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Stubble burning in Punjab: A review

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Abstract

In Punjab, agriculture was supported by input and output price structure and superior yields of rice and wheat compared to other crops has almost become a rice-wheat monoculture. Use of combined harvester has further problem of crop residue management as it leaves behind a large amount of rice stubble to be burnt in the open fields. This study brings the problem of agriculture waste burning was 35 million tonnes in the forefront. It tries to form the more amount of pollution being caused by rice stubble burning and its adverse effect on human health. Burning of farm waste causes severe pollution of land and water on local as well as regional scales. It is estimated that burning of paddy straw results in nutrient losses viz., 3.85 million t of organic carbon, 59,000 t of nitrogen, 20,000 t of phosphorus and 34,000 t of potassium. This also adversely influence the nutrient condition in the soil. It results in the emission of smoke, if that smoke is added to the gases present in the air like methane, nitrogen oxide and ammonia can cause severe atmospheric air pollution problem occurs from stubble burning. These gaseous emissions can result in health risk, irritating asthma, chronic bronchitis and decreased lung function. Stubble burning also contributes indirectly to the increased global warming which leads to ozone depletion. The uses of rice residue as fodder; use of rice residue in bio-thermal power plants; use for mushroom cultivation, for bedding material for cattle; its use for production of bio-oil; paper production; bio-gas production, etc. Other uses include the adding of paddy straw in soil, energy technologies and thermal combustion.

Keywords: Combined harvester, stubble burning, crop stubble management, air pollution, alternate uses of rice residue, residue use in bio-thermal

Introduction

Stubble burning is setting a fire to the straw stubble that quite simply, the act of removing paddy crop residue from the field to sow wheat and it remains after a crop has been Harvested (Fig.1). It's usually required in areas that use the combine harvesting method which leaves crop residue behind. An estimated 35 million tons of crop waste is burned in northern parts of India each year. While this practice is a cheaper way of clearing the fields of waste and weeds for farmers, it emits huge volumes of thick smoke (Fig.2). Punjab is known as the country's chief granary contributing almost $\frac{1}{4}$ th share of rice and more than $\frac{1}{3}$ rd of wheat to the central pool. In Punjab, the major problem in rice-wheat cropping system is the available short time between rice harvesting and sowing of wheat and delay in sowing majorly affects the wheat crop. There is a burden on the farmer to sow the next crop in time for gaining high yield with disease resistant. Combine harvester is the machine that harvest, thresh i.e. divides the grain and also clean the separate grain all at once leaving behind 8-12 inches of paddy stalk on the field. However, problem is that the machine does not cut close enough to the ground, leaving stubble behind that the farmer has no use. The fast and cheap solution is to clear the field by burning the stubble (P. Kumar *et al.*, 2015) [1].



Fig 1: Burning of rice stubble by farmer



Fig 2: Huge volume of thick smoke

The modern inputs introduced in Punjab to harvest the rice crop within a short period of time. One of the inputs which has become the most important machinery in the rice-wheat cropping system is the use of combine harvester. The use of this has increased at a stupendous rate in Punjab. The maximum percentage (80%) of the rice crop is harvested using the machine only. However, use of this harvester has exacerbated the problem of crop residue management and leaves behind a large amount of rice residue to be burned in open fields. Punjab cumulatively utilize minimal quantity (0.94 mt) of paddy straw for bio mass power projects against estimated 19-20 mt of production (P. Kumar *et al.*, 2015)^[11].

“The time gap between Rabi planting and Kharif harvesting is between two to three weeks. During this time, farmers clear the fields and ready them for the winter wheat crop. We are already held-up with so much of work, reaching out to customers for taking the residue is a tough task,” Amlok Singh, farmer from Bathinda says.

Prahlad Singh, Head of the Department of Veterinary Gynaecology and Obstetrics, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), says unlike other states rice straw is not used as fodder in Punjab and Haryana.

“Rice straw in Punjab and Haryana has high silica content and thus it is non-palatable to animals. If the stubble is used as fodder it impacts the quality of milk. The quantity of calcium in milk decreases by at least two percentage points if rice straw is used as fodder,” Prahlad Singh says.

