Effect of paddy straw incorporation on growth and yield of rice under wetland ecosystem.

ABSTRACT

A field experiment was conducted during summer season to find out the effect of enriched paddy straw incorporation on growth and yield of rice. This study was carried out in strip plot design with 3 main plots and 6 sub plots which is replicated thrice. The treatments comprise of main plot Continuous flooding (Conventional) (M1), AWDI (field water tube): Irrigation at soil moisture depletion by 10 cm (M2), AWDI (field water tube): Irrigation at soil moisture depletion by 15 cm (M3). In subplot, Rice raw straw incorporation + 75% RDF (S1), Rice raw straw incorporation with Pusa Decomposer Capsules + 75% RDF (S2), Rice raw straw incorporation with TNAU Bio mineralizer + 75% RDF (S3), Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4), 75% RDF (S5), 100% RDF (S6) were tested. The findings of the study showed that incorporation of rice straw along with Pusa decomposer, TNAU biomineralizer and 75% RDF recorded higher growth parameters at different stages as well as high grain and straw yield of 5187 kg/ha and 7712 kg/ha respectively. Soil properties like pH, EC, OC values have increased from initial values and the available K have raised nearly 50.36% from the initial analysis.

Keywords: Rice straw, amendments, incorporation, decomposer, biomineralizer

1. INTRODUCTION

Rice, a vital staple food supporting over half of the global population, and have major role in human sustenance. Its cultivation in diverse terrains and climates has made it the backbone of numerous societies and economies worldwide. As of the latest available data rice production remains a pivotal agricultural activity, with the Food and Agriculture Organization (FAO) reporting a staggering 515 million metric tons of rice production (FAO, 2020) [1]. Nearly 46.38 million hectares of land produces more than 130.29 million tonnes of rice which is higher than any other food crops cultivated here [2].

India is one of the leading agricultural countries, experiences higher agricultural output, leading to a considerable amount of crop residue after harvest. A significant proportion of this residue is disposed through burning in the fields, resulting in severe environmental pollution, threats to human health, emission of greenhouse gases contributing to global warming and depletion of vital soil microbial diversity and essential plant nutrients, including nitrogen, phosphorus, potassium, and sulfur [3]. To improve crop productivity, the utilization of crop leftovers has become important.

Current sustainable agricultural practices focus on the adoption of organic sources, rather than artificial fertilizers, to boost soil productivity [4]. The recycling of organic waste plays a pivotal role in agriculture by increasing organic matter in the soil. However, the incorporation of dried rice straw presents challenges, such as hindrance to seedbed preparation and impediments to germination of subsequent crops [5], along with the unavailability of essential nutrients, particularly nitrogen to plants. To overcome these issues, incorporation of dried rice straw emerges as the safest approach for environment.

Composting rice straw, as opposed to burning or direct soil application, offers numerous benefits. It reduces air pollution caused by residue burning, minimizes the loss of organic matter and enhances nutrient availability for plant absorption. Comparative studies conducted by [6] and [7] demonstrated that employing composted rice straw significantly improves soil fertility and crop yield. According to [8] highlighted that the addition of organic matter, such as composted straw, enhances the soil's nutrient retention capacity, making nutrients more readily available to plants. AWD irrigation was found to reduce the total seasonal methane (CH_4) emission by 22.3% to 56.2% when compared with continuous flooding while maintaining rice yield [9].

The incorporation of composted rice straw holds great promise for sustainable agricultural production. It not only improves soil fertility and crop productivity but also mitigates greenhouse gas emission from rice ecosystem [10]. The significance of composting rice straw as a sustainable approach to manage crop residues. Embracing composting practices not only increases soil health and agricultural productivity but also aligns with global efforts toward environmentally conscious agriculture

2. MATERIALS AND METHODS

2.1 Site Description

The field experiment was conducted wetland rice ecosystem at Wetland Farm, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India (Figure 1) during the summer season / Sornavari (Chittirai pattam) (April to August). The Coordinate of the experimental site is 11º00'11.5N 76º55'37.1E with 411m above the mean sea level and it comes under the Western Agro Climatic Zone of Tamil Nadu. The average Maximum and Minimum Temperature of 37ºC and 30.1ºC were recorded during 16th and 27th Standard weeks respectively. The total rainfall received during the period is 287.5 mm in 23 rainy days.

