PUSA DECOMPOSER: A CUTTING-EDGE TECHNIQUE FOR THE MANAGEMENT OF PADDY STRAW

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Rice straw, a by-product of rice cultivation, presents both an opportunity and a challenge. With an annual production of 500 million tons in India (according to the Ministry of New and Renewable Energy), this lignocellulosic waste offers potential for various applications. However, a significant surplus of 140 million tons remains, and unfortunately, nearly 92 million tons are burned annually. This practice, while seemingly convenient and inexpensive, creates a multitude of environmental problems. Compared to wheat straw, rice straw poses a unique challenge due to the narrow window between rice harvest and wheat sowing. This timeframe often compels farmers in Punjab and Haryana to resort to burning as a quick and affordable way to clear their fields. However, this approach comes at a steep cost to the environment.

Rice straw even though poses a significant disposal challenge, this abundant lignocellulosic resource has immense potential to get converted to valuable products due to its composition of biopolymers like cellulose and hemicellulose. Here, the microbial fermentation comes in, offering an avenue for quick and efficient utilization of rice straw. Unlocking the potential of rice straw which is rich in fermentable carbohydrates like cellulose and hemicellulose (50-70% of its composition), rice straw stands as an attractive feedstock for various value-added products. Utilizing diverse microorganisms in fermentation processes allows for the breakdown of rice straw's complex structure. These microbes produce a unique arsenal of enzymes-cellulases, hemicelluloses and ligninase – that work together to efficiently degrade the plant biomass.

DETRIMENTAL EFFECTS OF BURNING

Air Pollution: Burning of rice straw releases harmful pollutants like CO_2 (1460 kg per ton), CO (60 kg per ton), particulate matter (3 kg per ton), and SO_2 (2 kg per ton), contributing significantly to air pollution and smog, particularly in North India during winter months.

Soil Degradation: Field burning depletes essential nutrients like nitrogen, phosphorus, potassium and micronutrients from the soil, hindering its fertility and long-term productivity.

Increased Evaporation: Field burning of straw not only removes organic matter from the soil but also lead to increased evaporation and reduced soil water retention, that in turn exacerbate water scarcity issues.

RECYCLING PADDY STRAW BACK TO FARM FIELD THROUGH COMPOSTING

Instead of burning, using paddy straw for composting offers a valuable alternative for managing this abundant resource while simultaneously restoring soil health. Composting involves decomposition and humification, transforming heterogeneous organic matter into nutrient-rich compost. Driven by the growing demand for eco-friendly waste treatment and organic farming, interest in composting has surged in recent years. It's widely recognized as the most sustainable method for recycling organic matter and agricultural residues. During composting, microorganisms break down organic materials, releasing ammonia, carbon dioxide, water, heat, and ultimately, humus – a valuable soil amendment. This process effectively utilizes large amounts of waste like paddy straw, converting them into compost rich in nutrients. These nutrients improve soil structure, increase organic matter content, and ultimately, enhance plant growth. While traditionally a time-consuming process, various techniques can accelerate composting.

The composting process typically involves four phases; (1) *Preparatory Stage or Mesophilic Phase (of 20-40°C)* where organic matter decomposition begins with the activity of mesophilic microorganisms; (2) *Thermophilic Phase (40-60°C)* where the intense microbial activity generates heat, raising the temperature; (3) *Second Mesophilic Phase* where the heat-resistant microbes re-establish themselves, stabilizing the compost; (4) *Maturity Phase* where nutrient content in the compost stabilizes, indicating it is mature and ready for use.

Advantages of Composting Paddy Straw: By promoting composting as a viable alternative to burning paddy straw, we can achieve multiple benefits: reducing environmental pollution, improving soil health, and fostering sustainable agricultural practices.

1. **Reduced Waste:** Diverts paddy straw from burning thereby, preventing air pollution and environmental damage.
2. **Improved Soil Health:** Compost increases organic matter, enhancing soil structure, water retention, and nutrient availability.
3. **Enhanced Plant Growth:** Nutrients in compost directly benefit plants, promoting robust growth and yields.
4. **Sustainable Resource Management:** Converts waste into a valuable soil amendment, promoting a circular economy.

