **0.98** | **0.86** |
| **Nutrient management (T)** | | | | | | | | | | | | |
| $T_1$: Absolute control | 34.79 | 31.98 | 33.38 | 34.10 | 30.97 | 32.53 | 42.65 | 39.15 | 40.90 | 42.12 | 38.04 | 40.08 |
| $T_2$: Recommended NPK | 66.27 | 67.13 | 66.70 | 66.27 | 66.87 | 66.57 | 81.19 | 82.34 | 81.77 | 81.33 | 81.98 | 81.66 |
| $T_3$: STL | 69.97 | 71.07 | 70.52 | 70.02 | 70.70 | 70.36 | 85.85 | 87.24 | 86.54 | 86.00 | 86.76 | 86.38 |
| $T_4$: STCR of 80 q ha$^{-1}$ | 73.16 | 74.48 | 73.82 | 73.35 | 74.11 | 73.73 | 88.63 | 90.47 | 89.55 | 88.86 | 89.75 | 89.30 |
| $T_5$: SSNM of 80 q ha$^{-1}$ | 74.28 | 76.09 | 75.19 | 74.93 | 75.60 | 75.26 | 91.07 | 93.27 | 92.17 | 91.78 | 92.50 | 92.14 |
| **S.Em.±** | **0.13** | **0.17** | **0.14** | **0.17** | **0.17** | **0.15** | **0.16** | **0.20** | **0.17** | **0.27** | **0.27** | **0.24** |
| **C.D. at 5%** | **0.38** | **0.48** | **0.42** | **0.49** | **0.50** | **0.43** | **0.46** | **0.57** | **0.48** | **0.79** | **0.77** | **0.69** |
| **Interaction (M × T)** | | | | | | | | | | | | |
| $M_1T_1$ | 34.47 | 31.58 | 33.02 | 33.74 | 30.62 | 32.18 | 42.37 | 38.66 | 40.52 | 41.65 | 37.78 | 39.71 |
| $M_1T_2$ | 65.56 | 66.11 | 65.84 | 65.21 | 65.92 | 65.56 | 80.32 | 81.15 | 80.73 | 79.98 | 80.88 | 80.43 |
| $M_1T_3$ | 69.13 | 69.79 | 69.46 | 68.69 | 69.54 | 69.12 | 84.74 | 85.53 | 85.13 | 84.16 | 85.20 | 84.68 |
| $M_1T_4$ | 72.18 | 73.03 | 72.60 | 71.73 | 72.73 | 72.23 | 87.46 | 88.66 | 88.06 | 87.00 | 88.08 | 87.54 |
| $M_1T_5$ | 73.05 | 74.52 | 73.78 | 73.48 | 74.21 | 73.85 | 89.54 | 91.23 | 90.38 | 89.82 | 90.60 | 90.21 |
| $M_2T_1$ | 34.91 | 32.04 | 33.48 | 34.21 | 31.16 | 32.68 | 42.80 | 39.29 | 41.05 | 42.42 | 38.24 | 40.33 |
| $M_2T_2$ | 66.35 | 67.52 | 66.94 | 66.50 | 66.99 | 66.75 | 81.51 | 82.50 | 82.00 | 81.68 | 82.12 | 81.90 |
| $M_2T_3$ | 70.23 | 71.36 | 70.80 | 70.53 | 70.94 | 70.74 | 86.46 | 87.77 | 87.11 | 86.74 | 87.22 | 86.98 |
| $M_2T_4$ | 73.64 | 74.77 | 74.21 | 74.07 | 74.24 | 74.15 | 89.24 | 90.76 | 90.00 | 89.49 | 90.03 | 89.76 |
| $M_2T_5$ | 74.90 | 76.33 | 75.61 | 75.50 | 75.62 | 75.56 | 92.02 | 93.46 | 92.74 | 92.31 | 92.70 | 92.51 |
| $M_3T_1$ | 35.23 | 32.45 | 33.84 | 34.58 | 31.40 | 32.99 | 42.98 | 39.74 | 41.36 | 42.65 | 38.29 | 40.47 |
| $M_3T_2$ | 67.49 | 68.62 | 68.06 | 67.91 | 68.34 | 68.13 | 82.51 | 84.33 | 83.42 | 83.48 | 83.70 | 83.59 |
| $M_3T_3$ | 71.22 | 73.05 | 72.13 | 71.93 | 72.31 | 72.12 | 87.45 | 89.80 | 88.63 | 88.72 | 88.84 | 88.78 |
| $M_3T_4$ | 74.46 | 76.72 | 75.59 | 75.69 | 76.30 | 76.00 | 90.20 | 93.40 | 91.80 | 91.73 | 92.32 | 92.02 |
| $M_3T_5$ | 75.93 | 78.58 | 77.25 | 77.02 | 77.88 | 77.45 | 92.97 | 96.69 | 94.83 | 95.02 | 95.62 | 95.32 |
| $M_4T_1$ | 34.54 | 31.86 | 33.20 | 33.86 | 30.71 | 32.28 | 42.44 | 38.89 | 40.67 | 41.77 | 37.86 | 39.81 |
| $M_4T_2$ | 65.70 | 66.27 | 65.98 | 65.44 | 66.25 | 65.85 | 80.41 | 81.39 | 80.90 | 80.20 | 81.23 | 80.72 |
| $M_4T_3$ | 69.31 | 70.06 | 69.69 | 68.90 | 70.02 | 69.46 | 84.75 | 85.84 | 85.30 | 84.38 | 85.76 | 85.07 |
| $M_4T_4$ | 72.35 | 73.39 | 72.87 | 71.93 | 73.14 | 72.54 | 87.63 | 89.06 | 88.34 | 87.21 | 88.56 | 87.88 |
| $M_4T_5$ | 73.26 | 74.93 | 74.09 | 73.71 | 74.67 | 74.19 | 89.75 | 91.71 | 90.73 | 89.96 | 91.07 | 90.52 |
| **S.Em.±** | **0.27** | **0.33** | **0.29** | **0.34** | **0.35** | **0.30** | **0.32** | **0.39** | **0.34** | **0.55** | **0.54** | **0.48** |
| **C.D. at 5%** | **0.77** | **0.96** | **0.83** | **0.99** | **1.00** | **0.86** | **0.93** | **1.13** | **0.97** | **1.58** | **1.55** | **1.38** |