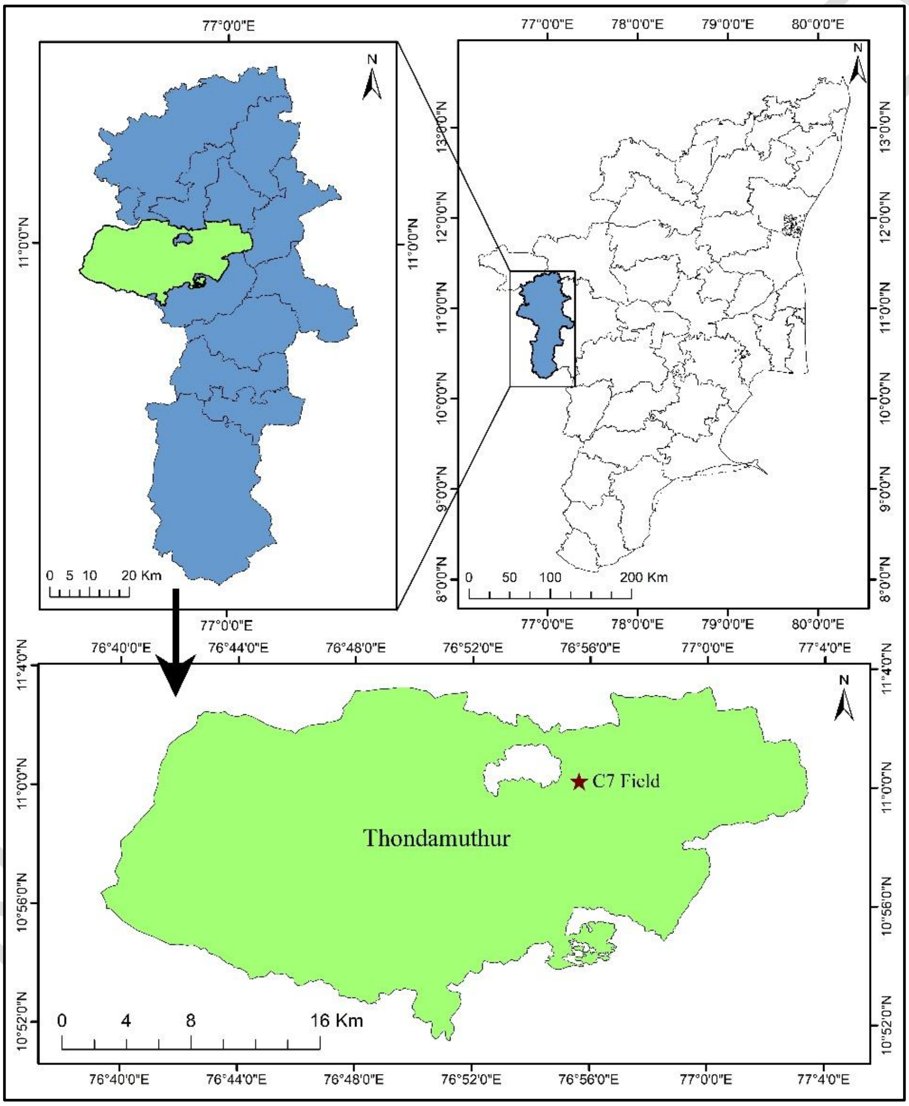

Figure 1: Location of experimental field

2.3 Experimental Description

The variety chosen for the experiment is ADT 53 which was released during 2019 by Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu, India. It is a short duration variety (110 - 115 Days).

The Soil type of the experimental site is Clay loam with EC and pH of 0.67 ds/m and 8.2 respectively. Before forming the field layout, the initial soil was subjected to Physiochemical analysis.

