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Does paddy straw biochar improved soil health, crop yields and economics in tropics?

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Abstract

After the Kharif season, farmers conventionally burned significant agricultural waste, primarily paddy crops, outside to remove this massive biomass and ensure timely sowing of the next Rabi wheat crop to maximize yields. However, the open burning of paddy straw (PS) pollutes the environment, ultimately fueling global warming and deteriorating the quality of nutrients in the soil that crops need to grow. Therefore, implementing climate-smart agriculture in the region requires sustainable management of paddy straw. Punjab Agricultural University, Ludhiana has proposed several solutions to address this issue. Among them one is to prepare the paddy straw biochar or paralichar, a low-tech, environmentally friendly method that replenishes soils with nutrients, enhances soil health, and lessens the adverse effects of global warming. The current article emphasizes the concept and methodological strategy for its wider national adoption which on one side managed the problem of paddy straw while on others improves soils health and mitigates the adverse effects of global warming.

Keywords: Paddy residues; Open burning; Soil health; Global warming

The state of Punjab grows 30 lakh hectares of paddy and produces 225 lakh tonnes of paddy straw annually. We must sweep up this massive quantity of paddy straw within 15 to 20 days to prepare the next wheat crop. As a result, most farmers combine paddy harvests and burn any surplus paddy. Burning crop residues results in a significant loss of plant nutrients, particularly nitrogen and sulfur, as well as organic carbon. This not only negatively impacts soil health but also poses health risks to humans, animals, and the environment. Scientists at the Punjab Agricultural University, Ludhiana (PAU, Ludhiana) have developed various technologies and methods to handle crop residues effectively and efficiently, particularly in light of the National Green Tribunal's prohibition on burning leftover paddy. We aim to present to you the latest techniques for harnessing the nutrients concealed in paddy straw, promoting soil health,

environmental sustainability, and human welfare. The Punjab Agricultural University advocates another technology that boosts crop output from the first year onwards. It converts paddy straw into prali char. The following sections cover the method for making prali char and the results of using it in the paddy-wheat system.

Biochar from paddy straw procedure and methodology

Biochar, also known as parali char, is a porous material rich in carbon that is created by thermochemically decomposing paddy straw at low temperatures in the absence of oxygen. We create it using the heap approach. This old method involves raising a brick kiln, which resembles a stack or pyramid, to a height of 14 feet and a circumference of 10 feet. Next, we place the paddy straw inside the kiln. Paddy straw is lit from the top of the dome to start the combustion, after which it is covered with an iron lid and quickly sealed with mud (Fig. 1). In order to let combustion products escape, vents are kept open. We partially burn the paddy straw until the fire becomes clean and a thin blue smoke begins to emerge from the vents located in the top half of the dome. It indicates that biochar is forming in this area.

Fig. 1 Preparation of paddy straw biochar (A) Kiln for preparing paralichar (B) Paralichar.

Now is the time to seal off the vents in the upper section of the dome with clay. Smoke starts to come out of the vents now that the combustion has reached the center of the dome. Hold off until the incredibly thin blue smoke starts coming out of these vents. When it starts, immediately block the central dome vents with clay. It proves that biochar is prepared here as well. As the thin blue smoke begins to emerge from these apertures, the combustion ultimately reaches the lower part of the dome, where clay seals the vents. This region is now producing biochar as well. Usually, the complete process takes ten to twelve hours. After that, we add

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diluted clay to water to initiate the cooling process. Two days later, we remove it using charcoal. If it is cooled with water, it can also be taken out that same day. This procedure can convert twelve quintals of paddy straw into 6.5–7.0 quintals of prali char.

Nutrient losses in conventional burnings of paddy straw:

Let's review some facts about what happens to nutrients when one acre of paddy straw is burned in open fields in order to better appreciate the benefits of this technique. It has adverse effect effects on the air quality which further effects the human health.

