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Bhumika Koma
College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Correspondence
Bhumika Koma
College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Application and mechanism of action of *Trichoderma* spp. in repairing environment and promoting crop growth

Bhumika Koma

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Abstract
The field investigation was conducted at farmer field of dhamtari district during *Rabi* 2019 and *Kharif* 2020 to study the efficacy of *Trichoderma* spp. degradable microorganisms on paddy straw. in dhamtari district during kharif paddy is cultivated 136205 ha. and in Rabi 40475 ha total area 176680 ha. Indicates that total production of residue of paddy is almost 69187.88 ton for the total livestock of 321127. Thus the consumption of paddy residue per livestock stands at 0.22t/animal. Highest imbalance of livestock and consumption is noted in dhamtari district with zero consumption per animal. In modern times, powered machinery has replaced many farm jobs formerly carried out by manual labour or by working animals. The crop residues and stubble which left about a foot long. Ploughing this back into the soil was difficult, uprooting or otherwise cutting and collecting it was labour intensive and increasingly expensive. The farmers prefer easiest and cheapest method was to burn it in the field. It self burning of paddy stubble in dhamtari is a relatively big problem. Farmers themselves are doubly harmed, by the local air pollution caused, and by the loss of soil nutrients such as nitrogen, potassium, phosphorous and sulphur due to the burning. The field experiment was laid out in Completely Randomized Design (CRD) with a treatment replicated thrice. In the present investigation, freshly harvested paddy straw dried under sunlight in field that paddy straw treated with combination of 40kg FYM: 5kg *Trichoderma* spp/acre had significant influence in degrading paddy straw similarly, enhanced production of treated land.

Keywords: Paddy Straw, *Trichoderma* spp., burning, production

Introduction
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. 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% P2O5, 1.4-2.0% K2O, 0.05-0.10% S and 4-7% Si on dry matter basis. 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%), 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. *Trichoderma* can promote plant growth, produce substances that can promote plant growth, improve the solubility of nutrients in the soil, and improve plant rhizosphere microecology, thereby promoting plant absorption and growth (Karuppiah *et al*., 2019a;) [4]. *Trichoderma* plant interactions can not only induce resistance but also improve the resistance of plants to abiotic stress factors (salt, high temperature, UV). Treatment of cucumber seeds with *T. asperellum* T203 improved the plant's salt tolerance, and the activities of Mn/Cu SOD and catalase (CAT), and significantly reduced ascorbic acid in the plant.

Trichoderma can significantly enhance the Na^+ efflux from the root system of *Lycium barbarum* and its transport to the upper ground, ensure K^+ absorption and maintain the ion balance in the plant, thus reducing the damage of PSII caused by ion toxicity and oxidative stress, protecting photosynthetic pigments, maintaining the photosynthetic performance of *L. barbarum* under salt stress, and reducing biomass loss (Brotman *et al*., 2013) [1].

Straw composting with biological agent can improve quality of compost. Straw compost is important for sustainable agriculture, as a source of nutrient and energy source of microbial agent. The combination of composting straw on the field and the use of bio-fertilizers consortium is expected to increase the availability of nutrients, grain yield and reduce the use of artificial fertilizers significantly (reducing the cost of fertilizer). The main principle of utilizing the potential of environmentally friendly natural and minimizing external inputs in revitalizing soil quality and sustainable agriculture.

Field investigation was based on the development of rapid composting method speeds up the process with a compost fungus activator, *Trichoderma* spp., and a set of procedures that provide favorable conditions for the quick decay of agricultural wastes.

Materials and Methods

Ordinary composting is too slow for farmers who plant two or three crops a year. The rapid composting method speeds up the process with a compost fungus activator, *Trichoderma* spp., and a set of procedures that provide favorable conditions for the quick decay of agricultural wastes.

A field experiment was conducted during *Rabi* 2019 and *Kharif* 2020 in vertisols and inceptisols of previously grown paddy field with the initial soil fertility status of five farmer fields located at dhamtari district which receives average annual rainfall of 1372 mm.

Inputs Required: *Trichoderma* spp. 5kg/acre, FYM 40kg/acre, Disc harrow, paddy straw of harvested plot.

Procedures: Freshly harvested paddy straw spread evenly and dried under sunlight for 5-6 days in field. Tillage the dried paddy straw 2-3 times through the disc harrow. At the time of second tillage that paddy straw treated with combination of 5 kg *Trichoderma* spp: 40 kg FYM /acre. Treated plot moistened trough flood irrigation method. Leaved the treated field unturned for the 20 to 25 days. Seedlings are transplanted in 30 days after treatment.

