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Impact of burning crop residues on soil health and environment

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Crop residues, in general are parts of the plants left in the field after crops have been harvested and threshed. These materials at times have been regarded as waste materials that require disposal, but it has become increasingly realized that they are important natural resources and not wastes. It is estimated that approximately 500-550 Mt of crop residues are produced per year in our country. These crop residues are used for animal feeding, soil mulching, bio manure making, thatching for rural homes and fuel for domestic and industrial use. The cereal crops (rice, wheat, maize and millets) contribute 70% while rice crop alone contributes 34% to the crop residues. Wheat ranks second with 22% of the crop residues whereas fibre crops contribute 13% to the crop residues generated from all crops. Among fibres, cotton generates maximum (53 Mt) with 11% of crop residues. Coconut ranks second among fibre crops with generation of 12 Mt of residues. Sugarcane residues comprising of tops and leaves, generate 12 Mt, *i.e.*, 2% of the crop residues in India.

Burning of crop residues : A large portion of the residues, approximately 90-140 Mt, is burnt in field mainly to clear the field from straw and stubble after the harvest of the preceding crop. It is because of unavailability of labour, high cost in removing the residues, lack of requisite machinery to incorporate crop residue in soil and use of combine harvesters in rice based cropping system. Primary crop types whose residues are typically burnt include rice, wheat, cotton, maize, millet, sugarcane and groundnut. About 82% of rice residue is burnt in the field, however most of the wheat residues are preferred as animal fodder.

Combine harvesters are used extensively to harvest the rice crop because of increased mechanization. Major reasons for rapid increase in the use of combine harvesters are labour shortage, high wages during harvesting season, ease of harvesting and thrashing and uncertainty of weather. On using combine harvester about 80 % of the residues are left in the field as loose straw in chopped form which poses difficulty in collecting the same and feeding it to the cattle. Rice straw in chopped form has been burnt in the field which may result in pollution problems and wastage of valuable resources.

There are some other reasons also behind intentional burning of crop residues. These include clearing of fields, soil fertility enhancement, and pest and pasture management. On farm burning traditionally provides a fast way to clear the fields off the residual biomass, thus, facilitating land preparation and sowing/planting. It also provides a fast way of controlling weeds, insects and diseases, both by eliminating them directly or by altering their natural habitat.

The problem of on-farm burning of crop residues is intensifying in recent years due to shortage of human labour, high cost of removing the crop residues by conventional methods and use of combines for harvesting of crops. The residues of rice, wheat, cotton, maize, millet, sugarcane and groundnut are typically burnt on-farm across different states of the country. The problem is more severe in rice growing regions.

Adverse consequences of on-farm burning of crop residues on soil and environment : Burning of crop residues leads to release of soot particles and smoke causing soil, environmental and human health problems. It leads to emission of greenhouse gases namely carbon dioxide, methane and nitrous oxide, causing global warming and loss of plant nutrients like N, P, K and S. Heat generated from the burning of crop residues elevates soil temperature causing death of active beneficial microbial population, though the effect is temporary, as the microbes regenerate after a few days. Repeated burnings in a field diminishes the microbial population permanently. Burning also helps reduce pest and disease populations that may occur due to reinfection from inoculum in the straw biomass.

Burning of crop residues on soil properties : Burning of residues converts a great deal of nutrients into gaseous form which is then lost from the site. Burning causes almost complete N loss, P losses of about 25 per cent, K losses of 20 per cent and S losses of 50 per cent from the amounts originally present in the straw. In areas where harvesting has been mechanized, all the straw remains in the field and is rapidly burned *in situ*; therefore, losses of S, P, and K are small. The burning of crop residues immediately increases the exchangeable NH_4^+-N, bicarbonate- extractable P content potassium in the surface 0-2.5 cm soil layer, but there is no build up of nutrients in the profile. The majority of the nitrogen, carbon and sulphur in burned residues will be lost to the atmosphere as gases, but the other nutrients present in the residues, such as phosphorus, potassium, calcium and magnesium will mostly be returned to the soil as ash residues. The ash from burning stubble is alkaline, which can give a rapid increase to the pH at the soil surface. In general, losses of nutrients due to burning decrease in the order N > Ca > S > K > Mg > P > Na. Estimates of losses of N to the atmosphere during burning are in the order of 30-90%, depending on the extent of combustion. This represents a loss of 10-25 kg N ha^{-1} for a straw crop of 5 tonnes per hectare. Long-term burning reduces total N and C, and potentially mineralizable N in the upper soil layer.

Burning of crop residues on atmosphere and human health : During burning, 50-70% of the residue carbon is commonly volatilized to CO_2 and CO, although losses of upto 90% have been measured when combustion of the residue is almost complete. The remainder of the carbon is returned to the soil surface as charred residue, which is not biologically active. Consequently, burning can change both the quantity and the quality of organic matter in the soil.

The burning of agricultural residues leads to significant emissions of chemically and radiatively important trace gases such as methane (CH_4), carbon monoxide (CO), nitrous oxide(N_2O), oxides of nitrogen (NO_x) and sulphur (SO_x) and other hydrocarbons to the atmosphere. About 70%, 7% and 0.7% of C present in rice straw is emitted as carbon dioxide, carbon monoxide and methane, respectively, while 2% of N in straw is emitted as nitrous oxide upon burning. It also emits a large amount of particulates that are composed of a wide variety of organic and inorganic species.

One tonne of rice straw on burning releases about 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2. Besides other light hydrocarbons, volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) including polycyclicaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), SO_x and NO_x are also emitted. These gases are of major concern for their global impact and may lead to increase in the levels of aerosols, acid deposition, increase in tropospheric ozone and depletion of the stratospheric ozone layer. These may subsequently undergo trans-boundary migration depending upon the wind speed/direction, reaction with oxidants like OH, leading to physico-chemical transformation and eventually wash out by precipitation. Many pollutants found in large quantities in biomass smoke are known or suspected carcinogens and could be a major cause of concern leading to various air-borne/lung diseases.

The crop residues are potential source of plant nutrients and their beneficial effect on soil fertility and productivity could be harnessed by recycling them in to the soil rather than burning and causing pollution to the atmosphere.

Fig. 1 : On- farm burning of rice straw

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