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STUBBLE BURNING: CAUSE, IMPACT AND MITIGATION

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Crop residue burning is not a recent trend adopted by Indian farmers during crop harvesting, especially in the months of Oct- Nov before sowing of Rabi season crop. But last few years it has been an alarming issue due to increasing pollution, mainly air and soil, which causes detrimental effects in not only human beings but also on the environment. According to the survey, India produces 371 million tones of crop residue annually, out of which wheat and rice contribute 27-36% and 51-57%, respectively. Uttar Pradesh is the largest in this regard, followed by Punjab, Maharashtra, and West Bengal. A large number of farmers have engaged in stubble burning techniques as they have a very short time span for preparation of land to next crop sowing during the winter season. Although Govt. has introduced new machineries such as combine harvester that helps farmers to cut the mature crop leaving behind a small portion of crop biomass(straw) above ground (up to 9.0 t ha^{-1}) that makes farmers difficult to sow next crop in this point, needs time for land preparation. As farmers are not furnished and prepared to manage the large mass of residues left in the field, to avoid delay sowing of next crop, farmers used to burn the stubble in their own land which they think of economic and cost effective strategy to manage these crop residues.

Major Causes

1. Scarcity of labour.
2. Short time duration for preparation and cleaning of field.
3. Low supply of adequate farm machinery for harvesting purposes.
4. Lack of knowledge of crop residue management.
5. Low cost management of pests and weeds in the field.
6. Getting short term availability of nutrients.

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Impact of Crop Residue Burning

1. Depletion of air quality standard

Uncontrolled combustion leads to the production of Co, Co_2, No_x, So_2, etc., in the atmosphere, which in turn causes air pollution. Studies revealed that the burning of one ton of paddy straw liberates 3 kg particulate matter, 60 kg carbon mono-oxide, 1460 kg carbon dioxide, 199 kg ash, and 2 kg of sulfur dioxide. The level of greenhouse gas also increases the annual contribution of 0.10 Tg of SO_2, 0.96 Tg of NO_x, 379 Tg of CO_2, 23 Tg of Co, and 0.68 Tg of CH_4 was estimated from the burning of crop residues (Badrinath *et al.* 2006) estimated the greenhouse gas (GHG) emissions from cereals burning mainly rice and wheat straw in Punjab during May and October 2005 and suggested that emissions from wheat crop residues in Punjab are relatively low compared to those from paddy fields.

The estimated value of PM 2.5 mass concentration varies from 60 to 390 mg m−3 during paddy residue burning (Gadde *et al*., 2009).

2. Harmful effects a human and animal

Increasing stubble burning practice contributes to emissions of harmful air pollutants, which can cause severe impacts on human health viz. chronic heart disease and lung cancer, as asthma, coughing; the effect is more prominent particularly affecting children, geriatrics and pregnant women. Other than these greater threats for leukemia, blood bone marrow disease, vertigo, drowsiness, headache, nausea, aplastic anemia, and pancytopenia and myelodysplastic syndrome cytopenia to benzene exposure (Chandra and Sinha 2016). Beneficial microorganism bacteria, earthworm etc. dies due to fire. Snakes, frogs, earthworms, lizards die in the holes. All green vegetation around the field burns, causing a decrease in the number of birds residing in Sparrows, eagles, vultures are becoming extinct because of this. This could lead to the loss of biodiversity.

3. Deteriorating the soil health quality

Burning of straw raised the soil temperature up to 33.8- 42.2 °C at 10 m depth (Gupta *et al*., 2004). Almost 23-73% of nitrogen is lost, and the fungal and bacterial populations are decreased immediately in the soil. Significant reduction in soil structural stability as organic carbon is decreasing due to stubble burning. The burning of straw raised

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the temperature of the soil, which creates an imbalance in the carbon-nitrogen equilibrium in the soil system.

4. Loss of nutrients

Nutrient budgeting and balance have been hampered due to residue burning. Carbon, nitrogen, and sulfur present in straw are entirely burnt and lost to the atmosphere. Complete loss of C, 80% of N, 25% of P, 50% of S, and 20% of K (Kumar, 2016) existing in straw occurs. It was estimated that one ton of paddy burning of paddy straw causes a loss of about 79.38 kg ha^{-1} N, 183.71 kg ha^{-1} P, and 108.86 kg ha^{-1} K (Jat *et al*., 2013).

Mitigation Techniques

1. Adaptation of Resource conservation technologies (RCTs)

RCTs provide a better promise in managing paddy residues for improving soil health, productivity, reducing pollution, and achieving sustainable agriculture. For direct seeding of the successive crop in standing crop stubble, advanced technology of zero-till seed-cum-fertilizer drill/seed planters (happy seeder, spatial zero seed cum fertiliser drill) has been developed.

