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EFFECTS OF PADDY STRAW INCORPORATION ON GROWTH AND YIELD ATTRIBUTES OF LOW LAND RICE

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Abstract

A field experiment on effects of paddy straw incorporation on growth, physiology and yield attributes of low land rice was conducted at Agronomy experimental field of Central farm, College of Agriculture, Bhubaneswar during *rabi*-2020.The experiment was laid out in completely randomized block design with six treatments symbolyzed as T1 to T6 along with recommended dose of fertiliser (80:40:40::N: P_2O_5:K_2O kg/ha). Results showed highest plant height, tiller number, leaf number, SPAD and LCC were in T5 followed by T4 and T6. These parameters were found to be highly correlated with grain yield. The growth analysis during different period of growth of the rice cultivar, Lalat, in respect to leaf area index(LAI), crop growth rate(CGR), specific leaf area(SLA), leaf area ratio(LAR), LAD(leaf area duration), total chlorophyll, total carbohydrate, amino acid and protein contents were found to be correlated with grain yield. Maximum values regarding these parameters were found to be highest in T5 followed by T4 and T6. The total biomass was found significant among the treatments and was highest in T5 followed by T4 and T6. Grain yield and straw yield were found to be highly correlated with total biomass (r^2=0.70) and physiological growth traits (LAI, SLA, CGR) were prominently significant in T5 with a tune of 4.94t/ha and 5.21t/ha, respectively followed by T4 and T6. In T5 yield attributing parameters like number of panicles, panicle weight, filled grain per panicle, 1000-grain weight were highest. The high percentage of C, H, N, S concentration and high ratio of C:N, C:H implies good quality grain harvested in T5. The soil microbial population and status after harvest was also found to be high inT5. Thus, paddy straw incorporation coupled with chemical fertilizer had significant effect on rice growth and yield with proper maintenance of microbial population in soil when the crop is treated with T5 with booster application of 20 kg/ha of N and P in the form of urea and DAP, respectively.

Introduction

India produces about 686 Mt crop residue annually out of which cereals contributes 386 Mt. Assuming a grain straw ratio of 2:3, the mass of rice straw produced was over 180 Mt in India. In paddy based cropping systems, management of paddy straw (6-8 t/ha) in field is a serious problem (Singh *et al.* 2010). Farmer generally follow the legally banned practice of burning paddy straw in their fields after combined harvesting. Though, burning of rice straw is age old practice but in recent year this process has gained momentum due to scarcity and high labour cost to remove straw. Also, collection, handling and storage are main problems associated with removal of paddy straw from the field.

Farmer can deal with rice straw in 2 ways, one is to return it to the field directly and other is to use it as feed or fuel. There are certain nutrients and cellulose, hemicellulose, lignin, protein and

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ashes which are present in rice straw. Rice residues are potential source of organic matter and it requires a proper effective management. If rice residue is managed efficiently, it can increase organic matter as well as soil N. Paddy straw incorporation affects physiological and chemical properties of soil, accelerates the decomposition of organic matter and adds a lot of energy to microorganisms. All these changes reflect on morphology, physiological, biochemicals and yield attributing characters of rice crop because soil is the food for crop. Incorporation of straw enhances total soil organic carbon and total N levels. With the increase of nitrogen levels, grain and straw yield, plant height, productive tillers filled spikelet per panicles, SLA, CGR increase. In long term production practices, farmers have found that paddy straw incorporation can indeed improve rice yield and there are significant differences in the effect of rice straw incorporation on rice growth, yield and quality (Vijayaprabhakar *et al.* 2020).With exploding population and rapid depletion and degradation of natural resources, it is necessary to save the natural resources, and to use them efficiently. Recycling of crop residues is an essential component in achieving sustainability. Proper management and utilization of rice residue is essential for improvement of soil quality and crop productivity. Improvement in soil condition leads to better crop growth and yield. The present study effects of paddy straw incorporation on growth physiology and yield attributes of low land rice were investigated.

