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Effective Recycling Of Paddy Straw through Microbial Degradation for Enhancing Grain and Straw Yield in Rice

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Abstract: *The field investigation was conducted at Agricultural and Horticultural Research Station, Kathalagere, Davanagere district, Karnataka during summer 2010 and Kharif 2010 (wet season) to study the efficacy of different biomass degradable microorganisms on rice straw. The results of the present investigation showed that rice straw treated with combination of cow dung slurry @ 5% + Trichoderma harizianum @ 5 kg/ha + Pleurotus sajor caju@ 5 kg/ha had significant influence in degrading rice straw as evidenced through the activity of N- fixing and P- solubilizing microorganisms in the soil. The highest population of N- fixing microorganisms 27.16 x 10^3 and 51.00 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 31.56 x 10^3 and 62.44 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010 were recorded compared to application of recommended dose NPK (10.37 x 10^3 and 20.00 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 11.52 x 10^3 and 21.87 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010)27.16 x 10^3 and 51.00 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively). The increased population of Phosphorus solubilizing microorganisms 20.00 x 10^2 and 30 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 24.65 x 10^2 and 36.77 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010 were recorded compared to application of recommended dose NPK (11.00 x 10^2 and 14.33 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 11.87 x 10^2 and 15.22 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010).Similarly, the enhanced grain and straw yields were also confirmed the efficiency of organic matter degradability microorganisms.*

Keywords: *Rice Straw, microbial degradation, N-fixing microorganisms, P-Solubilising micro organisms.*

I. Introduction

Rice (Oryza sativa L.) is the principal food crop to people in India. India occupies a pride place in rice production among the food crops cultivated in the world. India's share in global rice production has been hovering around 19.50 to 24.52 %. In Karnataka, it is grown in an area of 1.48 m ha with an annual production of 3.8 million tones and a productivity of 2670 kg ha^{-1} [1].

The rice productivity is declining in recent years which are attributed to soil degradation because of puddling coupled with declining amendment of organic matter to soil, decreased soil fertility, occurrence of nutrient imbalances, inadequate crop and nutrient management, inappropriate fertilizer application practices and adverse change in climatic parameters [2]. The sustainability of crop production system in future largely depends on the soil fertility, adequacy and balanced supply of nutrients. Soil fertility and nutrient availability could be enhanced by improving the physical properties and organic matter content of soil through organic amendments. Rice straw is one of the potential sources of immediate organic substance available in the field itself. Rice straw contains a good amount of plant nutrients and one ton of rice straw is reported to contain 0.5-0.8% N, 0.16-0.27% P_2O_5 , 1.4-2.0% K_2O , 0.05-0.10% S and 4-7% Si on dry matter basis [2]. In addition to the above, it consists of digestible organic matter (51.5%), cellulose (47.2%), lignin (3.0%) and soluble phenolic compounds (4.3%) [3].

In recent years, paddy is being harvested using a combined mechanical harvester and large quantities of straw is being unutilized and left in the field. A majority of the farmers in Karnataka burn rice straw and other plant debris in-situ due to problem related to disposal. Although, rice straw is one of the important sources of plant nutrients, its natural decomposition a slow process owing to the presence of cellulose and lignin in the straw. The microbes play a pivotal role in the breakdown of the above complex compounds into simple ones and in available form.

A survey of literature suggested that soil is an abode of microorganisms capable of degrading lignocelluloses material of dead plants. Fungal species are predominately cellulose and lignin degrading that is converted into simple sugars and phenolic acids [4], which further supports a host of other microbes in the soil. Some of the soil fungi economically employed in crop soil amendments are species of Trichoderma and Pleurotus [5]. The utilization of the above species in the degradation of rice straw before its incorporation into soil for rice cultivation has not been studied in detail. A comparative account of the common farmer's practices and microbial degraded rice straw in rice cultivation is not available.

In view of the above, fungal species like Trichoderma harizianum and Pleurotus sajor caju were evaluated for their ability to degrade paddy straw before its addition to soil for rice cultivation.

II. Materials And Methods

A field experiment was conducted during summer and Kharif seasons of 2010 in moderately shallow and dark reddish brown clay soils of previously grown paddy field with the initial soil fertility status of p^H-6.40, 0.68 % organic carbon, 288 kg/ha available nitrogen, 12.3 kg/ha available phosphorus and 211.4 kg/ha available potash at Agricultural and Horticultural Research Station located at Kathalagere (situated between 13^0 2' to 13^0 05' North latitude and 76^0 15' East longitude and an altitude of 561.6 meters above mean sea level), Channagiri taluk, Davanagere district that comes under Southern Transitional Zone (Zone-7) of Karnataka which receives average annual rainfall of 654.0 mm.