Application of nutrients through SSNM targeted yield of 80 q $ha^{-1}$ showed significantly higher grain (75.19 & 75.26q $ha^{-1}$) and straw (92.17 & 92.14 q $ha^{-1}$) yield followed by STCR targeted yield of 80 q $ha^{-1}$ ($T_4$) > STL method ($T_3$) > recommended NPK ($T_2$) over absolute control ($T_1$) during *kharif* and *rabi-summer,* respectively (Table 3).The prerequisite for getting higher yield in any crop is due to higher total dry matter production and it's partitioning into various plant parts coupled with maximum translocation of photosynthates to the sink. Growth and yield attributes could have been promoted by sufficient and balanced availability of the nutrients for a prolonged period during crop growth and development stages and evidenced through higher uptake of nutrients *viz.,* nitrogen, phosphorous and potassium. The increase in the grain yield under $T_5$ was 12.72 & 13.05 per cent over recommended NPK during *kharif* and *rabi-summer,* respectively. Raghavendra *et al*. [7] reported significantly higher grain yield of 54.73 q $ha^{-1}$ and straw yield of 68.55 q $ha^{-1}$ in SSNM approach targeted yield of 55 q $ha^{-1}$ which resulted from increased growth and yield attributes in the same treatment. Similar result was also reported by Rajesh *et al*. [12].

It is evident from the data that interaction effect on grain & straw yield differed significantly with values varied from 33.02 to 77.25 q $ha^{-1}$and 40.52 to 94.83q $ha^{-1}$, respectively during *kharif* season; 32.18 to 77.45 q $ha^{-1}$and 39.71 to 95.32 q $ha^{-1}$, respectively during *rabi-summer* season. Wherein, significantly higher values were recorded under residue incorporation + compost culture with SSNM targeted yield of 80 q $ha^{-1}$ ($M_3T_5$) as compared to other treatment combinations (Table 3). It was very clear that residue incorporation in combination with inorganic fertilizers (SSNM) increased the vegetative growth of plants as observed earlier and thereby increased yield of paddy [13]. Similar to our findings, Patra [14] reported enhanced grain and straw yield with increase in N level (180 kg $ha^{-1}$) under residue incorporation over residue removal and burning.

### 3.3 Nutrient uptake by paddy

During both *kharif* and *rabi-summer* season of the study, residue incorporation along with compost culture ($M_3$) significantly enhanced total N (141.11 & 140.51 kg $ha^{-1}$), P (40.51 & 40.36 kg $ha^{-1}$), K (148.18 & 148.39 kg ha-1), S (19.95 & 20.04 kg $ha^{-1}$), Zn (316.83 & 318.91 g $ha^{-1}$) and Fe (3829.58 & 3836.63 g $ha^{-1}$) uptake by paddy followed by residue incorporation alone, residue burning and residue removal (Table 4, 5, 6 & 7). Straw incorporation has been shown to enhance nutrient recycling and provide soil fertility benefits [15]. In the present study, the incorporation of the microbial inoculated straw recorded higher total N, P, K, S, Zn and Fe uptake (grain + straw) over other three residue management as it is supported by increase in biomass as well as increased availability of these nutrients during both *kharif* and *rabi-summer.* The *in-situ* decomposition of paddy straw in combination with cow dung slurry (5 %) + *T. harizianum* (5 kg $ha^{-1}$) + *P. sajorcaju* (5 kg $ha^{-1}$) enhanced N, P and K uptake by paddy grain and straw [11]. It might be due to increase in rate of crop residue decomposition in soil and easy availability of plant nutrient from the soil solution, which favored higher degree of vegetative growth. The better availability of Zn through organic & inorganic $ZnSO_4$ and increased Fe concentrations in the soil solution through reduced redox potential might have helped in better absorption and translocation of these nutrients from the soil solution, which resulted in higher dry matter production, inturn increased total Zn & Fe uptake by paddy [16].

