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## Crop residue its impact and management

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### Abstract

Residue managing task is growing dare for sustainable advancement of Indian agriculture science and environmental protection usually in Indo-Gangetic plains. Farming societies need awareness regarding the harmful impacts of field burning of crop residues and the significance of crop residues combination in the soil for conserving supportable agricultural production and reduction of the cost of production by adopting alternatives. Proper collection and management of crop residue are needed to use it as retention, a substrate for mushroom cultivation, incorporation in the fields, bio-energy fuel, biochar production, etc. The crop residues can be used livestock feed, fuel, industrial raw material, compost precursor, etc. and also are of great economic as well as significant value. The resource-conserving technologies which involve zero-tillage, usage of the happy seeder, bed planting, polyculture with innovations in residue management, the participation of farming communities, and support of political and Govt. Organizations and NGOs are the best probable replacements to conservative energy and input-intensive farming.

**Keywords:** Crop residue, impact, proper collection and management options

### 1. Introduction

Crop residue is the remaining plant material or leftover biomass, after harvesting or processing of economic components of planted crops, it includes leaves, stalks, and roots. The excess farm waste can be transformed into useful farm products that ensure meeting the nutrient requirement of succeeding crops. Crop residue contributes to the plant nutrients and also consider as a source of organic carbon for soil microorganisms. The agricultural crop residues are of two types- field residue and process residue

- a) **Field residue:** These are the waste residue in an agricultural field after the crop has been collected. These can be stocks, stubble stem leaves, and seedpods which can either be tilled directly into the ground or burnt. Proper managing of residue can help to increase the competence of irrigation and prevention of erosion.
- b) **Process residue:** This is the waste residue after the crop is managed into a reusable source. These waste products comprises of bagasse, molasses, husks, seeds, and roots. They can be used as a soil change, animal fodder, manures, and in development.

The mostly practiced cropping systems in India are Rice-Wheat cropping systems and about 90% of the area is focused on the Indo-Gangetic Plains. The burning of agricultural crop remains, like stalks and stubbles, after, through the wheat and rice harvesting periods in the Indo-Gangetic Plains which is widely practiced by the farmers of this region, results in release of harmful gases and particles.

According to IARI (2012) <sup>[13]</sup> with the outline of combine harvesters, more than 75% of rice area is harvested through machines in northwestern area of IGPs, which leaves behind a swath of loose rice residues. This creates a problem in operating seed drill used for planting wheat. To duck this problem farmer burnt these crop residues (90-140 Mt annually). Increased mechanization, particularly the use of combine harvesters in the IGP (just 2000 in 1986 to 10,000 in 2010), and lack of traditional use of crop residues for a domestic purpose such as for animal feeding, domestic fuel, roof thatching, packaging, and composting are the major cause foremost to compulsory residue burning by the farmers and scientists are forced to think about crop residue management.

Field burning of crop residue (FBCR) which is counted as the major agricultural pollutant directly affecting the environment and human health was not given much concerned by officials in the last twenty years because it was a small scale, but nowadays, it is considered a

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matter of serious concern for creating the smog in outskirts of capital Delhi. Globally, the burning of crop residues is the second major cause of the fire twenty five percent due to more carbon density just after forest burning, representing nearly 2020 Tg (approx. 25 percent of total biomass burned). organic carbon, nutrients, but also cause adverse effects on soil properties as well as soil flora and soil fauna. So, we need to embrace means and other methods to manage this important resource.

Nowadays, tight laws including huge penalties and imprisonment against law breakers are now in place. The government and high courts are displaying zero percent tolerance against FBCR. In the absence of an acceptable and profitable alternative, farmers are still forged to follow this practice as otherwise, it is a big burden for farmers. We demand either on field or post harvest management of residues either by advancement in existing technologies, awarding farmers, adjusting the cropping pattern, and using rice straw in industry and power production. In this article, efforts have been made to cover major aspects related to crop residue its impact and management.