“Marginal farmers do not have alternatives for utilising the stubble effectively. Therefore, blaming only the farmers may not solve the problem of air pollution and there is a need to find sustainable technological solutions that can help farmers

and simultaneously allow everyone to breathe clean air,” Prahlad Singh says, adding the remaining ash on the farm land also has an adverse impact on soil health.



Fig 3: Red colour indicating the burning regions

The red spots (Fig.3) is the image revealed by NASA representing the stubble burning incidents in Punjab. The story of Punjab agriculture was based on the negative environmental concerns i.e., over exploitation of ground water resources of the state. Punjab has the largest percentage of over exploited and dark blocks.

According to the Ground Water Resources Estimation Committee (GEC), the recent ground water development in the state is 145 % (March 2004). Also, latest data provided by Central Ground Water Board and Department of Irrigation Punjab, there are having total 137 blocks of the state. Out of which,

1. 103 blocks are over exploited,
2. 5 blocks are critical,
3. 4 blocks are semi critical and
4. Only 25 blocks are in safe category. (P. Kumar *et al.*, 2015)^[11].

All the blocks of various districts like Amritsar, Jalandhar, Moga, Kapurthala, Sangrur, Fatehgarh Sahib, Patiala and Ludhiana have been found to be overexploited leading to sharp depletion of the water table in these districts (P. Kumar *et al.*, 2015)^[11].

Political leaders and media have been rapid to hold farmers liable for the declining air quality and the exacerbation of respiratory diseases and low in visibility. Due to the reason Punjab government banned the burning of stubble in 2013. The problem of stubble burning became like Demand-Supply chain between the government and village farmers. The government entitled it has raised subsidy to village farmers to by machines like happy seeders and shredders, but the farmers emphasized they are yet to receive assistance and demanded Rs 300/q to stop stubble burning excludes on machines. Farmers say disposing of the rice straw in an environment friendly manner but it leads to additional expenditure of Rs 5,000-6,000/acre (Joydeep Thakur, Hindustan Times, 2017).

“What will we do with this stubble? We’ve no option but to burn them. Heard about a government aid of Rs 100/q but have never got a penny,” said a villager (Fatehgarh channa, Punjab).

In 2015 the National Green Tribunal ordered when pollution became increasingly felt in NCR-Delhi region. In Punjab only 20% of straw is managed through biomass power plants and cardboard mills remaining quantity of over 15 mt is burnt in open fields. The stubble emits high quantities of particulate matter, mainly the terrific PM_{2.5} including with other noxious gases. The NGT had given directions to the district

administrations to levy fine on the farmers found burning stubble. The NGT allows a fine of Rs 2,500 on stubble burning in two-acre land, Rs 5,000 fine in land measuring 2-5 acres, Rs 7,000 fine in land up to 10 acres and Rs 15,000 fine on burning stubble in fields above that measurement. Past 72 cases were detected in Punjab and Rs 1,75,000 penalty was collected (Joydeep Thakur, Hindustan Times, 2017). Up to oct 2018, 14,321 cases of stubble burning cases were recorded in Amritsar and there were only 81 in Patiala (Jacob Koshy, THE HINDU, 2018).

“It is economical to pay the penalty than to invest on cutting the stubble and fine is a small price compared with the cost of alternative equipment,” Amlok singh says.

By declaring that it is a serious about controlling rice and wheat stubble burning, the Punjab government is providing on applications for subsidy by farmers who want to buy the ‘baler’-an agriculture machine that cuts the remains of crop from the root and used to bail rice-wheat straw for later use (Raakhi Jagga, 2016) [12]. The new invention for incorporating rice stubble is the Happy seeder machine instead of using rotavator or zero drill machines. After stubble burning Zero tillage is now being adopted by many farmers due to Happy seeder machine, which combines stubble mulching and seed drilling functions into one machine.

It is a dispute that burning of crop residues and scarcity of fodder coexists in this country, leading to significant increase in prices of fodder in recent years. To manage the crop stubble in a productive and profitable manner, conservation agriculture (CA) offers a good promise. With the adoption of conservation agriculture-based technologies these residues can be used for improving soil health, increasing crop productivity, reducing pollution and enhancing sustainability and resilience of agriculture (IARI, 2012).