The field experiment was laid out in Randomized Complete Block Design (RCBD) with nine treatments replicated thrice. The rice nursery and the main crop were raised as per the package of practices except for the recommended fertilizers in the package [6]. The rice variety JGL-1798 healthy seedlings of 25 days old were planted in each plot size of 8.4 x 6.9 m with the spacing of 20 cm x 10 cm.

In the present investigation, freshly harvested rice straw was collected and segmented upon 12-inch-long segments and dried under sunlight in field. Then the paddy straw was treated with cow dung slurry (CDS) at 5% and mixed with inocula of Trichoderma harizianum and Pleurotus sajor caju either individually or in combination. Rice straw treated with CDS at 5% but not with any fungal culture, left out in the field, burnt and incorporated to soil and standard dose of NPK were other treatments. The details of the treatment are given in the TABLE 1.

The microbial cultures of T. harizianum , P. sajor caju obtained from the department of Agricultural microbiology, college of Agriculture, Shimoga (University of Agricultural Sciences, Bangalore) were pre-inoculated to paddy husk piece for 15 days and incubated for 45 days then the cultures and cow dung slurry were sprinkled on moist paddy straw depending on the treatment. The microbial decomposed paddy straw was incorporated to rice field and ploughed to mix the same into the soil.

The 500 g soil samples were collected by using post-hole auger at five locations in each treatment before application of treatments, at transplanting and 60 days after transplanting (DAT). The population density of nitrogen fixing bacteria (Azotobacter and Azospirillum) and phosphate solubilizing microorganisms (Bacillus megaterium and Aspergillus awamori) in soil were calculated by total plate count method and expressed in cfu g^{-1} (colony forming unit). The yield attributes like grain and straw yields were recorded at harvest. The data were subjected for statistical analysis [7].

III. Results And Discussion

Build up of useful microflora in the soil for mineralization of various nutrients will be of paramount importance for the plant growth. The results of the present investigation revealed that incorporation of rice straw treated with cow dung slurry @ 5% ha^{-1} and mixed with inocula of T. harizianum and P.sajor caju individually or in combination had significant influence in build- up of nitrogen fixing bacteria (Azotobacter and Azospirillum) and phosphate solubilizing microorganisms (Bacillus megaterium and Aspergillus awamori) in the soil (TABLE 1 and 2).

3.1 Efficacy of different rice straw decomposing microbial agents on build-up of nitrogen fixing bacteria and Phosphate solubilizing microorganisms in paddy soils

The results of the present investigation on build-up of nitrogen fixing and Phosphate solubilizing microorganisms as influenced by the incorporation of paddy straw treated with different decomposing microorganisms revealed that straw treated with combination of cow dung slurry @ 5% + T. harizianum @ 5 kg/ha + P.sajor caju@ 5 kg/ha had recorded significantly highest population of nitrogen fixing microorganisms (Azotobacter and Azospirillum) during summer 2010 (27.16 x 10^3 and 51.00 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively) and Kharif 2010 seasons (31.56 x 10^3 and 62.44 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively) compared to application of recommended dose NPK (10.37 x

10^3 and 20.00 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 11.52 x 10^3 and 21.87 x 10^3 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010) (TABLE 1).Similarly, the activity of Phosphate solubilizing microorganisms (Bacillus megaterium and Aspergillus awamori) in the soil was also significantly increased due to incorporation of paddy straw treated with combination of cow dung slurry @ 5% + T. harizianum @ 5 kg/ha + P. sajor caju@ 5 kg/ha by recording highest population both during summer 2010(20.00 x 10^2 and 30 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively) and Kharif 2010 seasons(24.65 x 10^2 and 36.77 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively) compared to application of recommended dose NPK (11.00 x 10^2 and 14.33 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during summer 2010 and 11.87 x 10^2 and 15.22 x 10^2 cfu /g soil at the time of transplanting and 60 DAT, respectively during Kharif 2010) (TABLE 2).