The experiment was conducted in strip plot design comprises of three Main Plots for water management and six sub plots for mitigation measures which is followed in three replications. In main plot, M1: Continuous flooding (Conventional) M2: AWDI (field water tube): Irrigation at soil moisture depletion by 10 cm M3: AWDI (field water tube): Irrigation at soil moisture depletion by 15 cm was studied. In subplot S1: Rice raw straw incorporation + 75% RDF S2: Rice raw straw incorporation with Pusa Decomposer Capsules + 75% RDF S3: Rice raw straw incorporation with TNAU Bio mineralizer + 75% RDF S4: Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF S5: 75% RDF S6: 100% RDF was studied.

2.4 Preparation of Pusa decomposer and TNAU bio mineralizer

Pusa decomposer capsules got from the Division of Microbiology, Indian Agricultural Research Institute (IARI), Pusa, New Delhi, India. 150 grammes of old jaggery was boiled in 5 litres of water to make culture, and the filth that floated on the surface of the boiling water was sieved out of the mixture. After being cooled to room temperature, the jaggery solution was combined with roughly 50 g of chickpea (*Cicer arietinum* L.) flour. Four Pusa decomposer capsules were cut open, thrown into the well-blended chickpea flour, and well mixed with a wooden stick. After that, the mixture was put onto a plastic tray, covered with a thin towel and kept in a warm location for one week.

TNAU biomineralizer @ 2 kg/tonne for rice straw was used and water was added @ 20 litres per 2 kg biomineralizer.

3. RESULTS AND DISCUSSION

3.1 Effect of Rice Straw incorporation on Plant Height

Generally, growth and yield attributes were significantly influenced by different methods of planting system and nutrient application. In this experiment the growth parameters were observed at three different stages of crop growth. The plant height was increased due to the positive effect of rice straw incorporation along with Pusa decomposer and TNAU biomineralizer + 75% RDF. According to [11] the application of Pusa decomposer along with RDF will increase the decomposition duration of rice straw and also increases the yield of the crop. The plant height was recorded at 30, 60 and 90 DAT which ranges between 32.2 - 40.3 cm, 59.1 – 63.3 cm and 96.7 – 106.2 cm respectively. Higher plant height was recorded in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) at all the stages of crop having the value of 40.3 cm, 63.3 cm and 106.2 cm during 30,60,90 DAT respectively. All the values are significant at all stages according to value P (Table 1).

Table 1: Effect of Rice Straw incorporation on Plant Height (cm)

Treatment	30DAS				60DAS				90DAS			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
S1	32.3	35.0	31.0	32.8	57.7	57.3	62.3	59.1	96.3	95.7	98.0	96.7
S2	36.3	37.3	35.3	36.3	61.3	60.7	60.3	60.8	101.7	101.0	100.0	100.9
S3	37.7	40.3	37.0	38.3	62.3	61.3	63.0	62.2	99.0	98.0	101.7	99.6
S4	40.3	42.3	38.4	40.3	63.5	64.2	62.3	63.3	102.0	111.0	105.7	106.2
S5	36.2	40.3	35.3	37.3	59.0	66.0	60.7	61.9	95.7	110.0	99.7	101.8
S6	36.0	41.0	36.3	37.8	61.2	61.7	59.5	60.8	101.3	106.3	98.0	101.9
Mean	36.5	39.4	35.6	37.1	60.8	61.9	61.4	61.4	99.3	103.7	100.5	101.2
Interaction	M	S	M×S		M	S	M×S		M	S	M×S	
SEd	0.5	0.7	0.9		0.6	0.6	1.1		0.3	0.5	1.2	
CD (0.05)	1.4	1.6	1.8		1.7	1.3	2.3		0.9	1.2	2.6	

3.2 Effect of rice straw incorporation on Number of tillers per hill

The maximum number of tillers per hill was recorded on Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) having 15,21 and 25 no of tillers per hill on 30,60,90 DAT respectively. The range varies from 14 to 16 tillers per hill on 30 DAT, 18 to 21 tillers per hill is recorded during 60 DAT and near 23 to 25 tillers per hill in 60 DAT (Table 2). According to [12] the incorporation of rice straw increases the crop growth and yield.