Among the different nutrient management approaches, the application of fertilizers through SSNM targeted yield of 80 q $ha^{-1}$ ($T_5$) recorded significantly higher total N, P, K S, Zn and Fe (172.22 & 169.67 kg $ha^{-1}$, 51.61 & 51.20 kg $ha^{-1}$, 186.69 & 186.20 kg $ha^{-1}$, 24.72 & 24.49 kg $ha^{-1}$, 397.35 & 395.16 g $ha^{-1}$ and 5179.08 & 5111.15 g $ha^{-1}$ during *kharif* and *rabi-summer*, respectively). Whereas, lower uptake values were recorded under absolute control (Table 4, 5, 6 & 7). Higher uptake of these nutrients under SSNM might be due to balanced fertilization as per crop need which is well reflected in terms of higher grain and straw yield. The increased availability of P, K and S from the native soil also facilitated better nutrient uptake by paddy from rhizoshpere. Raghavendra *et al*. [4] and Rajesh *et al*. [12] also noticed higher nutrient uptake (grain + straw) by dry DSR through SSNM approach as compared to RDF, farmer's

**Table 4: Effect of residue and nutrient managementon nitrogen, phosphorus and potassium uptake by paddy during *kharif*season**

| Treatment | N (kg ha$^{-1}$) | | | P (kg ha$^{-1}$) | | | K (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled |
| **Residue management (M)** | | | | | | | | | |
| $M_1$: Residue removal | 122.91 | 128.27 | 125.59 | 35.27 | 36.32 | 35.79 | 136.95 | 138.52 | 137.73 |
| $M_2$: Residue incorporation (RI) | 129.38 | 136.90 | 133.14 | 37.22 | 39.24 | 38.23 | 141.69 | 144.36 | 143.03 |
| $M_3$: RI + Compost culture | 135.31 | 146.91 | 141.11 | 38.95 | 42.07 | 40.51 | 145.23 | 151.13 | 148.18 |
| $M_4$: Residue burning | 124.18 | 130.23 | 127.21 | 35.51 | 36.84 | 36.18 | 137.70 | 139.93 | 138.82 |
| **S.Em.±** | **0.64** | **0.70** | **0.51** | **0.11** | **0.25** | **0.14** | **0.39** | **0.82** | **0.39** |
| **C.D. at 5%** | **2.21** | **2.43** | **1.77** | **0.39** | **0.88** | **0.50** | **1.33** | **2.84** | **1.36** |
| **Nutrient management (T)** | | | | | | | | | |
| $T_1$: Absolute control | 52.64 | 46.48 | 49.56 | 13.12 | 11.42 | 12.27 | 61.50 | 55.86 | 58.68 |
| $T_2$: Recommended NPK | 126.15 | 132.32 | 129.23 | 35.95 | 37.42 | 36.68 | 135.57 | 139.22 | 137.39 |
| $T_3$: STL | 141.20 | 150.33 | 145.77 | 40.43 | 42.93 | 41.68 | 145.57 | 149.90 | 147.73 |
| $T_4$: STCR of 80 q ha$^{-1}$ | 155.59 | 168.46 | 162.03 | 44.61 | 47.67 | 46.14 | 176.25 | 182.14 | 179.19 |