## 2. Impact of crop residue

### 2.1 Burning biomass emits greenhouse gases

India largely depends on agriculture which generates a huge quantity of agricultural wastes. To cope with this leftover material burning of crop residues is done as a means of clearing land at fast rate, economically, and permitting tillage practices to proceed unrestricted after removal of crop residues. The crops whose residues are primarily burnt are rice, maize, millet, sugarcane, etc. Crop residue burnt is converted to gases, such as carbon dioxide, methane, nitrous oxide, SO<sub>2</sub>, NO<sub>2</sub>, CO; aerosols, and ash. This emission adds to greenhouse gases which ultimately lead to global warming.

### 2.2 Crop residue burning affects soil fertility

The soil organic carbon level has been reduced to very low due to the poor application of organic fertilizers and non-reusing of crop stubbles. Gupta *et al* (2004) [11] expected that the burning of crop stubble increases the soil temperature to 33.8–42.2°C. Burning deteriorates the nitrogen quantity (27–73%) of nitrogen and also reduces the bacterial and fungal populations in the top 2.5 cm of the soil. Long period burning also decreases total nitrogen and carbon and potentially mineralized nitrogen in the 0–15 centimetres soil layer along with a harm in the soil organic substance. It has been reported that the fire gradually decreased soil organic matter and biological activity.

### 2.3 Residue burning leads to environmental issues

Every year at the onset of the winter, emission of gasses takes place due to extensive FBCR in IGP mainly covering Punjab, Haryana, and Western Uttar Pradesh (Sarkar *et al* 2013) [19]. At the onset of the winter (October–November), climatic condition in IGP is fairly represented by dry weather, moderate relative humidity (40–70%) 40–70%, fair temperature 20–30 °C and light blowing winds (1–2 ms<sup>-1</sup>) from the northwest direction which support the buildup of aerosols and their slow movement along with the Himalayan mountain range over the IGP region (Mishra and Shibata 2012) [17]. Because of all the above favorable conditions, the emissions travel thousands of kilometers from its actual burning location (Punjab, Haryana, and western Uttar Pradesh) and cover the whole IGP from West to East; the

Arabian sea and central India is also affected but not noticed (Badarinath *et al* 2009) [1].

### 2.3.1 Residue Management

To prevent nutrient losses, soil fertility reduction, air pollution (@ CO<sub>2</sub> 13 t ha<sup>-1</sup>), road accidents, health hazards, etc. we need to manage crop residue either by use as an amendment to improve soil health or as industrial raw material. It should be diverted from field burning. To bring out some productive outcome and efficiently utilize the crop residue following practices can be implemented.

## 3. Utilization options for crop residues

### 3.1 Crop residue can be used as livestock feed

Usually, the crop stubble in India are used as livestock feed as such or by improvising it with positive additives. Though crop stubble are less in digestibility, unpleasant, and cannot be used as the single ration for livestock feed. This rice straw is considered poor feed because of the high Silica-content. There are various methods available for the up-gradation of the nutritional value of rice straw. According to Sarkar *et al.* (2004) [19] physical, chemical, and biological methods have been used to disable and break down lingo-cellulose bonds in field crop residues, thereby results in rising their nutritional value. Wheat stubble after chopped into little pieces with the help of different machines designed for the purpose is available for livestock consumption and about 75% of wheat straw is used as livestock feed. In the example of rice, straw stems are extra digestible than leaves because silica substance is slighter in stems, so the rice crop should be harvest as close to the soil surface as possible if the crop straw is to be fed to animals. To complete the nutritve requirements of livestock, the crop residues must process and enriching with urea and molasses, and supplementing with fodders (leguminous or non-leguminous).

### 3.2 Crop residue can be used as compost

Sidhu and Beri (2005) [20] explained that crop residue has higher absorption capacity as in animal barn one kilogram of stubble can hold 2-3 kilogram of urine which improves it with nitrogen content. For the production of manure or compost, crop residue generally used for animal base layering and then covered in dung pits. On Composting, the rice crop residue from 1 hectare of land, provide about three tons of organic compost are high in nutrients as FYM. The rice stubble fertilizer can be stop with Phosphorus using a native source of small class rock phosphate to make it value-added compost by 1.5% Nitrogen, 2.3% P<sub>2</sub>O<sub>5</sub>, and 2.5% K<sub>2</sub>O.