Table 2: Effect of Rice Straw incorporation on Number of tillers per hill

Treatment	30DAS				60DAS				90DAS			
	M1	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
S1	14	15	15	15	18	17	20	18	22	22	24	23
S2	14	14	15	14	19	20	18	19	24	24	23	24
S3	15	17	14	15	21	18	21	20	25	22	22	23
S4	17	15	16	16	20	21	21	21	26	23	26	25
S5	14	14	14	14	19	19	20	19	23	22	23	23
S6	17	14	15	15	18	18	19	18	22	25	24	24
Mean	15	15	15	15	19	19	20	19	24	23	24	23
Interaction	M	S	M×S		M	S	M×S		M	S	M×S	
Sed	0.1	0.1	0.4		0.2	0.2	0.3		0.2	0.2	0.5	
CD (0.05)	0.2	0.3	0.8		0.5	0.5	0.7		0.4	0.5	0.9	

3.3 Effect of rice straw incorporation on soil available nutrients

The levels of soil nutrients like N, P and K were assessed during tillering, panicle development and harvest. After the stubble is absorbed, the nutrients are returned to the soil, aiding in the long-term retention of soil nutrient reserves. Soil moisture determines a major role in increasing the rate of decomposition and yield [13]. Rice straw act as a main source for K for most of the rice growing farmers. When compared to the application of ash to the field, rice straw incorporation increases the soil pH, organic carbon and nutrient content. Large quantity of rice straw is required to attain adequate amount of N to the crop. As a result, the initial soil was analysed. The soil pH and EC are 8.2 and 0.67 dS m^{-1} respectively. After incorporation the level of pH and EC increases to 8.33 and 0.76 dS m^{-1} respectively. The initial the available NPK are 123.6kg, 37.5 kg, 278 kg respectively (Table 3). Then the soil samples were collected and analysed during the harvest, the level of NPK is 103.3 kg, 5.13 kg and 418.03 kg respectively which is shown in fig 2. Approximately 50.36% rise in the available K was observed. The current results were akin to the findings of [14].

Table 3: Initial and final value of N, P, K, OC and soil pH in experimental site

Properties	Initial values	Final values	Methodology	Reference
Available Nitrogen (kg/ac)	123.6	103.3	Alkaline Permanganate method	Subbiah and Asija, [15]
Available Phosphorus (kg/ac)	8.75	5.13	Olsen’s extractant method	Olsen *et al*. [16]
Available potassium (kg/ac)	278	418.03	Neutral normal ammonium acetate method	Stanford and English 1949 [17]
Organic Carbon (%)	1.10	1.42	Chromic acid wet digestion method	Walkley and Black 1934 [18]
Soil pH	8.2	8.33	pH meter	Jackson 1967 [19]