Details of data collection

1. **Rice sampling:** Data of yield components (total number of tillers, plant height at harvest stage (cm) and grain yield (q/acer)
2. **Economics efficiency:** total of cost (input cost), gross return, benefit cost and benefit cost ratio /acre.

Results and Discussion

The results of the present investigation revealed that incorporation of rice straw treated with combination of 5kg *Trichoderma* spp: 40 kg FYM /acre.

Agronomic characteristics

Efficacy of different rice straw decomposing microbial agents on yield attributes, and plant height Incorporation of paddy straw treated with combination of 40kg FYM: 5kg *Trichoderma* spp./acre recorded significantly more number of productive tillers (12.61 and 12.82/plant), plant height (139.70 and 144.78 cm) as compared to farmer practice (9.18 and 9.75 /plant) productive tillers and (127.21 132.08 cm) plant height, during *Rabi* 2020 and *Kharif* 2021. Incorporation of paddy straw treated with 40kg FYM: 5 kg *Trichoderma* spp/acre recorded significantly highest grain (3360 and 3680 kg/acre), as compared to farmer practice (2940 and 2860 kg/acre) *Rabi* 2019 and *Kharif* 2020. The significant increase in yield attributing factors, grain yields may be attributed to the increased activity of useful microorganisms by decomposition process of rice straw treated with 40kg FYM: 5kg *Trichoderma* spp/acre for release of plant nutrients. Promotion of plant growth is one of the beneficial traits of *Trichoderma* (Shukla *et al.*2012) [6]. Roots in association with these fungi frequently are larger and more robust as evidenced in soybean plants in which an increase of 123% in yield was obtained when inoculated with T-22 (Harman 2000) [3]. Significant increase in the height (28%) and weight (8%) of dwarf tomato plants grown in sterile conditions after treatment with *T. viride* has been reported (Lindsey and Baker 1967) [7]. Similarly, *Trichoderma longipile* and *Trichoderma tomentosum* increased leaf area (58-71%), shoot dry weight (91-102%) and root dry weight (100-158%) of cabbage seedlings in glasshouse trials (Rabeendran *et al.* 2000) [8]. In the case of the pepper cultivars Merlin Belle, Vanguard Belle and Bonanza, applications of T-22 in the commercial product RootShield® increased significantly the yields (5.9, 3.6 and 5.4 kg vs 10.2, 8.6 and 9.6 kg, respectively) (Harman 2000) [3].

Table 1: Shows the treatments number of productive tillers/plant, plant height cm and grain yield kg/acre

S. No.	Treatments	number of productive tillers/plant		Plant height cm		Grain yield kg/acre	
		Rabi 2019	*Kharif* 2020	*Rabi* 2019	*Kharif* 2020	*Rabi* 2019	*Kharif* 2020
1	Rice straw treated with 40kg FYM: 5kg *Trichoderma* spp/acre	12.61	12.82	139.70	144.78	3360	3680
2	farmers practice	9.18	9.75	127.21	132.08	2940	2860

Economic efficiency

Comparison with existing farmers practice Average Cost of cultivation *Rabi* 2019 and *Kharif* 2020 Rs. / acre

Table 2: Shows the Particulars Rice straw treated with 40kg FYM: 5kg Trichoderma spp/acre and farmers practice

S. No.	Particulars	Rice straw treated with 40kg FYM: 5kg *Trichoderma* spp/acre	Farmers practice
1	Field preparation (including disc harrow, culture, FYM)	3000.00	2000.00
2	Seed	1700.00	1700.00
3	Transplanting	3500.00	3500.00
4	Fertilizers	1700.00	3200.00
5	Herbicide	2000.00	2000.00

6	Weeding	1500.00	1500.00
7	Spraying pesticide	4000.00	4000.00
8	Harvesting	2350.00	2350.00
9	Threshing	1750.00	1750.00
Total		21500.00	22000.00
Output			
1	Yield q/acre	35.20	29.00
2	Grass Income (Rs)	54560.00	44950.00
3	Net Income (Rs)	33060.00	22950.00

Table 3: Shows Treatments Yield (q/acre) % change in yield Net Income Rs/acre B:C Ratio