The results of the present investigation revealed that the activity of nitrogen fixing and Phosphate solubilizing microorganisms were increased in the soil due to incorporation of rice straw treated with T. harizianum and P. sajor caju along with cow dung slurry. The nitrogen transformation and solubilization of phosphate in the way of breakdown of cellulose, hemicelluloses and lignin content of the straw as decomposing process resulted in release of plant nutrients. Artificial supplementation of cellulolytic bacteria and fungi enhanced the composting process of rice straw because of their hydrolytic enzymes [8].T. harizianum treated rice straw accelerated the rate of decomposition and white-rot fungi P. sajor caju is considered as one of the useful decomposers of various agricultural waste including rice straw which hasten the decomposing process [9].The better decomposition rate of paddy straw in soil may be assessed for presence of useful soil bacteria and fungi. The microbial agents T. harizianum and P. sajor caju along with cow dung slurry treated straw had significant influence in buildup of soil micro flora responsible for rapid decomposition process [5].

3.2 Efficacy of different rice straw decomposing microbial agents on yield attributes, grain and straw yield

Incorporation of paddy straw treated with cow dung slurry @ 5% + T. harizianum @ 5 kg/ha + P. sajor caju@ 5 kg/ha recorded significantly more number of productive tillers (12.64 and 12.78/plant, respectively during summer 2010 and Kharif 2010 seasons), longer panicle length (21.92 and 21.87 cm) compared to straw burning (9.56 and 9.72 cm panicles/plant, respectively during summer 2010 and Kharif 2010 seasons and 19.12 and 19.21 cm panicle length, respectively during summer 2010 and Kharif 2010 seasons) (TABLE 3).

The grain and straw yields were also significantly increased by incorporation of paddy straw treated with different decomposing microorganisms. Incorporation of paddy straw treated with cow dung slurry @ 5% + T.harizianum @ 5 kg/ha + P. sajor caju@ 5 kg/ha recorded significantly highest grain (6012 and 5978 kg/ha, respecively during summer 2010 and Kharif 2010 seasons) and straw yield (9251 and 9090kg/ha, respectively summer 2010 and Kharif 2010 seasons) compared to straw burning (4792 and 4761 kg/ha grain and 7348 and 7254 kg/ha straw yield, respectively summer 2010 and Kharif 2010 seasons). The significant increase in yield attributing factors, grain and straw yields may be attributed to the increased activity of useful microorganisms by decomposition process of rice straw treated with T. harizianum and P. sajor caju along with cow dung slurry for release of plant nutrients. The better aerobic decomposition rate of paddy straw treated with T. harizianum and P. sajor caju had positive effect in enhancing both grain and straw yield [5].

IV. Conclusion

The results of the present study showed the usefulness of biomass degrading microorganisms. Incorporation of rice straw to the soil treated with decomposing microbial agents like T. harizianum and P. sajor caju along with cow dung slurry had enhanced the organic carbon and nutrients content of the soil, which resulted in increased grain and straw yield. The practical application of the present study could be adopted under mechanically harvested rice crop for effective utilization of biomass for increasing the soil nutrients status, grain and straw yield for sustainability of soil productivity.

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Table 1. Efficacy of different rice straw decomposing microbial agents on build-up of nitrogen fixing microorganisms in paddy soils during summer 2010 and Kharif 2010(wet) seasons

Sl. No.	Treatments	N-fixing microorganisms (10^3 cfu/g soil)					
		Summer 2010			*Kharif* 2010		
		Initial population	At the time of transplanting	60 days after transplanting	Initial population	At the time of transplanting	60 days after ransplanting
T_1	Straw left out in field and incorporation (Farmers Practice)	10.50	11.70	27.00	11.42	12.05	29.46
T_2	Straw burning (Farmers Practice)	11.10	4.00	10.66	10.98	5.12	9.65
T_3	Straw treated with cow dung slurry(CDS) @ 5% and incorporated after 1 ½ month	10.73	20.66	48.00	11.02	22.87	54.66
T_4	Straw treated with *Trichoderma harizianum* (*T.h.*)@5 kg/ha	10.84	5.00	15.00	10.56	8.69	19.87
T_5	Straw treated with Pleurotus sajor caju(*P.s c*) @ 5 kg/ha	10.80	14.66	22.33	11.11	17.56	25.47
T_6	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha	11.10	21.33	39.00	11.53	26.54	43.77
T_7	Straw treated with CDS @ 5% + *P.s c* @ 5 kg/ha	10.44	12.00	31.66	11.78	14.56	39.74
T_8	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha + *P.s c* @ 5 kg/ha	10.59	27.16	51.00	10.45	31.56	62.44
T_9	Recommended dose of NPK (100: 50: 50 kg NPK)	10.83	10.37	20.00	11.24	11.52	21.87
	S.Em±	**0.48**	**2.11**	**3.52**	**0.52**	**2.43**	**3.61**
	CD at 5%	**NS**	**6.32**	**10.54**	**NS**	**7.24**	**10.86**