No-tillage (NT) coupled with stubble retention (SR) and nitrogen (N) fertilizer application (90 N, 90 kg N ha^{-1} application) can help improve soil aggregation(somadun-darum,2016). Sun et al. 2007 reported that soil organic matter increased 15.8% -18.1%, 6.6% -10.6%, and 1.3% 1.9% stubble retention compared with straw removal in the 0–10,10–20, 20–40 cm depths in Wushan soils of China after 15 years. It is reported that the yield of wheat was 21% (0.344 t ha−1), which more under no till with stubble cover than conventional tillage after eight years of cultivation (Huang,2012). It is evident that better soil aggregation was recorded under no tillage that could have a positive influence on soil C sequestration.

2. Mulching effect

Residue retention in the soil surface can control soil temperature by lowering it in the summer season and increasing minimum soil temperature during the winter season. Thus it minimizes the evaporation loss of moisture in summer months and maintains optimum soil temperature in both the season for crop growth and enhances the microbial activity. It reduces

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soil erosion through surface runoff and also lowering soil compaction that directly affects root growth and poor crop establishment. Organic mulches actively accelerate soil desalinization and help to degrade the residual effects of pesticides and other contaminants, which would decline the soil fertility status. Mulches can also reduce seed germination of many weed species and reduce light exposure to weeds, which stresses existing weeds to sprout.

3. Improving soil health biodiversity

In-situ incorporation of crop residue has several positive impacts on soil health attributes such as pH, organic carbon, infiltration rate, and water holding capacity. It increases hydraulic conductivity, cation exchange capacity (CEC), and reduces bulk density of soil by improving soil structure and aggregate stability, minimizes surface crust formation, water evaporation from the top few inches of soil, and prevents leaching loss of nutrients. It also increases the microbial biomass, their population and enhances activities of enzymes such as dehydrogenase and alkaline phosphatases, which helps in nutrient mineralization and mobilization. It is reported that 6 g of Nitrogen and 0.8 g of phosphorous per kg of paddy straw leads to saving 15–20% of total fertilizer's use (Lohan *et al*., 2018).

4. Increasing nutrient availability

Stubble-induced changes in soil total N are often directly related to changes in soil organic C content as soil organic matter could influence nutrient retention and supply. Both stubble retention and not tillage can increase soil total N concentration significantly at the soil surface 0–5 cm. No significant increase in total P concentration in the lower layer (10-30cm) in soil due to immobilization of fertilizer P and surface stubble cover. But in the topsoil layer increasing trend of total p concentration was observed in Field pea and wheat rotation. Available K concentration was significantly greater in the top 5 cm depth of stubble retention treatments in wheat and field pea rotation sequence. Therefore, the combined use of rice or wheat straw and inorganic fertilizer can, however, increase the yield of rice and wheat in rice-wheat systems in Indian conditions.

5. Off farm use of residue after harvest

Collected residue can also be used for animal feeding, domestic fuel purposes etc. Wheat straw is mainly used for fodder purposes instead of rice; this is mainly because high

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silica content in the rice residue. In this aspect, straw baler machines can effectively use and commercially available that provide a solution for straw management in an environmentally friendly manner. Paddy straw can also be used for the cultivation of mushrooms such as Agaricus *bisporus*, *Volvariella volvacea*, and Pleurotus *spp*. One kg of paddy straw yields 300, 120–150, and 600 g of (Ojha and Tiwari, 2019) these mushrooms, respectively. Surprisingly bio thermal power plant uses paddy straw for generation of electricity. A 10 MW biomass based power plant is set up at village Jalkheri, Fatehgarh Sahib, where paddy straw is used as fuel. Paddy straw can also be used in paper and pulp production company Punjab state govt have been advised to use paddy straw as bedding material for crossbred cows during winter months. This paddy straw bedding provides comfort, good udder health, and leg health to the animals resulting in the increased quality and quantity of milk produced.

Conclusion

Stubble burning in India enhances the concentration of greenhouse and other toxic gases like benzene and toluene, which would increase the risk of farmers and villagers nearest to the field. The use of agricultural waste is an essential hinge not only for sustainable agriculture but also in the equilibrium of the entire human society. In this sense, the practice of utilizing crop residues as amendments to improve the soil fertility status and also maintain the ecological balance. Accusing only the farmers may not the solution to these problems; there is a need to find sustainable technological strategies. In this context, Promotion of technologies for optimum utilization and in-situ diversified uses of agricultural waste, Capacity building of various stakeholders including farmers and extension functionaries through different scheme and development programs, and organizing of field level demonstrations, and formulation and implementation of necessary policy measures for control of agricultural waste through suitable laws/ legislation/ executive orders.

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