| $T_5$: SSNM of 80 q ha$^{-1}$ | 164.14 | 180.29 | 172.22 | 49.56 | 53.65 | 51.61 | 183.08 | 190.31 | 186.69 |
| **S.Em.±** | **0.63** | **0.79** | **0.50** | **0.22** | **0.24** | **0.18** | **0.49** | **0.60** | **0.47** |
| **C.D. at 5%** | **1.81** | **2.28** | **1.44** | **0.62** | **0.70** | **0.51** | **1.40** | **1.72** | **1.35** |
| **Interaction (M × T)** | | | | | | | | | |
| $M_1T_1$ | 51.70 | 45.40 | 48.55 | 12.72 | 11.09 | 11.90 | 60.84 | 55.04 | 57.94 |
| $M_1T_2$ | 121.39 | 126.71 | 124.05 | 34.58 | 35.46 | 35.02 | 132.43 | 134.73 | 133.58 |
| $M_1T_3$ | 135.54 | 142.21 | 138.87 | 38.87 | 40.50 | 39.69 | 141.84 | 144.41 | 143.13 |
| $M_1T_4$ | 149.20 | 158.41 | 153.81 | 42.79 | 44.73 | 43.76 | 171.82 | 175.59 | 173.70 |
| $M_1T_5$ | 156.73 | 168.59 | 162.66 | 47.38 | 49.79 | 48.58 | 177.84 | 182.81 | 180.32 |
| $M_2T_1$ | 52.89 | 46.71 | 49.80 | 13.21 | 11.37 | 12.29 | 61.69 | 56.06 | 58.87 |
| $M_2T_2$ | 127.41 | 133.69 | 130.55 | 36.24 | 38.18 | 37.21 | 136.38 | 140.33 | 138.36 |
| $M_2T_3$ | 143.06 | 152.05 | 147.56 | 40.84 | 43.77 | 42.31 | 146.94 | 151.37 | 149.15 |
| $M_2T_4$ | 157.32 | 170.15 | 163.74 | 45.34 | 48.42 | 46.88 | 178.00 | 183.01 | 180.51 |
| $M_2T_5$ | 166.20 | 181.89 | 174.05 | 50.49 | 54.45 | 52.47 | 185.45 | 191.02 | 188.24 |
| $M_3T_1$ | 53.89 | 47.78 | 50.84 | 13.57 | 11.98 | 12.78 | 62.21 | 56.78 | 59.49 |
| $M_3T_2$ | 133.34 | 141.14 | 137.24 | 38.24 | 40.34 | 39.29 | 140.46 | 146.19 | 143.32 |
| $M_3T_3$ | 149.41 | 162.73 | 156.07 | 42.96 | 46.54 | 44.75 | 150.91 | 158.12 | 154.52 |
| $M_3T_4$ | 164.97 | 184.20 | 174.59 | 47.24 | 52.18 | 49.71 | 182.38 | 192.30 | 187.34 |
| $M_3T_5$ | 174.96 | 198.68 | 186.82 | 52.72 | 59.30 | 56.01 | 190.16 | 202.26 | 196.21 |
| $M_4T_1$ | 52.09 | 46.01 | 49.05 | 12.98 | 11.23 | 12.11 | 61.26 | 55.56 | 58.41 |
| $M_4T_2$ | 122.46 | 127.74 | 125.10 | 34.76 | 35.68 | 35.22 | 133.01 | 135.63 | 134.32 |
| $M_4T_3$ | 136.81 | 144.33 | 140.57 | 39.06 | 40.88 | 39.97 | 142.58 | 145.68 | 144.13 |
| $M_4T_4$ | 150.88 | 161.08 | 155.98 | 43.09 | 45.33 | 44.21 | 172.79 | 177.65 | 175.22 |
| $M_4T_5$ | 158.66 | 172.01 | 165.33 | 47.66 | 51.08 | 49.37 | 178.87 | 185.14 | 182.00 |
| **S.Em.±** | **1.26** | **1.58** | **1.00** | **0.43** | **0.48** | **0.35** | **0.97** | **1.20** | **0.94** |
| **C.D. at 5%** | **3.62** | **4.57** | **2.87** | **1.25** | **1.40** | **1.02** | **2.80** | **3.45** | **2.71** |