MAJOR CHALLENGES IN CONVENTIONAL COMPOSTING

- The high C:N ratio and recalcitrant nature of agro residues results in slow decomposition
- Low Phosphorous content of plant biomass results in nutrient-poor compost
- Requires long time (120-150 days) to decompose and prepare quality compost
- Plant pathogens and weed seeds often survive during natural composting
- Incomplete degradation of plant parts results in phytotoxicity when applied

RAPID DEGRADATION OF AGRI RESIDUES USING PUSA DECOMPOSER

Pusa Decomposer is a promising option for managing agricultural residues like paddy straw, promoting both environmental and economic benefits. Developed by ICAR-IARI and disseminated *via* the central scheme 'Promotion of Agricultural Mechanization for *In Situ* Management of Crop Residue' in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi. A report from PIB, 2022, conveyed that PD has efficiently disposed of paddy straw, which is equivalent to 2.4 million tonnes in 3,91,485 ha. On one side, its application accelerates the degradation of agri-residues, including stubbles in the field itself and on the other side, it also helps to generate value-added products with *ex-situ* management of agri-residue to compost, Phospho-Rich Organic Manure (PROM) and enriched FYM. Its use enriches the soil with organic carbon (OC) and nutrients while improving the soil's biological properties.

The liquid *Pusa* Decomposer formulation is ready to use in the field after harvesting of the crops. To decompose the stubble and residue of one acre of harvested land, mix 10 liters of Pusa Decomposer liquid with 200 liters of water and spray it evenly in the field. After spraying, incorporate the residue thoroughly into the soil using machinery. To aid the decomposition process light irrigation need to be provided if necessary. The decomposition process takes nearly 25 days and sowing of the next crop can be done after this period. In 2021, it expanded the scope through collaboration with specific industry partners. The decomposer was applied to 100,000 hectares of land in Punjab, another 100,000 hectares in Haryana, and approximately 360,000 hectares in western Uttar Pradesh (Chawla, 2022).

Pusa Decomposer offers a sustainable approach in managing paddy straw. It seamlessly integrates with conservation tillage practices, happy seeder, and super seeder, promoting responsible residue management. Also, it is an economically efficient method using a cheap source of C like jaggery, that is, 750g needed for 25L preparation at Rs. 40 per kg. The total cost of preparation of *Pusa* Decomposer solution for one hectare is 17pprox.. Rs. 85.50 (Rs. 50 for four capsules + Rs. 30 for jaggery and Rs. 5.50 for besan).

Recent research provides compelling evidence for Pusa Decomposer's effectiveness in managing paddy straw. A two-year field study by Manu et al. (2022) demonstrated that its application significantly degraded straw, leading to improved nitrogen uptake by plants in the Rice-Wheat Cropping System (RWCS). This finding was further supported by Raising et al. (2023), whose work confirmed that Pusa Decomposer effectively decomposed paddy straw in situ, enhancing nitrogen availability for subsequent crops, particularly wheat.