Pollution caused by crop stubble burning

By burning of rice stubble leads in release of high harmful gases in the atmosphere like CO, N₂O, NO₂, SO₂, Methane. One ton of stubble burning releases 2 kg of SO₂, 60 kg of CO, 1,460 kg of CO₂ and 199 kg of ash (Joydeep Thakur, Hindustan Times, 2017). These gases have additional effects not only on the environment but also on human and animal health. A study conducted by the National Remote Sensing Agency in Punjab reported that rice straw/stubble burning was estimated to contribute 261 Gg of CO, 19.8 Gg of NO₂, 3 Gh of CH₄, 30 Gg of PM₁₀ and 28.3 Gg of PM_{2.5} (P. Kumar *et al.*, 2015) [11].

Table 1: Particulates releasing in air

Particulates	Range
PM _{2.5}	146-221 µg/m ³
PM ₁₀	300 µg/m ³
NO ₂ and NH ₃	40–50 µg/m ³

The data issued by Punjab Agricultural University (PAU) to the State Environmental Council also estimated that within a short span of time 15-20 days, crop residues contained about 6.0 mt of carbon that on burning could produce about 22.0 mt of CO₂.

A Study conducted by the Punjab Pollution Control Board (PPCB) shown that the permissible limit of CO in ambient air is 4.0 µg/m³, this was a major health hazard for local people and road travellers in the area. Particulates were also being

released in large quantities follows: (Table No. 1) (P. Kumar *et al.*, 2015) [11].

Further, concentrations of organic pollutants were also found to be significantly high. The smoke was also found to be toxic due to presence of heavy metals, mainly iron and zinc. Iron concentrations were in the range of 6,778–13,240 µg/m³, whereas zinc concentrations were in the range of 1,021–4,854 µg/m³ (P. Kumar *et al.*, 2015) [11].

Effects of crop stubble burning on the fertility of the soil

Table 2: Soil nutrients condition

Nutrients	Index
Nitrogen	low
Phosphorus	low to medium
Potassium	medium to high

Rice stubble burning results in extensive impacts both on and off farm, e.g., losses in soil nutrients (vital compounds such as Nitrogen, Phosphorus, Potassium and sulphur from top soil layer, making the land less fertile), soil organic matter, production and productivity, air quality, biodiversity, water and energy efficiency on humans and animal health (P. Kumar *et al.*, 2015) [11]. As per the Punjab, Department of Agriculture, the soils of Punjab state are generally: (Table-2)

Table 3: Loss of nutrients from soil

Nitrogen	339 kg/ha
Phosphorus	6 kg/ha
Potassium	140 kg/ha
Sulphur	11 g/ha

The organic carbon in Punjab soil has been reduced to very low and deficient levels due to the insufficient application of organic manures and non-recycling of crop residues. The burning of crop stubble in open fields has adverse impact on the fertility of the soil, reducing the amount of nutrients present in the soil. In one hectare 5 tons of straw were left, by burning the straw there was loss of valuable nutrients like: (Table No. 3) (Joydeep Thakur, Hindustan Times, 2017).

According to the Department of Soil, Punjab Agricultural University, burning results in the soil organic carbon being lost to the atmosphere as CO₂, nitrogen equilibrium in the soil changes rapidly and nitrogen is converted to nitrate. As a result, there is a loss of 0.824 million tonnes of NPK from the soil. It is estimated that burning of paddy straw results in nutrient losses *viz.*, 3.85 million t of organic carbon, 59,000 t of nitrogen, 20,000 t of phosphorus and 34,000 t of potassium. Burning of crop stubble increases the temperature in the soil up to 33.8–42.2 °C. Long-term burning also reduces total nitrogen and carbon and potentially mineralized nitrogen in the 0–15 cm soil layer along with a loss in the soil organic matter (P. Kumar *et al.*, 2015) [11].

Health Impacts of Pollution Due to Residue Burning

Burning of paddy stubble leads to the emission of dangerous chemicals, dioxins like polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAH's) and polychlorinated dibenzofurans (PCDFs). Furthermore, the release of CO₂ in the atmosphere due to paddy stubble burning results in the depletion of the oxygen layer causing greenhouse effect. Due to burning of crop stubble results in the death of animals by polluted air, as the high levels of CO₂ and CO in the blood can convert normal haemoglobin into deadly haemoglobin and severe adverse impacts especially for

people suffering from respiratory disease, cardiovascular disease. Pregnant women and small children are also likely to suffer from the smoke produced by stubble burning (P. Kumar *et al.*, 2015)^[11].