**Table 5: Effect of residue and nutrient managementon nitrogen, phosphorus and potassium uptake by paddy during *rabi-summer* season**

| Treatment | N (kg ha$^{-1}$) | | | P (kg ha$^{-1}$) | | | K (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled | 2019-20 | 2020-21 | Pooled |
| **Residue management (M)** | | | | | | | | | |
| $M_1$: Residue removal | 121.74 | 124.05 | 122.89 | 34.43 | 35.20 | 34.82 | 135.47 | 137.15 | 136.31 |
| $M_2$: Residue incorporation (RI) | 131.27 | 132.06 | 131.66 | 37.76 | 38.00 | 37.88 | 142.54 | 142.64 | 142.59 |
| $M_3$: RI + Compost culture | 139.98 | 141.03 | 140.51 | 40.12 | 40.61 | 40.36 | 148.24 | 148.53 | 148.39 |
| $M_4$: Residue burning | 122.86 | 125.54 | 124.20 | 34.90 | 36.03 | 35.47 | 136.65 | 138.58 | 137.61 |
| **S.Em.±** | **0.94** | **0.79** | **0.81** | **0.28** | **0.35** | **0.25** | **0.34** | **0.54** | **0.37** |
| **C.D. at 5%** | **3.26** | **2.75** | **2.80** | **0.97** | **1.20** | **0.87** | **1.18** | **1.87** | **1.28** |
| **Nutrient management (T)** | | | | | | | | | |
| $T_1$: Absolute control | 50.72 | 45.16 | 47.94 | 12.51 | 10.87 | 11.69 | 60.27 | 54.20 | 57.24 |
| $T_2$: Recommended NPK | 126.98 | 129.38 | 128.18 | 35.89 | 36.61 | 36.25 | 135.73 | 138.13 | 136.93 |
| $T_3$: STL | 142.00 | 145.10 | 143.55 | 40.39 | 41.70 | 41.04 | 145.96 | 148.57 | 147.26 |
| $T_4$: STCR of 80 q ha$^{-1}$ | 157.64 | 161.83 | 159.74 | 44.84 | 46.12 | 45.48 | 176.99 | 180.02 | 178.50 |
| $T_5$: SSNM of 80 q ha$^{-1}$ | 167.47 | 171.87 | 169.67 | 50.40 | 52.00 | 51.20 | 184.69 | 187.71 | 186.20 |
| **S.Em.±** | **0.87** | **0.78** | **0.76** | **0.26** | **0.31** | **0.23** | **0.64** | **0.62** | **0.57** |
| **C.D. at 5%** | **2.52** | **2.24** | **2.18** | **0.75** | **0.89** | **0.66** | **1.84** | **1.78** | **1.63** |
| **Interaction (M × T)** | | | | | | | | | |
| $M_1T_1$ | 49.64 | 44.16 | 46.90 | 12.02 | 10.68 | 11.35 | 59.51 | 53.71 | 56.61 |
| $M_1T_2$ | 120.12 | 123.13 | 121.63 | 33.62 | 34.49 | 34.06 | 130.87 | 133.88 | 132.37 |
| $M_1T_3$ | 134.38 | 138.11 | 136.25 | 37.72 | 39.03 | 38.37 | 139.88 | 143.38 | 141.63 |
| $M_1T_4$ | 147.69 | 152.75 | 150.22 | 41.74 | 43.10 | 42.42 | 169.82 | 173.94 | 171.88 |
| $M_1T_5$ | 156.85 | 162.08 | 159.47 | 47.07 | 48.69 | 47.88 | 177.26 | 180.86 | 179.06 |
| $M_2T_1$ | 50.86 | 45.46 | 48.16 | 12.57 | 10.93 | 11.75 | 60.63 | 54.49 | 57.56 |
| $M_2T_2$ | 129.06 | 130.86 | 129.96 | 36.80 | 37.28 | 37.04 | 137.16 | 139.08 | 138.12 |
| $M_2T_3$ | 144.93 | 147.07 | 146.00 | 41.51 | 42.46 | 41.98 | 148.25 | 149.94 | 149.10 |
| $M_2T_4$ | 160.63 | 163.83 | 162.23 | 46.15 | 46.79 | 46.47 | 179.55 | 181.03 | 180.29 |
| $M_2T_5$ | 170.84 | 173.09 | 171.97 | 51.76 | 52.57 | 52.16 | 187.11 | 188.67 | 187.89 |
| $M_3T_1$ | 52.21 | 46.47 | 49.34 | 13.13 | 11.13 | 12.13 | 61.08 | 54.66 | 57.87 |
| $M_3T_2$ | 137.41 | 139.15 | 138.28 | 39.10 | 39.60 | 39.35 | 142.96 | 144.50 | 143.73 |
| $M_3T_3$ | 153.37 | 155.63 | 154.50 | 44.09 | 45.20 | 44.64 | 154.47 | 155.81 | 155.14 |
| $M_3T_4$ | 173.10 | 176.08 | 174.59 | 49.12 | 50.35 | 49.74 | 187.22 | 189.22 | 188.22 |
| $M_3T_5$ | 183.82 | 187.84 | 185.83 | 55.16 | 56.76 | 55.96 | 195.49 | 198.46 | 196.97 |
| $M_4T_1$ | 50.15 | 44.56 | 47.36 | 12.32 | 10.74 | 11.53 | 59.84 | 53.96 | 56.90 |
| $M_4T_2$ | 121.31 | 124.37 | 122.84 | 34.03 | 35.05 | 34.54 | 131.92 | 135.06 | 133.49 |
| $M_4T_3$ | 135.33 | 139.62 | 137.47 | 38.22 | 40.12 | 39.17 | 141.23 | 145.14 | 143.18 |
| $M_4T_4$ | 149.14 | 154.68 | 151.91 | 42.32 | 44.25 | 43.28 | 171.38 | 175.87 | 173.63 |
| $M_4T_5$ | 158.35 | 164.49 | 161.42 | 47.62 | 49.99 | 48.81 | 178.89 | 182.86 | 180.88 |
| **S.Em.±** | **1.75** | **1.56** | **1.52** | **0.52** | **0.62** | **0.46** | **1.28** | **1.24** | **1.13** |
| **C.D. at 5%** | **5.03** | **4.49** | **4.37** | **1.50** | **1.77** | **1.33** | **3.68** | **3.56** | **3.26** |