### 3.3 Crop residue can be used in mushroom cultivation

Rice and wheat straw provides an excellent quality substrate for the cultivation of *Agaricus bisporus*, *Volvariella volvacea*, and also three or four most commonly grown edible fungi. Demand for mushroom in food items is now rising because it imparts higher nutritional value as protein content provided by mushroom is three to four times more than meat. This rising industry needs crop residue as a substrate input to start mushroom production. Mushroom production has the potential to produce valuable edible things from inedible crop residue.

### 3.4 Crop residue can be used as biofuel

An essential strategy to decrease necessity on fossil fuel is the usage of biofuel. Biofuel can be used as a neat fuel in internal combustion engine after change of lignocellulosic biomass

into liquor (alcohol) which is of huge significance as ethanol can also mixed with gasoline as a fuel modifier and octane boosting agent. Theoretical approximations of ethanol making from following feedstock (Rice stubble, wheat straw, and bagasses) from 382 to 471 l per t of dry material. This invention of ethanol manufacturing from crop residues is newer to India.

### 3.5 Crop residue can be used as biochar

Lemann and Joseph (2009) <sup>[15]</sup> explained that biochar which is fine-grained charcoal that has high carbon material which is generated by slow pyrolysis (anaerobic process) of has involved lots of care as a reliable approach for conserving soil health.

It can help in storing carbon in the soil for the long term. Biochar when got converted from plant biomass contains a unique recalcitrant form of carbon that is resistant to microbial degradation, therefore can be used as a carbon sequester, when applied to the soil.

According to Spokas *et al.* 2009, Zhang *et al.* <sup>[27]</sup> biochar helps in the reduction of greenhouse gas (GHG) from agricultural fields and also improves water quality through its strong absorption nature of contaminants. Jeong (2015) <sup>[14]</sup> resulted that the properties of biochar depend on biomass sources and pyrolysis conditions.

### 3.6 Crop residue management for soil health

Rice-Wheat system leads to excessive nutrient mining of soils which is major causes of poor soil health because they are exhaustive feeder. The amount of nutrients used by rice and wheat exceeds the amount added through fertilizers and recycled. (Beri *et al.*, 1995) <sup>[2]</sup>, (Singh *et al.* 2008, 2005) <sup>[22, 23]</sup> to improve soil physical (i.e., structure, percolation rate, plant available water), chemical (i.e., exchangeable cation, soil pH), and biological (i.e., SOC confiscation, microorganism biomass C, movement and biodiversity of soil biota) class residue retention is needed.

### 3.7 Crop residue can be used as surface mulch

For management of soil and to avoid aquatic losses by evaporation residue retention on the soil surface looks to be improved choices. It may be useful in the reduction of weed seed sprouting and multiplication of the soil microorganism's population which ultimately effects in rising soil organic carbon- a straight indicator of soil condition.

A new developed generation seed drill is developed for this method. According to Sidhu *et al.*, (2007) <sup>[21]</sup> that the Happy Seeder will lead to broader assumption of preservation agriculture.

The Happy seeder working fine for direct drilling in erect as well as loose stubble delivered the stubble are spread equally.

Chakraborty *et al.* (2008, 2010) <sup>[7, 8]</sup> stated that in comparison with no much rice stubble mulch can increase wheat crop yield, reduce crop water use by 3-11 percent, and enhanced water use efficiency by 25 percent.

Also, mulch formed root size length densities 40% as competed to no-mulch in lower layer (less than 0.15 m), perhaps due to more holding of soil moisture in lower layers.

### 3.8 Energy extraction and biofuel production

There are numerous methods frequently used to take out energy from biomass, such as corn, sugarcane, wood, and other agricultural waste material. Energy can be obtained from biomass by two simple options: burning it or changing it into energy.