Materials and Methods

The present field experiment was carried out during *rabi*-2020-2021 at Agronomy experiment field of Central farm, College of Agriculture, Bhubaneswar. The soil characteristics of the experimental plot were analysed in the soil test crop response (STCR) laboratory, Department of Soil science and Agricultural Chemistry. The weather data during the entire period of field experiment were also collected from department of agro-meteorology, OUAT. The popular rice cultivar, Lalat, was transplanted with six treatments *viz.*, paddy straw (residue) removal (T1), residue burning (T2), paddy straw incorporation (T3), paddy straw incorporation +20 kg N/ha (T4), paddy straw incorporation + 20 kg N/ha+20 kg P_2O_5(T5)and paddy straw incorporation + waste decomposer(T6) which was suitably fitted in Randomized Block Design. Each treatment was replicated four times. The biochemical analysis was done spectrophotometrically following Lowry test for protein (Lowry *et al.*1951) and anthrone method for carbohydrate analysis (Yosidha *et al.*1976). Estimation of C, H, N, S in percentage level was analysed by C,H,N,S and O analyzer by instantaneous oxidation of the sample by “flash combustion” which were then detected with the help of thermal conductivity detector (make-Elementar, model-UNICUBE,070721). Different growth attributes on morphophysiological (LAI by Williams (1946), CGR by Watson (1958),LAD by Power *et al.* (1967), biochemical and yields parameters mentioned above were examined during growth stages with an interval of 20DAT. Bacteria, actinomycetes and fungi cultivation methods and growth/ colonies were determined by modified standard serial plate count method (Gaind*et al.*2007) using *viz.* Nutrient Agar for bacteria, Potato Dextrose Agar (PDA) for fungi, Actinomycetes Isolation Agar for Actinomycetes. Preparation of the three media was carried out aseptically by pouring and solidification of the media. Serial dilution of the provided soil was done using sterile (NSS) followed by aseptic inoculation on the media by using spread plate technique. The Plates were then kept for incubation in the respective optimal temperature (28±2 °C) for the required time period (24 hrs for bacteria, 48 hrs for Fungi, 5 days for actinomycetes growth). Then these were counted as colony forming units/g (cfu) fresh weight of the soil. The microbial population was exposed as number of colonies forming units per gram of the soil and the data generated were statistically analyzed (Panse and Sukhatme1985).

Results and Discussion

The morphological parameters like plant height, tiller number, leaf number, LCC reading, SPAD reading were recorded in the maturity stages at 90DAT and presented in Table 1. Results showed that the plant height, tiller number and total number of leaves per hill were higher in T5 and lower in T2, respectively and the later was lower than the residue removal, the control (Table 1). The Leaf colour chart and SPAD value indicated that T5 was at optimum greenness and chlorophyll content at its optimum level of N content (Table 1).In the above findings, the higher impact in T5 might be due to blending of rice straw incorporation with inorganic sources of additional 20 kg/ha N and P over and above the recommended dose of inorganic fertilizer application.

Table 1.Variation in different morphological parameters in leaf to paddy straw incorporation in soil.

Treatment	Plant height(m)	Tiller no.	No.of leaves	LCC	SPAD
T1	112.45	12.5	19.75	1.75	10.03
T2	110.875 (-1.40%)	9.25 (-26%)	17.5 (-11.39%)	1.5 (-14.28%)	8.58 (-14.50%)
T3	115.95 (3.11%)	13.5 (8%)	21.5 (8.86%)	1.75 (0%)	11.77 (17.31%)
T4	126.125 (12.16%)	14.75 (18%)	27.25 (37.97%)	2 (14.28%)	12.72 (26.73%)
T5	129.7 (15.34%)	19.25 (54%)	35 (77.21%)	2 (14.28%)	13.24 (31.94%)
T6	120.9 (7.51%)	14.25 (14%)	27.5 (39.24%)	2 (14.28%)	12.53 (24.89%)
SE(m)+	0.49	0.61	0.94	0.20	0.15
CD (0.05)	1.50	1.84	2.86	0.62	0.44

Parentheses indicate (+) percentage increase, (-) percentage decrease over control.[Paddy straw (residue) removal(T1), Paddy straw (residue) burning(T2), paddy strawincorporation(T3), paddy straw incorporation +20 kg N/ ha(T4), paddy straw incorporation + 20 kg N/ ha+20 kg P_2O_5(T5)and paddy straw incorporation + waste decomposer(T6)].

Biomass accumulation reflects plant growth and metabolic activity which ultimately control the economic yield (r=0.99**). In present study, the biomass increased simultaneously with the plant growth and attained maximum value in T5, the plants treated with paddy straw incorporation along with 20 kg N and 20 kg P per ha was of highest biomass (1907.15 g m^{-2}) and the lowest biomass was observed in plants treated with residue burning T2(1031.45 g m^{-2}) over control, residue removal (T1).At every stage of plant growth T_5 had more SLA and CGR(r=0.84*)(Table 2). If the SLA is high, the photosynthetic surface will be high. T5 showed highest SLA followed by T4 and T6.The CGR simply indicated the changes in dry weight over time. It is the dry matter accumulated per unit land area per unit time and was decreased with a tune of 34.73 and 23.54 g m^{-2} day^{-1} followed by T4 and T6, respectively.The above finding might be due to readily response of photosynthetic rate to N and P supply which contributes in increasing biomass and leaf growth (Motazedian*et al*.2019, Vijayaprabhakar*et al*.2020,Iqbal*et al*.2021). .