**Table 6: Effect of residue and nutrient managementon sulphur, zinc and iron uptake by paddy during *kharif*season**

| Treatment | S (kg $ha^{-1}$) | | | Zn (g $ha^{-1}$) | | | Fe (g $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled | 2019 | 2020 | Pooled |
| **Residue management (M)** | | | | | | | | | |
| $M_1$: Residue removal | 17.15 | 17.77 | 17.46 | 272.39 | 279.07 | 275.73 | 3231.11 | 3326.74 | 3278.92 |
| $M_2$: Residue incorporation (RI) | 18.05 | 19.44 | 18.75 | 290.32 | 307.52 | 298.92 | 3463.03 | 3708.89 | 3585.96 |
| $M_3$: RI + Compost culture | 18.81 | 21.10 | 19.95 | 302.23 | 331.43 | 316.83 | 3638.66 | 4020.50 | 3829.58 |
| $M_4$: Residue burning | 17.24 | 18.05 | 17.64 | 274.23 | 283.52 | 278.87 | 3289.53 | 3386.10 | 3337.81 |
| **S.Em.±** | **0.11** | **0.18** | **0.13** | **1.67** | **3.62** | **1.95** | **30.35** | **53.38** | **39.76** |
| **C.D. at 5%** | **0.39** | **0.62** | **0.46** | **5.77** | **12.52** | **6.73** | **105.03** | **184.71** | **137.58** |
| **Nutrient management (T)** | | | | | | | | | |
| $T_1$: Absolute control | 7.45 | 5.92 | 6.68 | 124.32 | 109.24 | 116.78 | 1169.95 | 956.79 | 1063.37 |
| $T_2$: Recommended NPK | 16.78 | 18.38 | 17.58 | 267.81 | 285.40 | 276.61 | 3006.92 | 3216.97 | 3111.95 |
| $T_3$: STL | 19.67 | 21.49 | 20.58 | 300.19 | 322.44 | 311.31 | 3528.16 | 3791.83 | 3659.99 |
| $T_4$: STCR of 80 q $ha^{-1}$ | 21.64 | 23.75 | 22.69 | 348.20 | 373.60 | 360.90 | 4357.43 | 4694.48 | 4525.96 |
| $T_5$: SSNM of 80 q $ha^{-1}$ | 23.53 | 25.92 | 24.72 | 383.45 | 411.24 | 397.35 | 4965.46 | 5392.71 | 5179.08 |
| **S.Em.±** | **0.13** | **0.14** | **0.11** | **1.43** | **2.52** | **1.40** | **21.47** | **33.10** | **22.65** |
| **C.D. at 5%** | **0.37** | **0.40** | **0.33** | **4.11** | **7.27** | **4.03** | **61.84** | **95.35** | **65.26** |
| **Interaction (M × T)** | | | | | | | | | |
| $M_1T_1$ | 7.34 | 5.82 | 6.58 | 122.75 | 107.39 | 115.07 | 1136.45 | 920.07 | 1028.26 |
| $M_1T_2$ | 16.20 | 17.15 | 16.67 | 255.26 | 263.56 | 259.41 | 2837.18 | 2945.92 | 2891.55 |
| $M_1T_3$ | 18.92 | 19.96 | 19.44 | 286.63 | 297.33 | 291.98 | 3344.40 | 3457.36 | 3400.88 |
| $M_1T_4$ | 20.76 | 21.97 | 21.36 | 332.44 | 345.96 | 339.20 | 4125.67 | 4313.61 | 4219.64 |
| $M_1T_5$ | 22.55 | 23.95 | 23.25 | 364.88 | 381.12 | 373.00 | 4711.85 | 4996.73 | 4854.29 |
| $M_2T_1$ | 7.48 | 5.94 | 6.71 | 125.07 | 109.63 | 117.35 | 1193.06 | 963.64 | 1078.35 |
| $M_2T_2$ | 16.94 | 18.72 | 17.83 | 273.43 | 293.54 | 283.48 | 3054.69 | 3325.02 | 3189.86 |
| $M_2T_3$ | 19.94 | 21.90 | 20.92 | 305.82 | 331.17 | 318.50 | 3577.47 | 3922.12 | 3749.79 |
| $M_2T_4$ | 21.99 | 24.20 | 23.09 | 355.11 | 382.58 | 368.85 | 4441.65 | 4834.67 | 4638.16 |
| $M_2T_5$ | 23.91 | 26.46 | 25.18 | 392.18 | 420.68 | 406.43 | 5048.29 | 5499.00 | 5273.64 |
| $M_3T_1$ | 7.60 | 6.05 | 6.83 | 126.19 | 111.57 | 118.88 | 1204.26 | 1009.86 | 1107.06 |
| $M_3T_2$ | 17.68 | 20.28 | 18.98 | 285.92 | 316.98 | 301.45 | 3235.01 | 3589.90 | 3412.45 |
| $M_3T_3$ | 20.85 | 23.78 | 22.32 | 319.81 | 358.90 | 339.36 | 3783.23 | 4259.45 | 4021.34 |
| $M_3T_4$ | 22.96 | 26.47 | 24.71 | 370.31 | 414.05 | 392.18 | 4676.07 | 5254.87 | 4965.47 |
| $M_3T_5$ | 24.98 | 28.89 | 26.93 | 408.95 | 455.64 | 432.29 | 5294.72 | 5988.44 | 5641.58 |
| $M_4T_1$ | 7.35 | 5.87 | 6.61 | 123.26 | 108.35 | 115.80 | 1146.01 | 933.58 | 1039.80 |
| $M_4T_2$ | 16.29 | 17.36 | 16.82 | 256.65 | 267.54 | 262.09 | 2900.79 | 3007.06 | 2953.92 |
| $M_4T_3$ | 18.98 | 20.30 | 19.64 | 288.49 | 302.36 | 295.43 | 3407.54 | 3528.38 | 3467.96 |
| $M_4T_4$ | 20.87 | 22.35 | 21.61 | 334.93 | 351.82 | 343.38 | 4186.34 | 4374.78 | 4280.56 |
| $M_4T_5$ | 22.70 | 24.36 | 23.53 | 367.80 | 387.53 | 377.66 | 4807.00 | 5086.67 | 4946.83 |
| **S.Em.±** | **0.25** | **0.28** | **0.23** | **2.85** | **5.05** | **2.80** | **42.94** | **66.20** | **45.31** |
| **C.D. at 5%** | **0.73** | **0.81** | **0.65** | **8.22** | **14.55** | **8.07** | **123.69** | **190.70** | **130.51** |