### 3.9 Pusa decomposers to curb stubble burning

The composers are in the form of capsules made by extracting fungi strains that help the paddy straw to decompose at a much faster rate than usual. The fungi help to produce essential enzymes for the degradation process. Decomposer mixture contains making a liquid preparation with decomposer capsules and inflaming it over eight to ten days and then spray the liquid mixture on fields with crop residue to certify quick bio-decomposition of the residue. The farmers can prepare 24 liters of the liquid mixture with 4 capsules, jaggery, and chickpea flour. The liquid mixture is adequate to cover 1 ha of land. It takes about 20 days for the degradation procedure to be finished. Under normal conditions, shredded and watered paddy stubble, which is uniformly mixed with soil, takes 45 days in soil to decompose.

#### Benefits

- It improves the soil fertility and crop productivity as the crop residue works as organic manure and compost for the field crops and reduced fertilizer requirement in the future.
- The Decomposer is an useful and effective, inexpensive, achievable, and practical methods to stop residue burning.
- It is an ecological and environmentally valuable method and will contribute to succeeding "Swachh Bharat Mission".

### 4. Government initiatives to control crop residue burning

Under the National Policy for Management of Crop Residues, 2014 Government of India has adopted two-way approaches to combat field burning of crop residues, which emphasize creating massive awareness about harmful effects of stubble burning along with imposing heavy penalties on the defaulters and other side promoting the use of agriculture equipment to manage the crop stubble in coordination with state governments. Ministry of Agriculture GOI (2016) <sup>[16]</sup> reported that for this, they are organizing campaigning program and providing agricultural machinery like reaper and binder (used to cut the paddy from ground level and make bundles for further threshing), paddy straw chopper (used to chop the loose straw so it is easy to mix in soil), baler (used to collect loose straw in the field and make the blocks), rotavator (used for land preparation and incorporation of straw in soil), zero-till seed-cum- fertilizer drill (used for sowing the next crop in standing stubble, without land preparation) and happy seeder (used for sowing of the crop along with crop residue as mulch), under different governments schemes Rashtriya Krishi Vikas Yojna, National Food Security Mission, Sub Mission of Agricultural Mechanization which recorded a considerable reduction in stubble burning in Punjab, Haryana, and Uttar Pradesh.

Business Standards 2017 <sup>[6]</sup>; Business Today 2017 <sup>[6]</sup>; New Indian Express 2017 <sup>[18]</sup> published that Punjab and Haryana governments are exploring the ways to make some modification in combine harvester by attaching cutter with it (Super-SMS), to mitigate the problem of the residue burning. The government of India is also planning to curb the residue burning issue by making rice straw available to the thermal power plant to be used along with coal to generate electricity and proposed a plan of 10% mixing of straw with raw material. For this, Rs 5500/ tonne will be given to farmers limited up to 2 tonnes/acre in this way farmer get Rs 11,000/ acre as an incentive to clear field in place of burning.

Brien *et al.* (2014) [5] explained that other than government organizations, private institutes are also working on residue burning to find out the solution. Massachusetts Institute of Technology (MIT) is working in collaboration with Tata trust, on a joint project to design a low-cost, small-scale, and mobile torrefaction system. Hans India (2017) [25] explained that this is based on the principle of thermo-chemical conversion of agriculture waste in situ in biochar which can be used as biofuel or carbon-negative fertilizer (Tata centre-MIT). Torrefaction is a mild pyrolysis process, carried out in controlled-oxygen supply. Efforts are going on to develop a mobile torrefaction, similar to combine harvester so that farmers need not carry their straw rather Torre faction approach them. But all of these efforts at present are at the designing level or laboratory level and are not ready to deploy at farmers' fields. The bulky nature of straw is a big issue in practical field conditions for satisfactory performance of torrefaction, and it is also a challenge for manufacturers to develop an affordable torrefaction for a broad range of farmers because in India > 85% of farmers having less than 2-hectare holding.