Total chlorophyll content analysed by acetone extraction method on fresh leaf at 67 DAT (2nd leaf) of crop presented in Table 3 revealed that the maximum total chlorophyll content was in

T5(5.62 mg/g FW) followed by T4 (5.27 mg/g FW) and T6 (4.75 mg/g FW), respectively. The protein content was highest in T5, 69.80 mg/g FW followed by T4, (47.67 mg/g FW) and T6 (41.06 mg/g FW).The highest carbohydrate content and free amino acid were found in T5 *i.e.*, 27.74% and 2.60 mg/g FW, respectively followed by T4 and T6. The above finding is highest in T5due to the fact that application of additional N and P along with paddy straw incorporation increase the soil fertility and plant nutrient absorption as leaf chlorophyll content and protein content, carbohydrates and free amino acid content are highly associated with leaf N concentration (Ndiso*et al.* 2018, Islam *et al.*2019).

Table 2.Variation in different physiological parameters to paddy straw incorporation in soil.

Treatments	Total biomass (g/m^2)	SLA (m^2/g)	CGR ($gm^{-2/}day$)
T1	1252.09	0.0071	13.58
T2	1031.45(-17.62%)	0.0073 (3.52%)	9.43 (-30.55%)
T3	1474.69(17.77%)	0.008 (14.73%)	18.15(33.57%)
T4	1773.73(41.66%)	0.012 (61.97%)	23.54(73.30%)
T5	1907.15(52.31%)	0.016 (124.01%)	20.43(50.39%)
T6	1622.67(29.59%)	0.010(45.34%)	20.90(53.86%)
SE(m) ±	7.50	0.0004	0.37
CD (0.05)	22.61	0.0014	1.12

Table 3.Variation in different biochemical parameters to paddy straw incorporation in soil.

Treatments	Total cholorophyll content (mg/g FW)	Total carbohydrate (%)	Free amino acid (mg/g FW)	Protein (mg/g FW)
T1	4.12	21.05	0.99	31.41
T2	3.90 (-5.52%)	11.59 (-44.95%)	0.40 (-59.21%)	14.91 (-52.54%)
T3	4.58 (11.12%)	22.25 (5.67%)	1.43 (43.84%)	35.83 (14.08%)
T4	5.27 (27.74%)	24.55 (16.61%)	2.34 (135.96%)	47.67 (51.78%)
T5	5.62 (36.31%)	27.74 (31.77%)	2.60 (162.28%)	69.80 (122.26%)
T6	4.75 (15.25%)	23.72 (12.65%)	2.14 (116.23%)	41.06 (30.75%)
SE(m) ±	0.03	1.37	0.13	1.32
CD (0.05)	0.09	4.12	0.38	3.99

The highest grain and straw yield were found significant among all treatments and maximum was recorded in T5 (4.94 t/ha, 5.21 t/ha, respectively) followed by T4 (4.61 t/ha,5.08 t/ha) and T6 (4.33 t/ha,5.01 t/ha), respectively. Maximum harvest index (48.55%) was recorded in T5, followed by T4 (47.57%) and T6 (46.37%), respectively.1000-seed weight was found highest (24.27 g)in T5 followed by T4 (23.88g) and T6 (21.72g), respectively. Number of filled grain per panicle was also highest in T5(143.5) followed by T4 (131.5) and T6 (123), respectively. Grains weight per panicle was found significant among the treatments and highest was in T5 (2.86g) followed by T4

(2.66g) and T6 (2.47g), respectively (Table 4). The length of panicle was found highest (24.9 cm), in T5,followed by T4 (23.765 cm) and T6 (23 cm), respectively. The number of panicles were found significant among treatments, highest in T5 (16.5) followed by T4 (15.5) and T6 (14.50) respectively. The highest panicle weight (5.76 g, 23.17g) was recorded in T5 followed by T4 (4.78g, 21.78g) and T6 (4.05g 21.03g) at reproductive and maturity stage respectively. The finding was in agreement with the result reported by Khatri*et al.*(2019) and Choudhary*et al.*(2020).

Table 4.Variation in different yield parameters to paddy straw incorporation in soil.