**Table 7: Effect of residue and nutrient managementon sulphur, zinc and iron uptake by paddy during *rabi-summer* season**

| Treatment | S (kg ha$^{-1}$) | | | Zn (g ha$^{-1}$) | | | Fe (g ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2019-20** | **2020-21** | **Pooled** | **2019-20** | **2020-21** | **Pooled** | **2019-20** | **2020-21** | **Pooled** |
| **Residue management (M)** | | | | | | | | | |
| $M_1$: Residue removal | 16.56 | 17.26 | 16.91 | 266.96 | 274.66 | 270.81 | 3104.77 | 3263.18 | 3183.98 |
| $M_2$: Residue incorporation (RI) | 18.48 | 18.84 | 18.66 | 294.84 | 299.03 | 296.94 | 3530.73 | 3628.08 | 3579.41 |
| $M_3$: RI + Compost culture | 19.76 | 20.32 | 20.04 | 315.88 | 321.94 | 318.91 | 3787.90 | 3885.36 | 3836.63 |
| $M_4$: Residue burning | 16.69 | 17.60 | 17.15 | 269.23 | 279.66 | 274.45 | 3153.57 | 3327.36 | 3240.46 |
| **S.Em.±** | **0.24** | **0.19** | **0.17** | **2.26** | **3.36** | **2.46** | **53.91** | **54.69** | **52.57** |
| **C.D. at 5%** | **0.82** | **0.65** | **0.59** | **7.83** | **11.64** | **8.51** | **186.57** | **189.24** | **181.91** |
| **Nutrient management (T)** | | | | | | | | | |
| $T_1$: Absolute control | 6.92 | 6.03 | 6.48 | 120.49 | 107.52 | 114.00 | 1105.76 | 971.57 | 1038.67 |
| $T_2$: Recommended NPK | 16.89 | 17.77 | 17.33 | 270.04 | 280.26 | 275.15 | 2973.55 | 3145.98 | 3059.76 |
| $T_3$: STL | 19.79 | 20.83 | 20.31 | 302.96 | 314.88 | 308.92 | 3513.93 | 3721.32 | 3617.62 |
| $T_4$: STCR of 80 q ha$^{-1}$ | 21.80 | 22.89 | 22.34 | 351.48 | 364.80 | 358.14 | 4364.30 | 4582.48 | 4473.39 |
| $T_5$: SSNM of 80 q ha$^{-1}$ | 23.97 | 25.00 | 24.49 | 388.67 | 401.66 | 395.16 | 5013.68 | 5208.63 | 5111.15 |
| **S.Em.±** | **0.18** | **0.17** | **0.15** | **2.24** | **2.52** | **2.08** | **32.83** | **36.10** | **31.59** |
| **C.D. at 5%** | **0.53** | **0.48** | **0.42** | **6.44** | **7.26** | **5.99** | **94.58** | **104.00** | **91.01** |
| **Interaction (M × T)** | | | | | | | | | |
| $M_1T_1$ | 6.80 | 5.96 | 6.38 | 118.64 | 106.19 | 112.41 | 1068.85 | 927.57 | 998.21 |
| $M_1T_2$ | 15.64 | 16.61 | 16.12 | 249.25 | 260.37 | 254.81 | 2681.79 | 2891.16 | 2786.48 |
| $M_1T_3$ | 18.23 | 19.37 | 18.80 | 279.96 | 292.86 | 286.41 | 3185.58 | 3415.80 | 3300.69 |
| $M_1T_4$ | 20.04 | 21.21 | 20.62 | 325.69 | 339.81 | 332.75 | 3965.84 | 4215.63 | 4090.73 |
| $M_1T_5$ | 22.11 | 23.12 | 22.61 | 361.28 | 374.08 | 367.68 | 4621.82 | 4865.76 | 4743.79 |
| $M_2T_1$ | 6.96 | 6.08 | 6.52 | 121.23 | 108.24 | 114.73 | 1129.82 | 1001.56 | 1065.69 |
| $M_2T_2$ | 17.47 | 18.06 | 17.76 | 278.95 | 286.49 | 282.72 | 3102.38 | 3259.32 | 3180.85 |
| $M_2T_3$ | 20.53 | 21.24 | 20.89 | 312.20 | 320.90 | 316.55 | 3683.06 | 3850.44 | 3766.75 |
| $M_2T_4$ | 22.62 | 23.33 | 22.98 | 362.01 | 371.11 | 366.56 | 4560.34 | 4730.62 | 4645.48 |
| $M_2T_5$ | 24.84 | 25.48 | 25.16 | 399.82 | 408.43 | 404.13 | 5178.08 | 5298.45 | 5238.27 |
| $M_3T_1$ | 7.06 | 6.12 | 6.59 | 122.76 | 108.97 | 115.87 | 1141.09 | 1017.12 | 1079.10 |
| $M_3T_2$ | 18.73 | 19.54 | 19.14 | 301.01 | 310.08 | 305.55 | 3368.62 | 3475.58 | 3422.10 |
| $M_3T_3$ | 22.02 | 22.87 | 22.44 | 336.98 | 346.79 | 341.89 | 3955.58 | 4117.45 | 4036.52 |
| $M_3T_4$ | 24.37 | 25.36 | 24.86 | 389.44 | 401.70 | 395.57 | 4913.93 | 5104.01 | 5008.97 |
| $M_3T_5$ | 26.64 | 27.70 | 27.17 | 429.19 | 442.15 | 435.67 | 5560.29 | 5712.63 | 5636.46 |
| $M_4T_1$ | 6.85 | 5.98 | 6.42 | 119.32 | 106.69 | 113.00 | 1083.30 | 940.04 | 1011.67 |
| $M_4T_2$ | 15.74 | 16.85 | 16.29 | 250.96 | 264.11 | 257.53 | 2741.40 | 2957.87 | 2849.63 |
| $M_4T_3$ | 18.38 | 19.83 | 19.11 | 282.70 | 298.97 | 290.84 | 3231.50 | 3501.57 | 3366.54 |
| $M_4T_4$ | 20.19 | 21.63 | 20.91 | 328.79 | 346.57 | 337.68 | 4017.10 | 4279.65 | 4148.37 |
| $M_4T_5$ | 22.31 | 23.69 | 23.00 | 364.40 | 381.96 | 373.18 | 4694.53 | 4957.68 | 4826.10 |
| **S.Em.±** | **0.37** | **0.33** | **0.29** | **4.47** | **5.04** | **4.16** | **65.67** | **72.21** | **63.18** |
| **C.D. at 5%** | **1.06** | **0.96** | **0.85** | **12.88** | **14.51** | **11.99** | **189.17** | **208.00** | **182.01** |

