

Crop Residues Management under Changing Climate Scenario

Comment [NR1]: According to the text, your goal was to study crop residue management. One of the influential factors of crop residues is climate change. Therefore, it is not appropriate to refer to climate change in the title.

Abstract

Soil is the fundamental and necessary natural resources for the agricultural production system. Due to the increasing global population and the impact of climate changes, natural resources are the major limited factor to use widely for food production. The major factors responsible for the deterioration of natural resources are an extreme event caused by man-made activities and unexpected and unpredictable adverse natural forces of nature. Among the different degradation processes, soil erosion is one of the serious threatens for the deterioration of soil for the agricultural sector and healthy ecosystem conservation. Intensive agricultural practices are particularly caused acceleration of the soil erosion process. Therefore, the good and systematic management of soil resources is indispensable not only for the sustainable agriculture or conservation agriculture but also for the protection and reduction of the natural ecosystem. Covering of crop residues on soil enhance organic matter, protects the soil surfaces, maintain water and nutrients, improves in soil biological activity and chemical composition and contributes to pest management. Therefore, crop residue management is a one of the conservation practices and designed to leave sufficient residue on the soil surface to reduce wind and water erosion. It includes all field operations that affect the amount of residue, its orientation to the soil surface and prevailing wind and rainfall patterns, and the residue distribution throughout the period requiring protection. This paper especially highlights the status of soil erosion, crop residues, and management in crop residues in sustainable agriculture.

Key words – soil, natural resources, crop residues, climate

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1. Introduction

Comment [NR3]: The introduction is very general. Given that most of the discussion in this manuscript is on rice straw, it was appropriate to pay more attention to it in the introduction.

Crop residues are the vegetative portions left in the agricultural field after the crop has been harvested and include stems, leaves, stalks, and seed pods. Generally, these crop residues are either harvested as fuel, animal bedding, feeding, and soil cover or are burnt in the field. Among different agricultural wastes, cereal residues are a particular used as feed for cattle. Rice straw and husk are used as domestic fuels such as fuel for cooking in rural households, protection of gnat, flies and other insects from cattle at night, and in boilers for parboiling rice. Most of farmers use crop residues not only for themselves but also sell it to landless households who further sell them to industries as well as make cottage industry. The remaining residues are left unused or burnt on-farm. Likewise, crop residues play a vital role not only in nutrient recycling to improve soil quality and sustain crop productivity system but also adaptation to climate changes. The recycling of crop residues has huge benefits to return the amount of plant nutrients to the soil. Crop residues on the soil surface acts as covering of mulching to decrease soil temperature and maintain higher soil moisture as well as adapting to variability of changing climate which are an unpredictable events happens like soil erosion may be instantly affected in sustainable agricultural productivity. It results in saving in irrigation water and fertilizer and in reducing weeds which compete the nutrients, water etc. based-needs for growth and developments thereby improves soil fertility and increases crop yield. In addition, these can be used in various kinds of fields as animal fodder, fuel, cottage industry, packing materials and raw materials for mushroom cultivation and so on and which aims to help farmers to earn more income through their crop production residues. However, it is a great challenge for the agriculturists to manage crop residues effectively and efficiently according to enhance in sustainability of crop production under climate changes (Uddin and Fatema, 2016). Therefore, management of crop residues has a crucial role in agricultural practices to achieve higher crop production against changing of environmental conditions.

2. Generation of Crop Residues in India and world

Hegazy *et al.* (2016) stated that now approximately 731 million tons per year rice straw is produced globally (Africa: 20.9 million tons, Asia: 667.6 million tons, Europe: 3.9 million tons, America: 37.2 million tons, and Oceania: 1.7 million tons). India is the second largest in the world with 17% of the world population and an agricultural background produces large amounts of paddy grains in Table -1 for domestic consumption as well as export. Moreover, According to the agricultural statistics at a glance 2018, the production of major crops in India were 99.70 MT

of wheat, 284.83 MT of food grains, 31.31 MT of oilseed crops, 376.90 MT of sugarcane, 25.23 MT of pulses and 34.89 MT of cotton. Government of India has estimated that about (500 Mt) of crop residues are generated in 28 states every year. The generation of crop residues in 28 states of India is the three highest states which are in Uttar Pradesh (60 Mt) followed by Punjab (51 Mt) and Maharashtra (46 Mt). There is a wide variability in the generated crop residues and their usage across different regions of the country depending on the crops grown, cropping intensity, productivity and market demand of these crops. Among different crops, cereals generate the highest residues (352 Mt), followed by ~~fibres~~fibers (66 Mt), oilseeds (29 Mt), pulses (13 Mt) and sugarcane (12 Mt). Generated crop residues of all crops contribute in the Figure -1. While 70% of contribution of cereal crop, while rice crop alone contributes 34% to the crop residues (NPMCR, 2014).