Table 1. Nutrients lost from the crop fields due to paddy straw burning

Sr No	Nutrient	Nutrient (kg) per ton of paddy straw	Nutrient lost (kg) during burning of one ton of paddy straw	Nutrient lost (kg) /acre	Equivalent to fertilizer (kg/acre)	Equivalent cost of fertilizers / acre (Rs)
1	Nitrogen	5.5	4.95	11.9	25.8 (Urea)	146.7
2	Phosphorus (P_2O_5)	2.3	0.58	1.4	8.6 (SSP)	77.6
3	Potash (K_2O)	25.0	5.00	12.0	20 (MOP)	240.0
4	Sulphur	1.2	1.08	2.6	2.9 (Bentonite sulphur)	311.0
5	Carbon	400	400	960		
Total						**775.3**

In northwest India, paddy farming produces 23 million tonnes of paddy straw annually. This enormous amount of paddy straw burning will cost Rs 743 crores in lost nutrients (N, P, K, and S) totaling 2.67 lakh tonnes. It has not yet been determined how much carbon is lost during the burning of paddy straw, despite the fact that soil health and microbial activity depend on the availability of nutrients to crop plants in the soil. In addition to this monetary loss, air pollutants, methane (CH_4), nitrous oxide

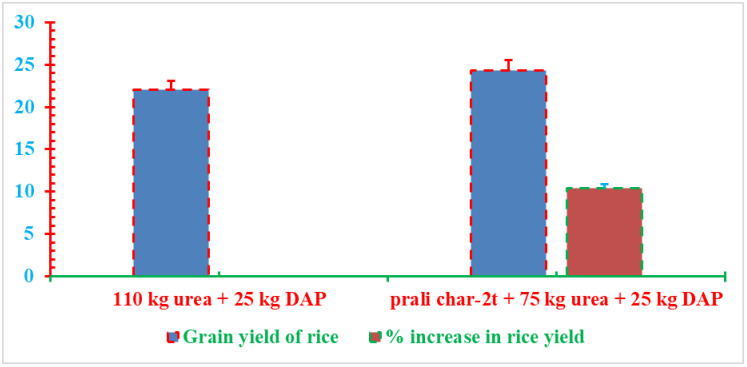

Fig. 2: Effect of *prali char* on the grain yield (q/acre) of paddy during 2016 at USF, Ladhowal

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(N_2O), and around 46 million tonnes of

carbon dioxide will be emitted into the environment. The burning of agro-residues releases around 75% of its greenhouse gas (GHG) emissions as CH_4, with N_2O accounting for the remaining 25%. Burning should be avoided due to its detrimental effects on the environment and soil production. Alternatively, prali char derived from paddy straw typically contains 30-36 percent carbon, 0.5–0.6 percent nitrogen, 0.1–0.22 percent phosphate, and 2.0–2.5 percent potassium. Figure 2 shows that applying 2 t/acre of prali char along with 75 kg of urea and 25 kg of DAP increased grain output by 10.4% in comparison to the recommended fertilizers. An additional 35 kg of urea were saved. The results of demonstrations done at different KVKs are displayed in Figure 3.