Nitrogen fixing bacteria: Azotobacter and Azospirillum

Table 2. Efficacy of different rice straw decomposing microbial agents on build-up of P-solubilizing microorganisms in paddy soils during Summer 2010 and Kharif 2010 (wet) seasons

Sl. No.	Treatments	P-solubilizing microorganisms (10^2 cfu/g soil)					
		Summer 2010			*Kharif* 2010		
		Initial population	At the time of transplanting	60 days after transplanting	Initial population	At the time of transplanting	60 days after ransplanting
T_1	Straw left out in field and incorporation (Farmers Practice)	10.33	11.66	16.00	11.52	12.06	17.54
T_2	Straw burning (Farmers Practice)	11.00	6.00	9.00	10.96	5.64	8.24
T_3	Straw treated with cow dung slurry(CDS) @ 5% and incorporated after 1 ½ month	10.66	16.00	22.00	11.02	16.54	23.41
T_4	Straw treated with *Trichoderma harizianum* (*T.h.*)@5 kg/ha	10.33	9.33	12.00	11.74	11.98	13.95
T_5	Straw treated with Pleurotus sajor caju(*P.s c*) @ 5 kg/ha	10.66	11.66	15.00	10.75	12.11	19.54
T_6	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha	11.33	8.66	17.33	11.15	12.11	22.41
T_7	Straw treated with CDS @ 5% + *P.s c* @ 5 kg/ha	12.00	12.00	20.00	10.98	15.42	26.71
T_8	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha + *P.s c* @ 5 kg/ha	10.00	20.00	30.00	11.06	24.65	36.77
T_9	Recommended dose of NPK (100: 50: 50 kg NPK)	11.66	11.00	14.33	10.54	11.87	15.22
	S.Em±	**0.67**	**0.82**	**2.42**	**0.62**	**0.78**	**2.61**
	CD at 5%	**NS**	**2.48**	**7.29**	**NS**	**2.38**	**7.81**

Phosphate solubilizing microorganisms: Bacillus megaterium and Aspergillus awamor

Table 3. Efficacy of different rice straw decomposing microbial agents on yield attributing components and grain and straw yield of rice during

Sl. No.	Treatments	No. of productive tillers/plant		Panicle length (cm)		Grain yield (kg/ha)		Straw yield (kg/ha)	
		Summer 2010	*Kharif* 2010	Summer 2010	*Kharif* 2010	Summer 2010	*Kharif* 2010	Summer 2010	*Kharif* 2010
T_1	Straw left out in field and incorporation (Farmers Practice)	10.16	10.05	20.48	20.54	5241	5198	7889	7781
T_2	Straw burning (Farmers Practice)	9.56	9.72	19.12	19.21	4792	4761	7348	7254
T_3	Straw treated with cow dung slurry(CDS) @ 5% and incorporated after 1 ½ month	10.54	10.65	20.72	20.78	5432	5502	8364	8301
T_4	Straw treated with *Trichoderma harizianum* (*T.h.*)@5 kg/ha	11.17	11.43	20.81	20.74	5672	5687	8761	8644
T_5	Straw treated with *Pleurotus sajor caju* (*P.s c*) @ 5 kg/ha	10.24	10.55	20.08	20.11	5318	5211	8192	8102
T_6	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha	11.82	11.68	20.89	20.56	5814	5677	8812	8765
T_7	Straw treated with CDS @ 5% + *P.s c* @ 5 kg/ha	11.08	11.31	20.46	20.64	5527	5501	8516	8466
T_8	Straw treated with CDS @ 5% + *T.h.*@5 kg/ha + *P.s c* @ 5 kg/ha	12.64	12.78	21.92	21.87	6012	5978	9251	9090
T_9	Recommended dose of NPK (100: 50: 50 kg NPK)	10.32	10.41	20.51	20.61	5412	5311	8275	8164
	S.Em±	**0.54**	**0.56**	**0.32**	**0.31**	**152**	**149**	**157**	**157**
	CD at 5%	**1.61**	**1.66**	**0.98**	**0.96**	**458**	**445**	**467**	**465**