#### Advantages of crop residues management:

- The finest achievable *in-situ* rice stubble management choice is its practice as mulch and direct drilling of wheat with Happy Seeder.
- Rice straw mulching reduces weed seedling emergence, weed biomass, and increase WCE up to 52 percent.
- Mulching decreases the rate of soil drying, water use, soil evaporation but increase WUE up to 34%.
- Mulching suppresses maximum soil temperature, elevates minimum temperature during the early season, and lowers the wheat canopy temperature by 2-3°C during terminal heat stress.
- Mulching delay anthesis and maturity, increase root growth, and apparent N recovery of applied fertilizer and wheat yield (1.4-10.6 q/ha).

#### 5. Future prospectus

- a) The government should focus on the need of the hour by diversifying and changing its policies in the favor or we can say somewhat biased towards promoting major cereal crops (rice and wheat). Due to political equation (more acreage comes under rice and wheat), governments always give top priorities to rice and wheat in the minimum support price (MSP), a public distribution system (PDS), and procurement which discourage farmers to think about other than rice and wheat (Yadav 2017; Singh *et al.* 2017) [26].
- b) Promotion should be given to the short-duration rice varieties like HKR-47, PR-114, and PR-126, those complete their crop cycle (seed to seed) in 120 days so farmers can harvest rice before October 15 and get almost one and half month time to manage the residue instead of 10 to 15 days in case of present long duration varieties *viz.* PUSA 44.
- c) We need to promote the practice of zero tillage in both rice and wheat crops and for this conduct field demonstrations at farmers' fields, because still in the vast area of IGP farmers do not accept this due to perception about clean cultivation to harness higher yields. Other than this awareness should be provided to farmers about adoption zero till with full package of practices.
- d) Strengthen the research works for the development of more microorganisms or biological processes such as

PUSA Decomposers by which the decomposition process of rice straw is fastened and farmers can use the straw as a valuable organic source to improve soil fertility.

- e) The government should promote the machinery on a cooperative basis to manage rice residues so that these become affordable for all farmers covering small and marginal farmers.
- f) The government should promote an alternative to mono-cropping such as an integrated farming system (IFS) approach because the IFS approach is more balanced and self-recycling in nature. IFS helps diversification of farming component and in IFS output of one component utilized as input for the other one.
- g) The government should focus on rice straw-based industries like paper, carton, ethanol, and brick plant. Small scale plants can be installed in a desert area of Rajasthan adjoining to IGP as it can help in meeting land demands.
- h) Power generation can be attained by using rice straw in those areas where it is found in large quantities. The government should provide some subsidies and incentives to promote biomass energy production.
- i) Exploring the possibilities of preparation of bio-char by control combusting and then use it as soil amendments.
- j) We need to emphasize more on the research area to improve the nutritional quality of non-basmati rice by treatments like physical, chemical, physicochemical, and biological.

#### 6. Conclusion

The crop residues can be used livestock feed, fuel, industrial raw material, compost precursor, etc. and also are of great economic as well as significant value. However, different problems are faced in different regions because of crop residues and associated with the socio-economic needs. Proper collection and management of crop residue are needed to use it as retention, a substrate for mushroom cultivation, incorporation in the fields, bio-energy fuel, biochar production, etc. Farming societies need awareness regarding the harmful impacts of field burning of crop residues and the significance of crop residues combination in the soil for conserving supportable agricultural production and reduction of the cost of production by adopting alternatives. The resource-conserving technologies (RCTs) which involve zero-tillage, usage of the happy seeder, bed planting, polyculture with innovations in residue management, the participation of farming communities, and support of political and Govt. Organizations and NGOs are the best probable replacements to conservative energy and input-intensive farming. The advancement in technologies can help in improving and attaining the goal of sustainable agriculture and also mitigates GHG emission which is responsible for climate change. Besides these, the prime importance is the value-orientation and perception of practitioners towards climate-friendly sustainable agriculture.

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