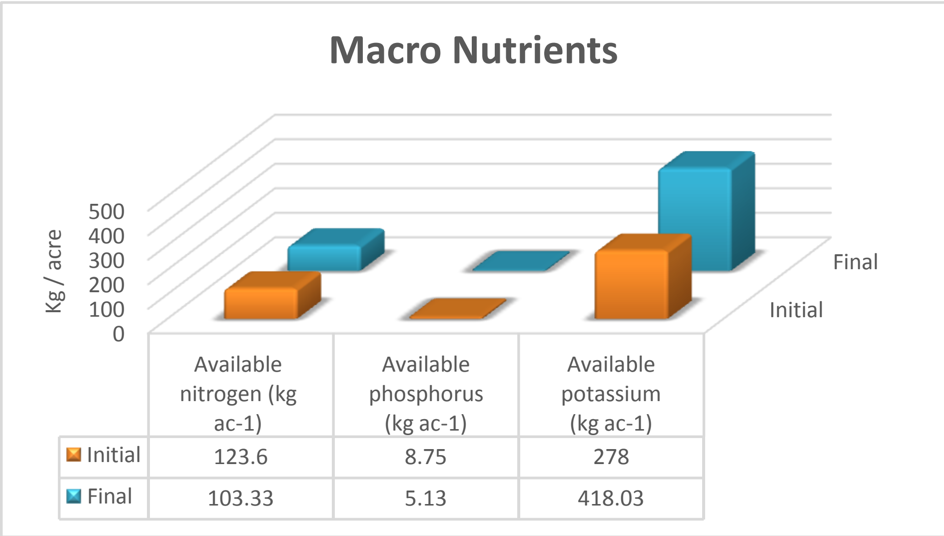

Figure 2: Effect of rice straw incorporation on soil available nutrients

3.4 Effect of rice straw incorporation on Leaf Area Index

LAI is calculated for three different stages of rice. At 30 DAT, LAI ranges from 0.7 to 0.8, for 60 DAT ranges from 2.1 to 2.5 and for 90 DAT ranges from 3.6 to 4.0 (Table 4). LAI usually depends upon plant density, leaf size and shape, leaf angle distribution, growth stage and nutrient availability. As a result, the maximum LAI is recorded in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) having 0.80, 2.47, 4.01 respectively at 30, 60 and 90 DAT. Similar results was also observed by [20].

Table 4: Effect of Rice Straw incorporation on Plant Leaf Area Index

Treatments	30DAS				60DAS				90DAS			
	M1	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**	**M1**	**M2**	**M3**	**Mean**
S1	0.62	0.77	0.75	0.71	2.15	2.3	2.28	2.24	3.46	3.81	3.45	3.57
S2	0.79	0.77	0.55	0.70	1.83	2.31	2.19	2.11	3.6	3.65	3.85	3.70
S3	0.70	0.66	0.81	0.72	2.50	2.38	2.41	2.43	3.44	3.56	4.12	3.70
S4	0.87	0.83	0.72	0.80	2.56	2.52	2.31	2.47	3.89	4.43	3.71	4.01
S5	0.87	0.65	0.76	0.76	1.92	2.67	1.95	2.18	3.61	4.05	3.81	3.82
S6	0.78	0.87	0.68	0.78	2.37	2.33	2.17	2.29	3.70	3.76	3.59	3.68
Mean	0.77	0.76	0.71	0.75	2.22	2.42	2.22	2.29	3.62	3.88	3.76	3.75
Interaction	M	S	M×S			M	S	M×S	M	S	M×S	
SEd	0.01	0.01	0.01			0.01	0.03	0.05	0.03	0.05	0.09	
CD (0.05)	0.02	0.01	0.02			0.04	0.06	0.1	0.09	0.11	0.18	

3.5 Yield Attributes

Yield Attributes like Grain yield (Kg/ha^{-1}), Straw yield (Kg/ha^{-1}), Harvest Index (HI), Number of panicles m^{-2} and Panicle length (cm) were observed at harvest.

3.5.1 Number of panicles m^{-2} and panicle length

At harvest stage more numbers of panicles m^{-2} are observed in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) having 270 panicles followed by 100% RDF (S6) having nearly 260 panicle m^{-2}. In this experiment, Rice raw straw incorporation + 75% RDF (S1) recorded less no. of panicles (238/m^2)

The panicle length was measured at the harvest stage and it ranges between 25 to 27 cm. The highest panicle length is observed in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) having nearly 27 cm where the both number of panicle m^{-2} and panicle length are greater in above (Table 5). Rice straw incorporation has implications for nutrient cycling and soil fertility in paddy fields, particularly under cool temperature conditions. It highlights the importance of N management to promote efficient straw decomposition and nutrient release, which can benefit subsequent rice crops. The above finding is supported by [21].

Table 5: Effect of Rice Straw incorporation on No. of panicles /m² and panicle length

Treatment	No. of panicles/m²				Panicle Length (cm)			
	M1	M2	M3	Mean	M1	M2	M3	Mean
S1	234	242	239	**238**	24.07	25.40	24.17	**25**
S2	240	257	242	**246**	24.67	26.43	25.23	**25**
S3	246	263	255	**255**	25.37	27.20	26.30	**26**
S4	257	290	264	**270**	26.17	28.53	27.30	**27**
S5	255	263	262	**260**	25.70	26.40	26.07	**26**
S6	260	271	266	**266**	25.43	27.30	26.43	**26**
Mean	249	264	255	**256**	25	27	26	**26**
Interaction	M	S	M×S		M	S	M×S	
SEd	0.52	0.89	1.97		0.03	0.06	0.11	
CD (0.05)	1.45	1.98	4.1		0.08	0.14	0.24	