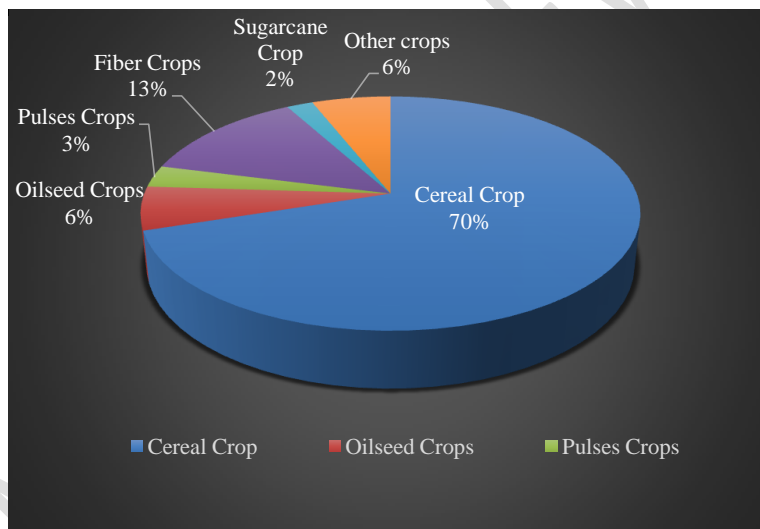


Figure-1. Generated Crop Residues in Different Crops in India

Table-1 Rice: State Wise Yield (Kg/hectare)

Season	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Autumn	1349	2804	2892	3107	2186	1776	1938	1674	1891	1645	-	-	-
Winter	1795	2000	1892	1968	1939	2338	2257	2283	2219	2310	-	-	-
Kharif	2199	1963	2138	2054	2053	2051	2399	2477	2434	2335	-	-	2477
Kharif Total	1990	2024	2095	2082	2019	2121	2311	2373	2319	2295	2305	2417	2477
Summer/Rabi	3127	3130	3149	3010	3055	3176	3238	3353	3232	3291	3382	3230	3474
Total	2102	2131	2202	2178	2125	2239	2393	2461	2416	2391	2400	2494	2578

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3. The Relationship between Climate Change Scenario and Crop Residues

Management

Climate change with changes, namely temperature, precipitation and relative humidity, rainfall are likely to be affected in crucial sectors like agriculture and poverty reduction in rural development and various kinds of fields. Impacts are already seen and known as natural disasters which are an unpredictable events like erosions, landslides, mud slides heat and cold waves, cyclones, floods, drought etc. and effects on agriculture and a live health and consequence decreases seriously in crop production and difficult to stand in living in rural people who are affected due to lower income (Singh *et al.*, 2010). To achieve a sustainable crop yield and stable farm income every year, there is needed to perform systematically maintainable one of the agricultural practice in field which is crop residue management. Even though it is not new technology, still requires how to apply effectively not only for crop productivity but also for adaptation of climate change from point of land users. In addition, from side of agriculturalists, there is needed to manage efficiently without affecting on a health environment. For example, among factors of climate changes, soil erosion is a majority risk in agricultural lands like splash and sheet erosion are the predominant erosion events and its adverse impact on agricultural productivity and sustainability (Figure -2). Though the soil erosion cannot be eliminated, it must be reduced to the minimum level through crop residues management such as covering with mulching crops residues on the soil surface to protect directly the torrential falling raindrops on the soil surface break the soil aggregates and scattered and splash soil particles horizontally and vertically and it may be affected the breakdown of soil aggregates and clogging of soil pores surfaces with fine soil and retarded water infiltration into the soil and then increasing water runoff with soil fertility, finally happens soil erosion. (Kumawat, *et al.*, 2020).

4. Possible solution to Crop Residue ~~Managemnt~~Management in Paddy

There are various management practices in crop residue in field, vary from region to region and from country to country depends upon the based-need of human being (Figure - 3).

