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Crop Residue Burning in South Eastern Rajasthan: Challenges and Solution

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INTRODUCTION

The agricultural industry plays a major role in the overall economic growth of the world. The sustainable management of agricultural waste has become a great challenge, especially for developing countries such as India with an increasing population, production rates and economic growth. The burning of crop residues in south eastern Rajasthan is a common practice due to the lack of technical awareness and lack of proper disposal opportunities. The burning of crop residues generates numerous environmental problems. The main adverse effects of crop residue burning include the emission of greenhouse gases that contributes to the global warming, increased levels of particulate matter (PM) and smog that cause health hazards, loss of biodiversity of agricultural lands, and the deterioration of soil fertility (Lohan et al., 2018). Crop residue burning also increases the quantity of air pollutants such as CO_2, CO, NH_3, NO_X, SO_X, Non-methane hydrocarbon (NMHC), volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs) and PM (Zhang et al., 2011). This basically accounts for the loss of organic carbon, nitrogen, and other nutrients, which would otherwise have retained in soil.

Crop residues are one branch of agricultural wastes that have posed especial challenges due to their vast volume and lack of capacities to manage them. Taking the fact into account that rice and wheat that usually produce the majority of crop residue being the major staples of India, the large-scale cultivation of these crops to feed the ever-increasing population has obviously led to generation of large quantities of crop residue that the country is not able to cope up with.

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Rice/soybean-wheat is by and large the most important cropping systems in south eastern Rajasthan and occupies 55-60 per cent of total cultivated area. Wide adoptability of rice-wheat and soybean-wheat cropping systems is mainly due to high productivity and less element of risk. Rapid and wide spread of this cropping system in irrigated area caused an eclipse on sustainability of soil productivity. Unsustainable high yields have been noticed in spite of liberal application of N,P&K in this region. This declining trend or stagnating yield trend has been attributed to multiple nutrient deficiencies and imbalances of nutrients which poses a serious threat to long term sustainability of crop production in south eastern Rajasthan.

Residue burning

Substantial area under soybean/rice-wheat cropping sequence is combine harvested. Harvesting of paddy/soybean and wheat leaves huge amount of residues in the field which is removed, burnt or incorporated in the field. Apart from that left over residues after the threshing of manually harvested crop is either used as fodder, industrial material or burnt in heaps. The primary factors hampering the residue management as a source of organics in rice/soybean-wheat cropping system are-

- Combine harvesting of rice/soybean-wheat cropping system leaves 6-8 tones/ha/annum crop residues. The physical removal of combine harvested material is no longer feasible because of increased labour cost and scarce labour availability. So, farmers prefer partial or complete burning of the residues in the field as per the situation.
- Low temperature at the time of wheat sowing slows down the decomposition process of incorporated residues.
- The crop residues have wide C:N ratio. Incorporation of crop residues results in temporary immobilization of nutrients, resulting in neutralizing the beneficial effects of incorporation of residue in soil and grain yield of succeeding wheat crop.
- The major component of straw is cellulose and hemicelluloses. Direct incorporation of residue in soil leads to decrease in crop yields due to production of microbial phytotoxins in addition to immobilization of available nitrogen in decomposing microbes, if the residue is not decomposed.
- Inadequate availability of moisture during the rabi season in the top 30-cm layer adversely the decomposition of incorporated residue.
- Uneven distribution of rice residue in heaps in the windrows, high residue load, non-availability of machinery for seeding wheat in the standing residue and lack of information on allied (fertilizer, water, pest and weed) management practices in relation to residue management are practical problems.
- Further, uneven distribution of residue causes frequent choking of seed drill resulting in inadequate plant stand and consequently low productivity in residue incorporated field.