S. No.	Treatments	Yield (q/acre)	% change in yield	Net Income Rs/acre	B:C Ratio
1	Rice straw treated with 40kg FYM: 5kg *Trichoderma* spp/acre	35.20	21.37	33060.00	2.53
2	farmers practice	29.00		22950.00	2.04

Conclusion and Future perspectives

- 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 *Trichoderma* spp along with cow FYM had enhanced the organic carbon and nutrients content of the soil.
- The normal time taken for compost preparation in most methods is rather long, ranging from 100-180 days. With this method degradation of paddy straw completed within 30 days.
- This Intervention will avoid air pollution and loss of soil nutrients.
- It can provide the farmer with an option for effective utilization of their farm waste.
- Yet farmers feel they have viable alternatives because state governments have taken sufficient and effective measures that would provide incentives to farmers to stop stubble burning.
- Enhanced grain and straw yield.

There are still several problems to be solved in the application of *Trichoderma* in the biological control of plant diseases (Caruso *et al*., 2020; He *et al*., 2020) [2, 9]. The first is to explore and produce efficient strains, which can be screened through genetic engineering technology to produce *Trichoderma* biocontrol-engineered strains that are resistant to chemical pesticides and low temperatures. At the same time, it is necessary to develop effective *Trichoderma* agents suitable for use with various application methods to enhance the control effect and improve the processing technology of *Trichoderma* agents to extend the shelf life of biological control agents. Second, exploring the combined effects of *Trichoderma* spp. and other microorganisms is necessary. The development of Pesticides with volatile and non-volatile secondary metabolites secreted by *Trichoderma* as the main active ingredient will be the focus of future research and the development of new Pesticides. To improve the quality of *Trichoderma* biopesticides, in addition to monitoring traditional indicators such as pH, dissolved oxygen, and temperature in the fermentation process, it is also necessary to monitor its correlation with the yield of antagonistic substances at the level of the cell metabolic flow, genome, proteome, and metabolome. However, it is necessary to establish more scientific quality standards for *Trichoderma* products *in vivo*, such as increasing the content of antagonistic substances or activity indicators (Niu *et al*., 2020) [5]. The development of new dosage forms, such as cell microcapsules, water-in-oil emulsions, and other protective dosage forms, should be strengthened, and the molecular mechanism of chlamydospore production should be further studied.

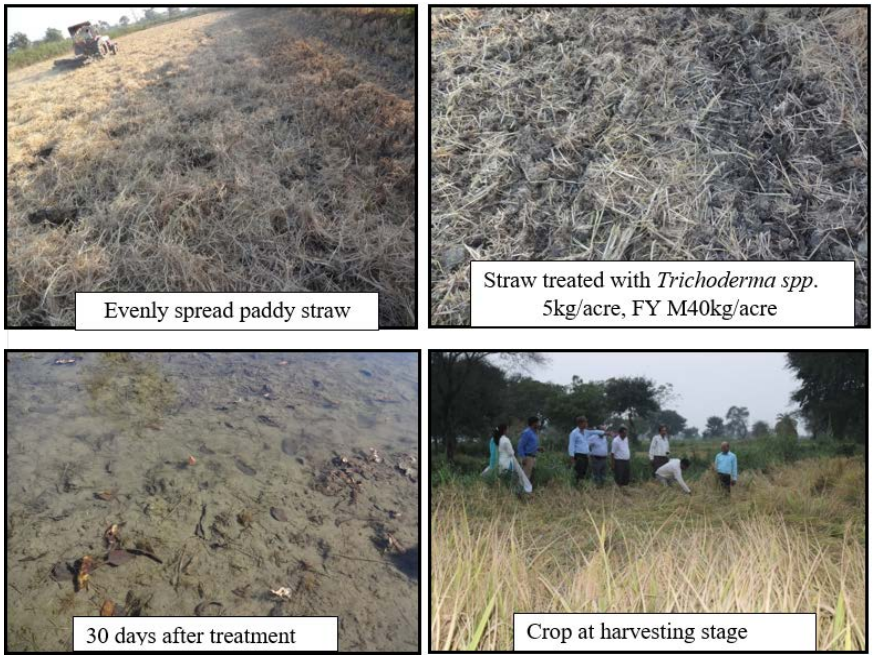

Fig 1: Shows evenly spread paddy straw straw treated with *Trichoderma spp* 5Kg/acre. M40kg/acre, 30 days after treatment and Crop at harvesting stage

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