practice and other soil test methods. The results are in line with the findings of Ravi *et al*. [17].

The data pertaining to interaction effect on total N, P, K, S, Zn and Fe uptake by paddy differed significantly. Wherein, the residue incorporation + compost culture with SSNM targeted yield of 80 q $ha^{-1}$ recorded significantly higher total N (186.82 & 185.83 kg $ha^{-1}$) P (56.01 & 55.96 kg $ha^{-1}$) K (196.21 & 196.97 kg $ha^{-1}$), S (26.93 & 27.17 kg $ha^{-1}$), Zn (432.29 & 435.67 g $ha^{-1}$) and Fe (5641.58 & 5636.46 g $ha^{-1}$) in comparison to other combinations during *kharif* and *rabi-summer*, respectively. Whereas, lower values were recorded under residue removal with absolute control (Table 4, 5, 6 & 7). The combined application of organic and inorganic sources of nutrients (residue incorporation + compost culture with SSNM targeted yield of 80 q $ha^{-1}$; $M_3T_5$) helped in higher translocation of macro & micro nutrients to straw and grain, which resulted for higher total uptake by paddy. This might be due to the fact that the number of soil microorganism can increase rapidly to decompose the residue to humus and release the nutrient components. The results are in line with Guo-Wei *et al*. [18] who indicated that both residue incorporation and SSNM increased N, P and K translocation from vegetative organs and grains of rice related to enhancement of enzyme activity in root surface [19]. Furthermore, improvements in total S, Zn and Fe uptake by paddy under $M_3T_5$ treatment is possibly due to improved fertility status as well as enhanced biomass production by the crop.

## 4 CONCLUSION

Disposal of paddy straw has become a major problem in paddy growing area resulting in frequent fires initiated by farmers as a time saving option. Our study suggests that paddy straw could be managed successfully with the supply of additional microbial inoculants. The results of the study showed that among the varied residue and nutrient management practices, residue incorporation + compost culture ($M_3$), STCR targeted yield of 80 q $ha^{-1}$ ($T_5$) and their combination ($M_3T_5$) was found to be ideal in increasing the growth, yield and nutrient uptake by paddy as compared to other combinations.

**Comment [s8]:** Please mention the performance of SSNM also.

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