More than 60 % of the population in Punjab live in the rice growing areas and is affected by polluted air that comes from burning of rice stubbles.

The field impacts by burning crop stubbles includes

- On field impacts like removal of a large portion of the organic material, denying the soil an opportunity to enhance its organic matter and incorporate important chemicals such as nitrogen and phosphorus.
- The off-field impacts are related to human health due to normal air quality degradation resulting in exacerbation of respiratory, eye and skin diseases (P. Kumar *et al.*, 2015)^[11].

“These are very fine particles and can penetrate into our lungs, triggering a range of ailments. The elderly, children and those suffering from chronic respiratory and cardiac problems are particularly at risk,” said Dr. A Mohan, professor, Department of pulmonary medicine and sleep disorders, AIIMS.

The black soot generated during burning also results in poor visibility which could lead to increased road side incidences of accident. It is thus important to manage impacts due to the burning of crop residue in the open fields and its sequential effects on soil, air and living organisms. According to the study, medical records of the civil hospital of Jira, in the rice-wheat belt increase by 10% in the number of patients within 20–25 days per every season (P. Kumar *et al.*, 2015)^[11].

Punjab Pollution Control Board (PPCB)

In Punjab, there are three major air pollution includes industrial, agricultural and vehicular pollution. The Punjab Pollution Control Board (PPCB) monitors the pollution levels at 20 different locations among them; residential areas (nine locations) and industrial areas (eleven locations). The PPCB involves the following Acts;

1. The Water (Prevention and Control of Pollution) Act, 1974, amended in 1988
2. The Water (Prevention & Control of Pollution) Cess Act, 1977, amended 1992
3. The Water (Prevention & Control of Pollution) Cess (Amendment) Act, 2003
4. Air (Prevention & Control of Pollution) Act, 1981, amended in 1987
5. Environment (Protection) Act, 1986
6. Public Liability Insurance Act, 1991 (<http://www.ppcb.gov.in/Acts.aspx>)

The Institutions that have been vested with the task of controlling pollution in Punjab are follows; The Punjab Pollution Control Board (PPCB), Punjab State Council for Science and Technology (PSCST), Punjab Energy Development Agency (PEDA) (<http://www.peda.gov.in/>). The Punjab Pollution Control Board in coordination with the Central Pollution Control Board that guides the government

on pollution related matters. The Government of Punjab provided a sum of Rs. 572 lakhs to the PPCB and Rs. 85 lakhs for Annual Plan 2004–2005 at the time of 10th Five Year Plan (P. Kumar *et al.*, 2015)^[11].

Gurubans Singh farmer from Bibipur said “previously he was not convinced about the benefits of machinery, but he was convinced by an environmental engineer at the PPCB to try out machines” (Jacob Koshy, THE HINDU, 2018)

Alternatives to stubble burning

1. Providing labour to collect the paddy to avoid stubble generation and it also creates the employment for the labour.
2. Providing stubble collecting machineries to farmers on subsidy or rent bases.
3. Allowing cattle to graze or feed also used as bedding material.
4. Decomposing the stubble and using it as manures in fields.
5. Setting up Bio-mass fuel plants to generate fuel using paddy straw.
6. Making fodder for livestock usage.
7. Government should be a part of inviting industries like cement factories to integrate in stubble collecting for it proficiently.
8. Inviting packing industries to collect stubble to make packaging boxes which are environment friendly.
9. In situ technical measures are ‘straw incorporation’ and ‘straw mulching’.
10. Use of stubble in mushroom cultivation, Bio thermal power plants.

Management of stubble burning

For managing stubble burning Rs 695 crores are sanctioned for 2018-2020, central government has disbursed Rs 269 crores. RS 250 crores spent by state government to provide 25,000 machines, 15,367 machines are delivered and rest to be delivered till end of October, 2018 (Ishani Duttgupta, THE ECONOMIC TIMES, 2018). The major equipments developed by PAU are: (i) Happy Seeder Machine for planting in standing paddy stubbles; (ii) Tractor Operated Paddy Straw Chopper; (iii) Straw Collector and Baler; (iv) Residue Incorporation in Soil; (v) Compositing Techniques using Paddy Straw (P. Kumar *et al.*, 2015)^[11].

