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Crop Residues Management

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India is an agrarian economy. A vast majority of land is used for farming and a wide range of crops are cultivated in its different agro-ecological regions. It is but natural that a huge volume of crop residues are produced both on-farm and off-farm. It is estimated that approximately 500-550 Mt of crop residues are produced per year in the 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. Thus crop residues are of tremendous value to the farmers. However, a large portion of the residues is burnt on-farm primarily to clear the field for sowing of the succeeding crop. 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. It is a paradox that burning of crop residues and scarcity of fodder coexists in this country, leading to significant increase in prices of fodder in recent years. Industrial demand for crop residues is also increasing. To manage the residues 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. The resource conserving technologies (RCTs) involving no or minimum tillage, direct seeding, bed planting and crop diversification with innovations in residues management are the possible alternatives to the conventional energy and input-intensive agriculture.

Adverse consequences of on-farm burning of crop residues Burning of crop residues leads to release of soot particles and smoke causing human and animal health problems. It also 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. The burning of crop residues is wastage of valuable resources which could be a source of carbon, bio-active compounds, feed and energy for rural households and small industries. 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, however, diminishes the microbial population permanently. The burning of crop residues immediately increases the exchangeable NH4+-N and bicarbonate-extractable P content, but there is no build up of nutrients in the profile. Long-term burning reduces total N and C, and potentially mineralizable N in the upper soil layer.

Reasons behind on-farm burning of crop residues Farmers and policy makers are well-aware of the adverse consequences of on-farm burning of crop residues. However, because of increased mechanization, particularly the use of combine harvesters, declining numbers of livestocks, long period required for composting and unavailability of alternative economically viable solutions, farmers are compelled to burn the residues.

Competing uses of crop residues

The crop residues can be gainfully utilized for livestock feed, composting, power generation, biofuel production and mushroom cultivation besides several other uses like thatching,mat-making and toy making.

Livestock feed

In India, the crop residues are traditionally utilized as animal feed as such or by supplementing with some additives. However, crop residues, being unpalatable and low in digestibility, cannot form a sole ration for livestock. Crop residues are low-density fibrous materials, low in nitrogen, soluble carbohydrates, minerals and vitamins with varying amounts of lignin which acts as a physical barrier and impedes the process of microbial breakdown. To meet the nutritional requirements of animals, the residues need processing and enriching with urea and molasses, and supplementing with green fodders (leguminous/non-leguminous) and legume (sunhemp, horse gram, cowpea, gram) straws

Compost making

The crop residues have been traditionally used for preparing compost. For this, crop residues are used as animal bedding and are then heaped in dung pits. In the animal shed each kilogram of straw absorbs about 2-3 kg of urine, which enriches it with N. The residues of rice crop from one hectare land, on composting, give about 3 tons of manure as rich in nutrients as farmyard manure (FYM). The decomposition process, which is hastened by a consortium of microorganisms, takes 75-90 days.

Energy source

Biomass can be efficiently utilized as a source of energy and is of interest worldwide because of its environmental advantages. In recent years, there has been an increase in the usage of crop residues for energy generation and as substitute for fossil fuels. In comparison with other renewable energy sources such as solar and wind, biomass source is storable, inexpensive, energy-efficient and environment-friendly. However, straw is characterized by low bulk-density and low energy yield per unit weight basis. The logistics for transporting large volumes of straw required for efficient energy generation represents a major cost factor irrespective of the bio-energy technology. Availability of residues, transportation cost and infrastructural settings (harvest machinery, modes of collection, etc.) are some of the limiting factors of using residues for energy generation.

Bio-fuel and bio-oil production

Conversion of ligno-cellulosic biomass into alcohol is of immense importance as ethanol can either be blended with gasoline as a fuel extender and octane-enhancing agent or used as a neat fuel in internal combustion engines. Theoretical estimates of ethanol production from different feedstock The technology of ethanol production from crop residues is, however, evolving in India. There are a few limiting steps in the process of conversion of crop residues into alcohol, which need to be improved. High energy requiring operating conditions, costly hydrolytic cellulase enzyme, and unavailability of natural robust commercial organism to ferment pentose and hexose sugars simultaneously either as single species or in combination of other species are some of the constraints, which require additional research efforts.

Biomethanation

The process of bio-methanation utilizes crop residues in a non-destructive way to extract high quality fuel gas and produce manure to be recycled in soil. Biomass such as rice straw can be converted into biogas, a mixture of carbon dioxide and methane, which can be used as fuel. Biogas of 300 $m^3$with 55-60% of methane can be obtained per ton of dry rice straw. The process also yields good quality spent slurry, which can be used as manure.

Gasification

Gasification is a thermo-chemical process in which gas is formed due to partial combustion of crop residues. The main problem in biomass gasification for power generation is the purification of gas for removal of impurities. The crop residues can be used in the gasifies for 'producer gas' generation The gasification technology can be successfully employed for utilization of crop residues in the form of pellets and briquettes. The generated 'producer gas' is cleaned using bio-filters and used in specially designed gas engines for electricity generation. The Central Institute of Agricultural Engineering (CIAE), Bhopal, has developed a power plant running on 'producer gas' generated from biomass.

Biochar production

Biochar is a high carbon material produced through slow pyrolysis (heating in the absence of oxygen) of biomass It is a fine-grained charcoal and can potentially play a major role in the long-term storage of carbon in soil, i.e., C sequestration and GHG mitigation. However, with the current level of technology, it is not economically viable and cannot be popularized among the farmers. However, once all the valuable products and co-products such as heat energy, gas like H2 and bio-oil are captured and used in the biochar generation process, it would become economically-viable. There is a need to develop low cost pyrolysis kiln for the generation of biochar to utilize surplus crop residues, which are otherwise burnt on-farm.