3.5.1 Grain Yield, Straw Yield and Harvest Index

At the harvest stage, yield parameters like Grain yield and Straw yield were recorded and harvest index is calculated. The Grain yield ranges between 3487 kg/ha to 5184 kg/ha and the straw yield ranges between 5170 kg/ha to 7712 kg/ha. The maximum Grain Yield and straw yield was observed in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) having about 5184 kg/ha and 7712 kg/ha respectively followed by 100% RDF (S6) treatment having nearly 4445 kg/ha of grain yield and 6680 kg/ha of straw yield. The least amount of yield is recorded in Rice raw straw incorporation + 75% RDF (S1) having about 3487 kg/ha of grain yield and 5170 kg/ha of straw yield. With this recorded values harvest index is calculated. It ranges between 0.399 to 0.403 which is shown in fig 3. All the above values are significant. Organic fertilizer formed from decomposed rice straw has a high nutritional potential, which promotes crop productivity, increase soil fertility and moisture content which improve crop development and grain yield. Rice output is determined by the quantity of photosynthate present in leaves and stems during the seed filling phase, which is largely dependent on the photosynthesis process that occurred after blooming. The use of rice straw compost increases the amount of photosynthates in the leaves. The current results were akin to the findings of [22] and [23].

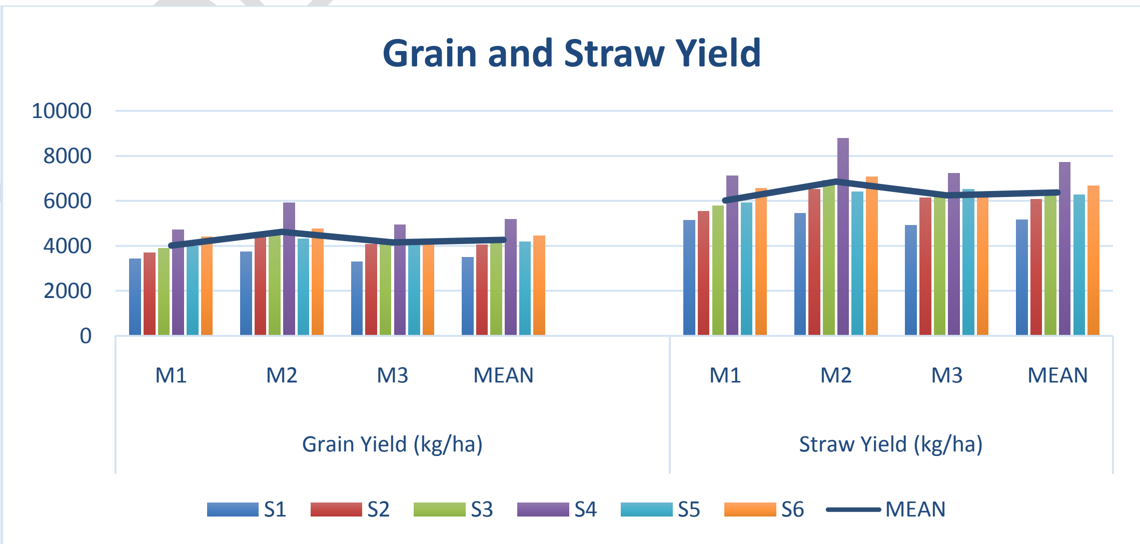

Figure 3: Grain Yield, Straw Yield and Harvest Index

4. CONCLUSION

From the above study it could be concluded that higher growth parameters like plant height, number of tillers per hill and leaf area index were observed in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) when compared to other treatments.

The soil properties of experimental site have been improved due to rice straw incorporation which is favorable for better crop growth and increases the soil microbial activity.

As a result, grain yield (5184 kg/ha) and straw yield (7712 kg/ha) was higher in Rice raw straw incorporation with Pusa Decomposer Capsules + TNAU Bio mineralizer + 75% RDF (S4) followed by 100% RDF (S6).

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