Happy Seeder

According to 82 % of the selected farmers, the easiest and quickest way of paddy stubble removal was burning while 14 % indicated incorporation using rotavator. A few farmers who included the stubble of paddy, they used either zero drill machines or rotavator. The happy seeder machine (Fig.4) (new invention for incorporating rice stubble) was using by selected farmers. As part of the ACIAR project LWR/2000/089, a new generation of seeders (Fig.5) capable of directly drilling wheat into heavy rice stubble loads without prior burning was developed. These machines have been called Happy Seeders. The main features of this machine are: Environment friendly technology, possibility of sowing wheat in the residual moisture, improved soil health and save fuel & time (P. Kumar *et al.*, 2015)^[11].



Fig 4: Happy seeder machine



Fig 5: Happy seeder with 55 HP tractor

The Happy Seeder technology is relevant to a large area of the northwest Indo-Gangetic plains of India in which the rice-wheat production system predominates. It is proposed within the ACIAR project proposal LWR/2006/124 that if the Happy Seeder technology is utilized over 10 % of the area currently under zero till plus burning regime in Punjab, it would result in potential financial benefits of Rs. 92 million (approximately, A\$2.7 million) (P. Kumar *et al.*, 2015) [11]. Accounting for externalities would result in potential economic benefits of an even larger magnitude. Apart from benefits like proper mulching of paddy residue instead of burning, timely sowing, reducing run off and soil erosion, lesser deep percolation and improving soil health by incorporating plant nutrients, the zero tillage increases farmer's profit by Rs. 2,200–3,000/- per hectare by saving 80 % of diesel as wheat is sown in one pass only (P. Kumar *et al.*, 2015) [11].

The Happy Seeder machine has low adoption because of its high price and less popularity among the farmers. The state although is providing subsidy on Happy Seeder but it needs to make the farmers educated on the various benefits of Happy Seeder machine. To understand farmers this technology appropriately, the Punjab government needs to demonstrate this technology and also need to encourage farmers using Happy Seeder by developing farmers groups and provide the facility to the low and medium level farmers (P. Kumar *et al.*, 2015) [11]. To adopt Happy seeder significantly majority of them showed interest to but such machine, if the Punjab government gives sufficient financial support for such machine given the price of happy seeder nearly Rs. 1.5 lakh in the market. The main drawback of this machine is having high cost and additionally it requires 50-60HP tractor.

Dr. H. S. Sidhu (Punjab Agriculture University, Ludhiana and Senior research engineer, BISA, Ludhiana) "*shared that till 2018 around 10,000 Happy seeder machines are utilized by Punjab farmers*" during panel discussion of 106th Indian Science Congress, 2019.



Fig 6: Baler machine

Baler

It is also another promising technology developed by PAU for collecting paddy straw. Balers make rectangular or round bales by collecting the loose straw from the ground (Fig.6).

One operation of stubble shaver in a combine harvested paddy field, created favourable conditions for operating a baler, which in turn, results in smooth sowing of the next crop (P. Kumar *et al.*, 2015) [11]. Therefore, 80% of machinery cost to be given to cooperative societies, self-help groups and other relevant agencies and 50% of machinery cost to be given to individual farmers (Ishani Duttgupta, The Economic Times, 2018).

Conclusion

Rice stubble burning has been identified as a major environmental and health hazard in Punjab. Extremely important to understand the underlying causes and the existing situations as to why the farmers burn stubble and then deal with the basic problem. Farmers left with few options but to burn the rice stubble due to lack of labour during the harvesting period and limit time available for preparing the field for wheat cultivation, and the burning is cheaper and requires less effort. Alternative efforts are made through kisan cams, trainings, workshops to informing farmers about the alternative usage of crop residues to overcome the burning. The state government, in collaboration with centre has rolled out schemes for providing subsidy on mechanical implements like happy seeders, Baler, shredders etc, and only a small number of farmers have access to these implements at the moment. The main theme is to cultivate the land with zero tillage to overcome the stubble burning by conservation agriculture. With the adoption of conservation agriculture-based technologies these residues can be used for improving soil health, increasing crop productivity, reducing pollution and enhancing sustainability and resilience of agriculture

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