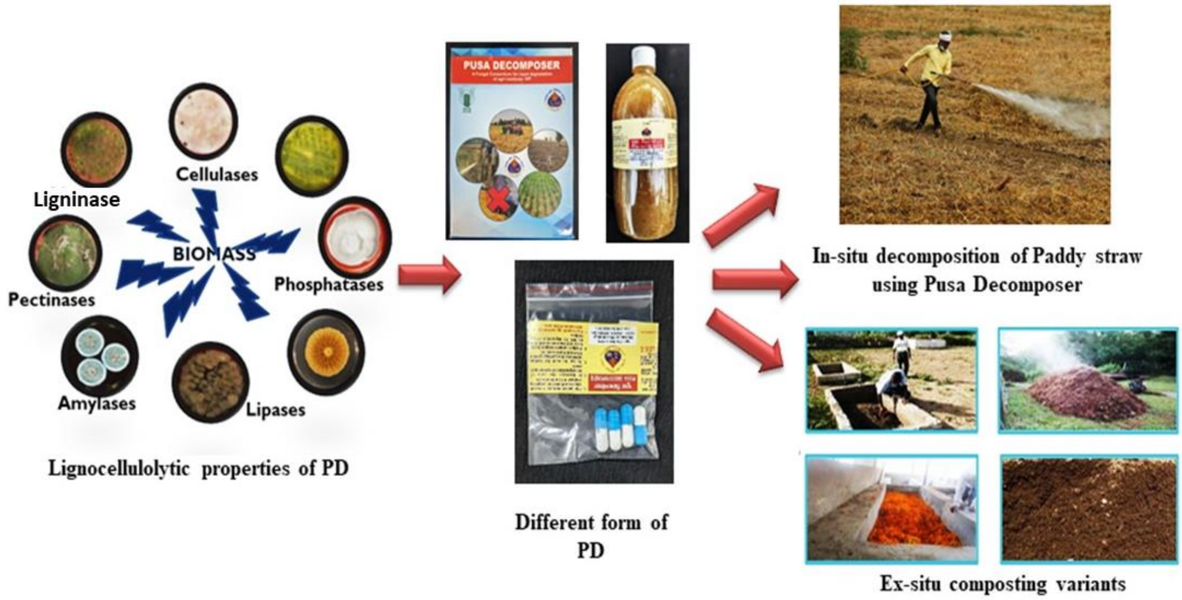

Figure 1: Various levels of field applications

HOW TO PREPARE CULTURE SOLUTION FOR *IN-SITU* FIELD APPLICATIONS?

1. Take 150g jaggery and add in 5 litres of water
2. Boil jaggary and sieve the solution to remove dirt
3. Allow the jaggary solution to cool in a deep square tray/tub till it is slightly warm
4. Add 50g gram flour and mix
5. Break four capsules and mix thoroughly
6. Cover the mixture with a thin cloth and keep it in a warm place. The fungal growth will start in 2-3 days in the form of a mat of different colors on the broth surface.
7. After 4 days, add 5 liters of warm jaggery solution again (no gram flour) and mix thoroughly. Repeat this step after every two days till 25 liters of culture is prepared
8. Mix nicely the 25 liters solution and then the liquid culture ready to apply in the field

THINGS TO BE TAKEN CARE IN THE CASE OF *EX-SITU* DECOMPOSITION:

1. The C:N ratio of crop residues is adjusted to 50:1 by the addition of poultry droppings / cow dung by mixing in 8:1 ratio
2. 1% rock phosphate is added as a source of insoluble P. Moisture is maintained at 65% by sprinkling water at regular intervals
3. Application of consortium of fungi is recommended at the rate of 5 litres /tonne of crop residues. Contents are mixed properly in the pits and turning is advisable at fortnightly intervals
4. The compost prepared by the traditional method contains only 0.5% N & 0.3 % P, while that prepared using *Pusa* Decomposer Inoculant contains higher N (1-1.5%) and P (0.3- 0.5%)
5. This compost can be used at the rate of 5 ton/ha, along with half of the recommended dose of NPK in different crops

Application: for *in-situ* decomposition, take 10 liters of *Pusa* Decomposer solution for 1 acre land, mix it with 200 liters of water and spray the mixture using a knapsack sprayer or any machine. Turn the straw in the field using a rotavator and slightly irrigate the field. For *ex-situ* decomposition in pits, heaps or windrows, use 5 liters *Pusa* Decomposer solution per ton of residue