Treatments	Grain weight (t/ha)	Straw weight (t/ha)	HI (%)
T1	3.53	4.74	42.73
T2	2.60 (-26.47%)	3.64 (-23.13%)	41.64 (-2.54%)
T3	4.12 (16.56%)	4.92 (3.85%)	45.57 (6.66%)
T4	4.61 (30.50%)	5.08 (7.29%)	47.57 (11.34%)
T5	4.94 (39.77%)	5.21 (10.03%)	48.66 (13.88%)
T6	4.33 (22.51%)	5.01 (5.70%)	46.37 (8.53%)
SE(m) ±	0.03	0.03	0.29
CD (0.05)	0.09	0.09	0.89

Table 5. Variation in C, H, N and S content, C-N, C-H ratio of grain to paddy straw incorporation in soil.

Treatments	C%	H%	N%	S%	C/N	C/H
T1	36.65	6.79	1.08	5.84	34.09	5.40
T2	34.50 (-5.86%)	6.68 (1.62%)	1.03 (4.41%)	5.65 (-3.13%)	33.57 (1.51%)	5.17 (-4.31%)
T3	38.10 (3.97%)	6.82 (0.44%)	1.10 (1.86%)	6.43 (10.11%)	34.80 (2.07%)	5.59 (3.51%)
T4	40.84 (11.45%)	6.99 (3.02%)	1.15 (6.51%)	6.89 (18.12%)	35.67 (4.64%)	5.84 (8.18%)
T5	42.70 (16.51%)	7.12 (4.86%)	1.17 (8.37%)	7.43 (27.24%)	36.65 (7.51%)	6.00 (11.11%)
T6	39.71 (8.37%)	6.85 (0.92%)	1.12 (3.72%)	6.53 (11.82%)	35.62 (4.48%)	5.80 7.38(%)
SE(m) ±	0.04	0.02	0.01	0.04	0.20	0.02
CD (0.05)	0.13	0.06	0.02	0.11	0.61	0.05

The rice contains mainly carbohydrate and some protein with virtually no fats or sugar, mainly composed of C, H, N, S and O. So, rice grain quality mainly related to the amount of C, H, N and S available in its grain and its proportion to quantity.T5 showed highest grain nitrogen percentage (1.17%) followed by T4 (1.15%) and T6 (1.12%) indicating proper translocation of nitrogen to grain (Table 5). Result of the present study demonstrated that the nitrogen concentration in rice grain was high when additional N, P @ 20kg/ha each was applied in the form of urea and DAP over and above the RDF with paddy straw incorporation in soil. Similar findings were also observed in C, H% and highest was found in T5 (42.70, 7.12%) followed by T4 (40.84, 6.99%) and T6 (39.71, 6.85%), respectively. S is also a constituent of protein and was also found highest in T5 (7.43%) which also implies high quality grain. The highest C/N ratio was noted in T_5 (36.65%) followed by T4 (35.67%) and T6 (35.62%), respectively. Similarly, C/H ratio was also found highest inT5 (6%) followed by T4 (5.84%) and T6 (5.80%), respectively. All these parameters were found significant among the treatments.

Table 6.Variation in different microbial population in soil to paddy straw incorporation in soil.

Treatments	Bacteria (cfu/g x 10^6)	Actinomycetes (cfu/g x 10^4)	Fungi (cfu/gx10^3)
T1	35.75	20.25	18.5
T2	28 (-21.67%)	17.5 (-13.58%)	15.25 (-17.56%)
T3	41.5 (16.08%)	23.5 (16.04%)	22.5 (21.62%)
T4	49 (37.06%)	32.5 (60.49%)	31.25 (68.91%)
T5	52.5 (46.85%)	39.5 (95.06%)	41.25 (122.97%)
T6	42.75 (19.58%)	28.5 (40.74%)	28.75 (55.40%)
SE(m) ±	0.84	0.66	0.80
CD(0.05)	2.52	1.99	2.40

The population of bacteria, actinomycetes and fungi was found highest in T5 (52.5 x 10^6, 39.5 x 10^4,41.25 x 10^3cfu/g) followed by T4(49 x10^6, 32.5 x 10^4 and 31.25 x10^3cfu/g) and T6 (42.75 x10^6, 28.5 x10^4 and 28.75 x10^3cfu/g), respectively (Table 6). This might be due to the integration of residue incorporation along with RDF and additional application of N and P. It may improve the microbial population, activity and energy and ultimately leads to more grain yield and grain quality facilitating in a way of more water and nutrient uptake by plants (Liu *et al.* 2021).

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