4.1 Crop Residue Burning in Field

Even though Farmers have the aims of rice straw burning after harvesting process, the main reason of straw burning urgently is to prepare the field to sow timely the next crops with the residual moisture in previous crops due to unpredictable weather and that is found a particular in

rained areas. Moreover, transportation costs, labor shortage and storage infrastructures of rice straws are the main challenges for farmers especially in developing countries. Farmers accepted that burning of straw is the cheap and easy traditional farming practice, improving of soil fertility, the clearance of land, shrubs and weeds, and controlling of pests. In order to India is an agrarian country and produce more than 500 million tons (Mt) of crop residues annually. There are so much of environmental risk concerned with straws burning. This risks followed continuously burning may be reduce soil quality and make land more susceptible to erosion process. Punjab and Haryana in India, where crop residues of rice are not used as cattle feed, a large amount is burnt on-farm. NASA captured in the aerial photograph taken on November of 2015 in Figure -3, which red spots seen shows the areas of crop burning in the farming lands in Punjab and Haryana after the rice harvesting time and (80 %) of rice straw was burnt in these areas while the fraction of crop residue subjected to burning ranged from (8–80) % for rice paddies across the states in the nationwide. Nevertheless, Revised Guidelines of In-Situ Crop Residue Management Scheme, 2019, highlighted that the losses of nutrients in soil in Nitrogen (5.5 kg t^{-1}), Phosphorus (2.3 kg t^{-1}), Potash (25 kg t^{-1}), Sulphur (1.2 kg t^{-1}), Organic carbon (400 kg t^{-1}) and Micro-nutrients (50-70%) for the sake of straw burning as well as in loss of approximately 80 - 90% N, 25% of P, 20% of K and 50% of S nutrients present in residues as in the form of various gaseous and particulate matters, causing impact on climate change like in atmospheric pollution (Bhuvaneshwari *et al.*, 2019). Furthermore, the burning of agricultural residues releases a significant emissions of 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 and impacts on climate change About (70)%, (7)% and (0.66)% of C present in rice straw is emitted as carbon dioxide, carbon monoxide and methane, respectively (Naresh *et al.*, 2017).