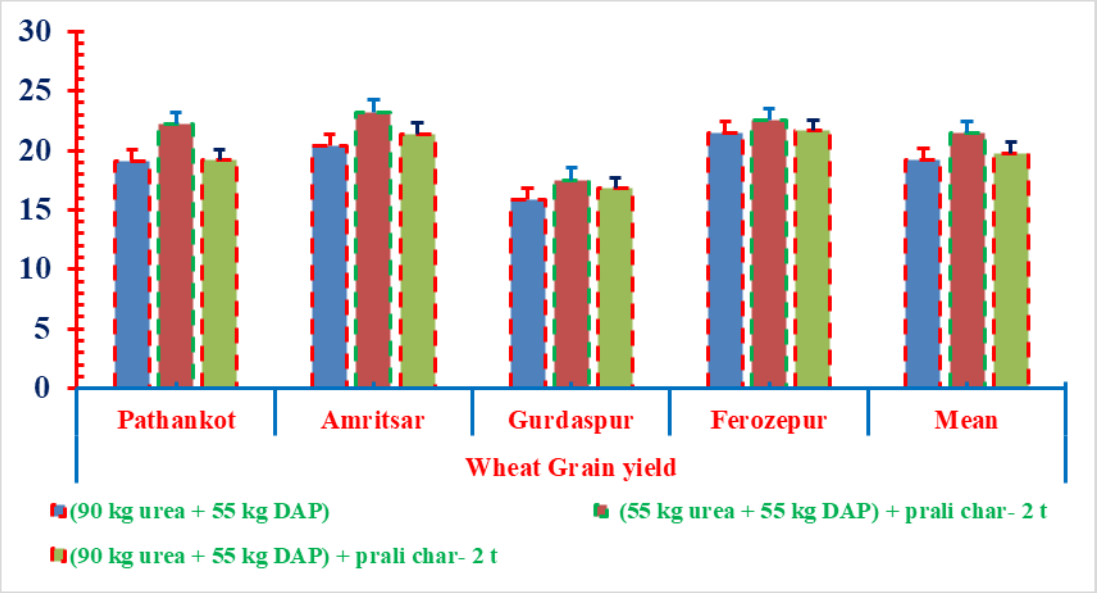

Fig 3: Effect of *prali char* on the grain yield (q/acre) of wheat at different KVKs during 2017-18.

The results shown in figure 3 show that at KVK Ferozepur, KVK Gurdaspur, KVK Amritsar, and Pathankot, respectively, applying 2 tonnes of prali char in addition to recommended fertilizers increased wheat grain yield by 8.8, 10.1, 13.7, and 16.2 percent. At the four sites, the application of prali char, as opposed to prescribed fertilizers, increased wheat grain production by an average of 11.5 percent. When 2 tons of prali char was added to 75% of the necessary fertilizers, the increase in wheat grain production ranged from 0.5 to 5.6%, with an overall 2.8% increase. The statistics indicate that you can either save 25% of the nitrogen with little yield improvement or achieve 11.6 percent higher yields by adding prali char over recommended fertilizer doses starting in the first year.

Biochar from paddy straw *viz-a-viz.* soil health

By strengthening soil structure, retaining more water, and increasing nutrient

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availability, biochar made from paddy straw enhances soil health. More crop development and sustainable agriculture result from its augmentation of soil organic carbon, promotion of advantageous microbial activity, and reduction of soil acidity, especially in degraded or nutrient-deficient soils. Biochar from paddy straw (paralichar) thus has a favourable effect on the different soil properties as shown in Table no. 2 which further helps to enhance the grain yields and hence livelihoods of the farmers

Table 2. Effect of paddy straw biochar on different soil properties

Treatments	pH	EC (dsm^{-1})	Soil organic carbon (%)	P (kg/ha)	K (kg/ha)
No amendment	6.70	0.17	0.41	14.60	99.6
RSB -5 t/ha	6.70	0.22	0.52	22.93	299.7
CD(0.05)	NS	0.05	0.06	1.86	21.7
Initial values	6.73	0.10	0.41	13.2	138.0

Following a two-year period, the incorporation of prali char resulted in an increase of 26.8% in organic carbon, 57% in phosphorus, and 200% in potassium (Table 2). Apart from these characteristics, the physical characteristics of the soil significantly improved.

Economics of paddy straw biochar:

Collection of paddy straw from one-hectare area costs Rs 3750/- (Rs 0.60/kg of paddy straw by baling) and labor required to convert paddy straw of one hectare into paddy straw biochar is Rs.3750 (five cycles), hence, total cost: Rs 7500/- while yield of biochar is 6500 q of paddy straw multiplied by 0.65 conversion factor or efficiency of biochar making kiln is 4225 kg. Further, 20 q of biochar is Rs 3550 which is sufficient for one acre. Reported wheat yield hike is 2.5 quintals per acre. Therefore, price of extra produce is = Rs 2.5×2000= Rs.5000 assuming MSP Rs. 2000 per qt. Therefor reported net income is Rs. 5000-3350=Rs 1650/- per acre. Hence, a net income or benefit of Rs. 1650 was observed with significant improvements in soil health.

Therefore, paddy straw biochar offers a sustainable solution for improving soil health, enhancing crop yields, and mitigating global warming. By enriching soil organic matter, it boosts nutrient retention and microbial activity, leading to improved soil fertility and crop productivity. Its ability to sequester carbon helps reduce greenhouse gas emissions, making it an effective tool in combating climate change. Additionally, biochar improves water retention and reduces soil erosion, ensuring long-term agricultural sustainability. Overall, incorporating paddy straw biochar into farming practices addresses both soil degradation and environmental challenges, offering a promising strategy for sustainable agriculture and climate resilience.

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