PUSA DECOMPOSER: GROUND-BREAKING SOLUTION FOR ADVANCING CARBON FARMING PRACTICES

By abandoning the harmful practice of field burning and adopting the soil incorporation of paddy straw with microbial based decomposers like Pusa Decomposer offers a win-win scenario. This helps to enrich the soil with organic carbon, sustaining its health and fertility. To further encourage this shift, farmers who responsibly manage straw with decomposers instead of burning it receive financial incentives. This not only reduces greenhouse gas emissions but also paves the way for carbon farming practices. Imagine earning around 1,500-1,600 rupees ($20–$22) per hectare for one carbon credit. This is the reality for farmers who embrace carbon farming initiatives (Chawla, 2022). The State Government of Haryana has launched the State plan scheme for management of crop residue for the year 2023-24. In order to encourage the farmers, the State Government has decided to provide an incentive of Rs. 1000/- per acre admissible to *in-situ* & *ex-situ* management of paddy crop residue. The incentive will be disbursed in the farmers' bank accounts after physical verification. This scheme not only improve the income of farmers but also helps in conserving natural resources. To avail the benefits of the scheme, farmers need to register their name in www.agriharyana.gov.in. The funds will be provided under the State plan scheme for management of crop residue for the year 2023-24. The details of incentives admissible during the current F.Y. are as under:

Ex-situ management of paddy crop residue by making bales@ Rs. 1000/- per acre. As per the revised modalities / process flow there is a provision of incentives to FPOS/Registered Societies after taking consent of the farmer.

In-situ management of paddy crop residue @ Rs. 1000/- per acre admissible to only non-basmati and muchhal variety of paddy by combination of machines having Happy Seeder, Super Seeder, Reversible M.B. Plough & Zero till Seed cum Fertilizer Drill. The verification will be made by village level committee based on the field visit and GPS location-based photograph of operation at farmer field followed by approval of DLEC. It must be ensured that farmers availing benefit under the scheme are not involved in crop residue/stubble burning (DoA&FW, 2023a). Similarly in Punjab, incentive of Rs. 1500/- is provided to farmers for promoting Direct Sowing of Rice instead of burning the crop residue to get more time between paddy harvest and wheat sowing (DoA&FW, 2023b). Soon, such sustainable practices will become the norm, benefiting both the environment and their livelihoods in all over world.

SUMMARY

Traditionally, biodegradation relied on single-fungus solutions, leading to slow composting due to their limited enzyme capabilities. This consortium harnesses the synergistic power of multiple fungi, enabling rapid paddy straw degradation. Developed to address

the burning problem in North India, it offers a sustainable solution. Initially available in capsules, it underwent a scalable fermentation process to generate larger quantities (25L). This 25L solution, mixed with water, covers one hectare of straw. Meticulous fermentation ensures consistent product quality.

FUTURE PERSPECTIVES

1. The decomposition period is still lengthy for the farmers: So, it is purposed to shorten the decomposition periods by enhancing the efficiency of the decomposer under the same conditions.

2. Multiplication of the decomposer in large volume requires at least 12 days hence, ready-to-use formulation should be provided for proper dissemination of the technology.

3. Population dynamics of fungal inoculant for long-term survival and proliferation in presence of native microbial communities should be studied for more effective use of the decomposer technology.

REFERENCES

Chawla, D.S. 2022. A conversation with Ashok Kumar Singh. *ACS Cent Sci.* 8(2):140-141. Doi: 10.1021/acscentsci.2c00095.

Department of Agriculture and Farmers Welfare. 2023a. https://agriharyana.gov.in/CRMCombineStraw, Accessed: 21 February, 2024.

Department of Agriculture and Farmers Welfare. 2023b. https://ppcb.punjab.gov.in/sites/default/files/documents/FINAL%20Action%20Plan%20Stubble%20Burning%2029May2022.pdf , Accessed: 21 February, 2024.

Manu, S.M., Singh, Y.V., Shivay, Y.S., Shukla, L., Sharma, V.K., Saha, N.D., ... & Gouda, H.S. 2023. Nitrogen budgeting under the influence of in situ rice residue management options in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *The Indian Journal of Agricultural Sciences*, 93(2), 151-156.

Raising, L.P., Singh, V.P., Chandra, S., Shukla, A., Pareek, N., Zhiipao, R.R., ... & Singh, V.K. 2023. Augmentation of nitrogen management reduce nitrogen stress and enhance productivity of super-seeder sown wheat under rice residue incorporation.

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