ISSN–0974–0759 | ●●● Article ●●● |Visit us : *www.researchjournal.co.in*|

Alternatives to crop residue burning

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The harvest waste, both the field residues that are left in an agricultural field or orchard after the crop has been harvested and the process residues that are left after the crop is processed into a usable resource is more popularly termed as 'crop residue'. Stalks and stubble (stems), leaves and seed pods are some common examples for field residues. Sugarcane bagasse and molasses are some good examples to process residue (Hoornweg and Bhada-Tata, 2012 and Obi *et al.*, 2016). India generates on an average 500 Million tons (Mt here after) of crop residue per year (MNRE, 2009). The same report shows that a majority of this crop residue is in fact used as fodder, fuel for other domestic and industrial purposes. However, there is still a surplus of 140 Mt out of which 92 Mt is burned each year.

Stubble burning in Punjab and Haryana i North-West India has been cited as a major cause of air pollution in Delhi (Anand, 2016). In late September and October each year, farmers mainly in these two states burn an estimated 35 million tons of crop waste from their wheat fields after harvesting, as a low-cost straw-disposal practice to reduce the turnaround time between harvesting and sowing for the second (winter) crop (Thakur, 2017). Smoke from this burning produces a cloud of particulates visible from space and has produced a "toxic cloud" in New Delhi, resulting in declarations of an air-pollution emergency (Ashok, 2017 and NASA, 2017).

Stubble burning is the process of intentionally setting fire to the straw stubble that remains after grains, like paddy, wheat, etc., have been harvested. The burning of stubble has a number of harmful consequences and effects on the environment (Ellison, 2013). Such as:

– Emission of green house gases (GHGs) that contributes to the global warming and production of other obnoxious gases

– Increased levels of particulate matter (PM) and smog that cause health hazards

– Increased quantity of air pollutants such as CO_2, CO, NH_3, NO_X, SO_X

– Pollution from smoke

– Respiratory trouble caused by unbearable smokes

– Adverse effect on soil biological reactions

– Impaired soil health due to declining SOM levels and associated nutrients

– Deterioration of soil fertility

– Damage to electrical and electronic equipment from floating threads of conducting waste

– Risk of fires spreading out of control

– Loss of biodiversity of agricultural lands

Pre-treatment with lignin degrading micro-organisms: Lignin degrading micro-organisms can be introduced to break down the lignin layer and degrade cellulose and hemicellulose matter to the corresponding monomers and sugars for effective biomass to fuel conversion (Chandra *et al.*, 2012). The pre-treatment could be mechanical, chemical, physico-chemical and biological. These methods result in increase of the accessible surface area, porosity and decrease in crystallinity of cellulose and hemicellulose and degree of polymerization. The management of agricultural waste using microbes could also be an excellent option for the detoxification of the soil and mitigation of environmental pollution. The bioremediation of the agricultural waste could be effectively carried out by anaerobic and aerobic processes, through some of the associated techniques like composting, vermicomposting, biogas production, bio-methanation and bio pile farming. Anaerobic digesters can turn biomass into biogas, a renewable energy source, containing approximately 50 per cent methane and a final solid residue usable as a fertilizer rich in nutrients (Bhuvaneshwari *et al.*, 2019).

Production of bio energy: Many countries such as

China, Indonesia, Nepal, Thailand, Malaysia, Japan, Nigeria and Philippines utilize their crop residues to generate bio energy and compost (Lohan *et al.*, 2018). The non-food-based portion of crops such as the stalks, straw and husk are categorized under lignocellulosic biomass (Chandra *et al.*, 2012). The major agricultural crops grown in the world such as maize, wheat, rice and sugarcane, respectively, account for most of the lignocellulosic biomass. Lignocellulosic biomass composed of cellulose, hemicellulose and lignin, are increasingly recognized as a valuable commodity, due to its abundant availability as a raw material for the production of biofuels. The Government of India recently directed the National thermal power corporation (NTPC) to mix crop residue pellets (nearly 10%) with coal for power generation.

On-farm residue management: Incorporation (*in-situ*), composting (*ex-situ*) and surface retention, are the promising on-farm management options to address the issue of burning as well as maintaining soil health and long-term sustainability of cropping system particularly for rice-wheat in rotation. For *in-situ* decomposition technique, fresh cow dung may be mixed thoroughly with water followed by ligno-cellulolytic microbes and spread over the residues. All these residues and ingredients are incorporated into soil by a tractor drawn rotavator. One irrigation is required immediately after mixing these consortia of microbes and other materials. Then, second irrigation is required after 15 days of *in-situ* decomposition. After one month of in-situ decomposition rice may be grown. Similar technology may be followed for wheat crop after harvest of rice. However, *in situ* incorporation and composting (*ex-situ*) are energy and cost intensive and time limitation options. Time needed for decomposition of rice residue is a major limitation, because of little turn-around time (15-20 days) available between rice harvest and optimal wheat sowing time. The delay in sowing due to time needed for residue decomposition adversely affects wheat productivity. However, this *in-situ* composting technology would be more viable if government give subsidy to farmers for sustainability of agriculture (Patra and Manna, 2018).

Conservation agriculture: The conservation agriculture based component technologies are zero or reduced tillage along with crop residue retention on the soil surface. Residue mulching also helps in moisture retention, nutrient transportation, reduces evapo-transpiration and minimizes weed population.

Innovative viable solution to residue management: In North Western India, the constraint has been resolved by the innovative latest version of the turbo happy seeder, which is recognized as a significant technological innovation for in-situ residue management (Jat, 2017). A straw management system (SMS) named as super-SMS has been developed and commercialized by Punjab Agricultural University, Ludhiana, to equip the combine harvesters with mechanized straw spreaders (Milham *et al.*, 2014).

Happy seeder is a tractor-mounted device. It cuts and lifts the residue of previous crop (in this case the rice straw) and sows a new crop (wheat) in its place. It is a direct sowing machine that is capable of seeding for the new wheat crop even in presence of the rice straw residues on the soil surface without any tillage. To add to the benefit for the farmers, the system can be deployed immediately after the harvest of the rice crop. It can deposit the straw over the sown area as mulch.

Other alternatives: The crop residues generated due to agricultural activities are exploited by several countries in different ways. They are utilized in processed or unprocessed form, depending on the end use. The possible options include its use as (Hayashi *et al.*, 2014; Devi *et al.*, 2017 and Kumar *et al.*, 2015).

– Bedding material for cattle
– Animal feed (Fodder)
– Composting
– Deployment in other extended agricultural activities such as mushroom cultivation Bio-thermal power plants
– Mushroom cultivation
– Production of bio-oil
– Paper production

Conclusion: Some of the laws that are in operation pertaining to crop residue burning are: The Section 144 of the Civil Procedure Code (CPC) to ban burning of paddy; The Air Prevention and Control of Pollution Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995 and The National Environment Appellate Authority Act, 1997. Particularly, in the states of Rajasthan, Uttar Pradesh, Haryana and Punjab stringent measures have been taken by the National Green Tribunal (NGT) to limit the crop residue burning. It is imperative that crop residue burning is an issue that needs priority attention at many levels. Technology interventions backed with strong policy support and people's participation will provide solution to much talk about problem of air pollution caused due to residue burning.The utilization of crop residue provides rationality to the widespread smallholder crop–livestock systems in India, being important sources of livestock feed and sometimes having other productive uses such as fuel and construction materials.

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Received : *13.09.2019* ***Revised :*** *18.10.2019* ***Accepted :*** *20.11.2019*