Advantages of Crop residue management

- Stubbles are renewable and readily available resource and their recycling is available strategy to meet at least a part of nutrient requirement of the crops.
- Escalating cost of fertilizers on one hand and their undesirable impact on physical properties of soil on the other call for immediate inclusion of crop- residue recycling in crop production.
- Crop responses to residues are not as spectacular as do fertilizer application. But, residues recycling in soil do enhance the use efficiency of applied fertilizers.
- Crop residues applied to the preceding crop benefit the succeeding crop to a great extent and the system productivity becomes sustainable through integrated use of organic and inorganic sources of nutrients.
- Recycling of crop residues has beneficial effect on moisture conservation, erosion control and weed control.
- Incorporation of crop residues preserves plant nutrients and improves physical–chemical and biological properties of soil.
- Burning of residues result in air pollution. It emits carbon dioxide, carbon mono-oxide, nitrous oxide, sulphur oxide and suspended matter in air. The oxides of nitrogen and sulphur are content source of acid rain and corbon dioxide and corbon mono-oxide for global warming. Such disastrous hazard can be avoided, if residues are recycled properly in soil.
- Residue recycling can significantly results in increased yield of crops. So, it is desirable to encourage crop-residues recycling with the hope that such approach may sustain the productivity of rice-wheat cropping system and soil health on one hand and maintain agro-eco system on the other in future.

Decomposing mechanisms of crop residues

General types of crop residues produced by the rice/soybean-wheat cropping system of south eastern Rajasthan are husk, bran and straw. These crop residues, specifically as a field residue is a natural resource that traditionally contributed to the soil stability and fertility through ploughing directly into the soil, or by composting. Good management of field residues can also increase irrigation efficiency and erosion control. However, the mass scale and rapid pace of crop production have imposed economic and practical limitations to such traditional sustainable practices. While burning creates environmental issues, ploughing field residue into the ground for millions of hectares within a short time requires new and expensive technical assistance. Plant biomass is mainly comprised of cellulose, hemicellulose and lignin with smaller amounts of pectin, protein extractives, sugars, and nitrogenous material, chlorophyll and inorganic waste. Compared to cellulose and hemicellulose, lignin provides the structural support and it is almost impermeable. Lignin resist fermentation as it is very resistant to chemical and biological degradation. The non-food-based portion of crops such as the stalks, straw and husk are categorized under lignocellulosic biomass.

The management of residues using microbes could also be an excellent option for the detoxification of the soil and mitigation of environmental pollution. Microbial populations degrade the complex substances present in the biomass to simpler ones that can be reused or recycled through environmental processes. The techniques adopted can either be aerobic or anaerobic, depending on the nature of bacteria, fungi or algae involved in the degradation. The microbial degradation techniques reduce the soil toxicity, promote plant growth through provision of growth accelerating metabolites and provide plant nutrients through sequestration from soil.

Limited time is available for decomposition of rice stubbles before wheat sowing, in particular. Direct incorporation of crop residue in soil causes enormous problem in the establishment and growth of succeeding crop and leads to decrease in crop yield due to production of microbial phytotoxins and immobilization of available nitrogen. The potential phytotoxins production can be reduced if the straw in degraded before planting of succeeding crop. Inoculation of residues with efficient cellulytic microorganisms produce enough simple sugars for growth and multiplication of beneficial soil micro flora. To enhance the process of residue management in the soil and to provide supplemental nitrogen, the use of starter dose in the form of bio-inoculants and fertilizer nitrogen or any other source to the decomposing residues could partially offset the mobilization process. Since no single residue management practice is superior under all the conditions, it becomes imperative to determine the benefits and adverse effects of residue management options in rice-wheat cropping system. So, development of appropriate residue management is therefore, very important for its successful use as component of integrated nutrient management. To hasten and facilitate the residue decomposition process by inclusion of nitrogen. Cellulytic microbes and other decomposing materials as farm yard manure and *Trichoderma virde* at the time of residue incorporation may solve the problems associated with residue management. Following technique should be opted to manage the residue in rice-wheat cropping system.

- Residue should be incorporated immediately after the harvest of rice and wheat crops in the field. The crop residues before incorporation in to the field should be chopped into pieces of size to near about 5 cm. lengths and spread across the field incorporated by mould board plough to 8 cm. depths.
- To facilitate and hasten the residue decomposition at the time of residue incorporation in the field, the starter should be applied uniformly on the residue.
- Field should be irrigated (7.5 to 8.0 cm.) immediately after residue incorporation, so as to provide congenial moist environment for higher microbial activity.

Wheat residue incorporation

Soybean crop after residue incorporation

- System productivity, profitability and soil health under soybean–wheat cropping system can be enhanced through adoption of recommended package of practices for the wheat and its residue incorporation after harvest along with irrigation and application of urea @ 25 kg/ha + Cellulolytic microbes @ 2.0 kg/ha; 125 % RDF (25 kg N: 50 kg P_2O_5: 50 kg K_2O/ha) of soybean and then application of two irrigation at flowering & pod development stages.

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