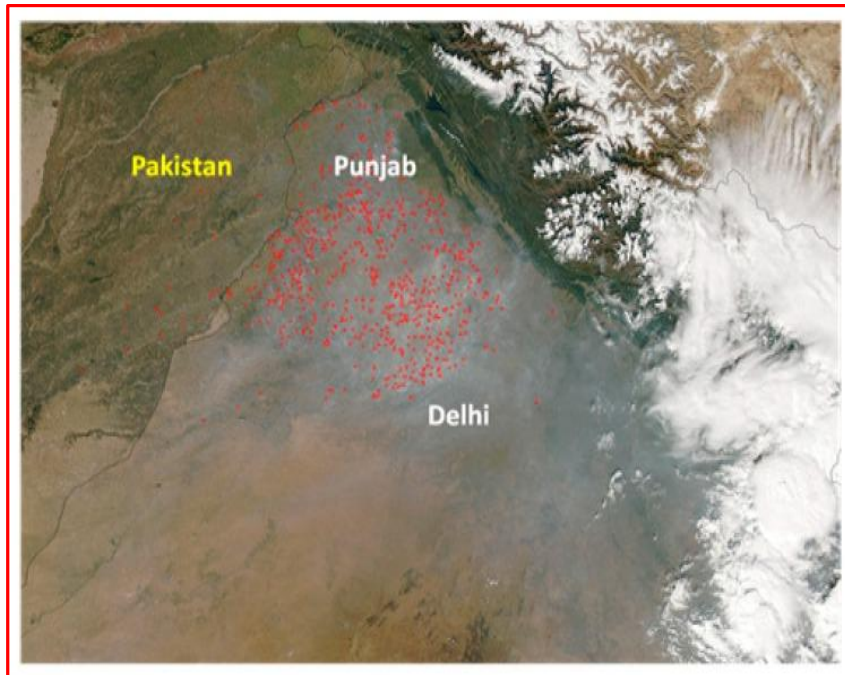


Figure - 3 Crop Burning captured by NASA

4.2 Utilization in Mushroom Cultivation

Mushroom production is one of the areas with great potential for exploitation of agricultural residues. It presents an expanded and economically important issue worldwide and an annual global market value in excess of \$ 45 billion. *Agaricus bisporus* (decomposing) cultivation is the most commonly cultivated mushroom worldwide and the cultivation of raw material consisting of straw. A big geographical distribution of crop residues is favored by huge crop productions in India and China, thus increased quantities of crop residues and agro-industrial by-products are generated whereas expanding agricultural crop production. Therefore, agro-industrial residues accumulate in fields and factories, ~~these issues~~ this issue tends to become a regional and local matter throughout their nationwide. Asia along with Europe, North America and Australia are world leader mushroom producing regions because the major residue demanding for this bio-based industrial activity. Among countries in the Asian and Pacific Region, China produces the largest quantities of agricultural and forest residues, mainly by-products of rice, corn and wheat and estimated quantities of waste products was to reach about 1

billion tons/year in China, are followed by India's agricultural residues was at least 200 million tons/year while the total amount of agro-industrial residues reaches 600 million ton in India (Antonios, 2009).

4.3 Baling of the Straw

Hegazy and Snadro (2016) is shown which are approximately 731 million tons per year rice straw is produced globally that include in Africa: 20.9 million tons, Asia: 667.6 million tons, Europe: 3.9 million tons, America: 37.2 million tons, and Oceania: 1.7 million tons along with the progress in the rice production system, the amount of straw will increase. Only about 20% of rice straw was used for purposes on making of ethanol, paper, fertilizers and fodders and the remaining is either removed from the field or burned, piled/spread in the fields. Straw baling is one of the residues managements and the least expensive method for harvesting and packing rice straw. Bailing can be commonly applied to improve the characteristics of agricultural residues for transportation and storage. The baled straw has relatively low moisture content and can be stored for long period without significant dry matter loss and deterioration in fuel quality. Baling of straw vary on different sizes (common size: 0.45 x 0.55 x 0.14 m³), shapes (square, rectangular and round etc.) and weight (such as 75-180 kg). Applying of bailing systems and technologies in crop residues from country to country vary and depends upon their farmer adaptations and government's policies, short and long terms strategies related to sustainable agricultural crop production and friendly environmental conservation. Current situation of straw collections in some countries in Asia, there is no clear technologies for straw collection and few baler have used in project area in Philippines. In Malaysia, the harvest of rice during the rainy season is a crucial event to the degradation of the straw development industry of some regions. Based on research and development, and the applying of the existing baler machine technology for rice straw can only be collected and acted when everything is dry. Moreover, the imported baler machine cannot be operated in wet soil conditions. There is no any techniques and baler machines in Myanmar. Even though Myanmar has 7.256 million hectares of rice sown area and production of rice was 28.09 million metric tons according to Myanmar Agriculture at a glance (2018), most of farmers are using rice straws as animal fodder by themselves as well as selling it to others for cultivation of mushroom, cottage industries etc. and the remains have been used

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burning of residues in the fields whereas they have been accepting that residues burning makes cleaning of the field and controlling of pests and diseases for next crops.

4.4 Biogas

Policy Challenges and Potential Solutions, 2019 indicated crop residue which is as a source of energy in the form of biogas is produced by using rice straw residue between 0.550-0.620 m³kg. It is mainly composed of cellulose, hemicellulose and lignin with smaller amounts of pectin, protein extractives, sugars, and nitrogenous material, chlorophyll and inorganic waste. There is an increasing trend in the use of crop residues as a valuable commodity, due to its abundant availability as a raw material for the production of biofuels. Many countries apply their crop residues to generate bioenergy (Bhuvaneshwari *et al.*, 2019).

4.5 Cottage Industry

Cottage Industry is generated one of the crop residues management and provide livelihood support to farmers or traditional artisans and craftsmen (Singh, 2017). Household families in rural area can earn extra income through cottage industry by using crop residues. This has a significant role in creating jobs in farm that mainly depend on family members especially jobless who are eldest, house wives etc. Therefore, its management acts on benefits of not only for job opportunities but also more income along with crop production. In addition, some of the cottage industry such as boater and painting can be maintained craftsmanship related to their own countries and then maintains inheritance of its craft as well culture as from generation to generation.

4.6 Composting

Crop Residue is incorporated completely or partially into soil by ploughing and improve in nutrient recycling in the soil qualities in both of physical and chemical properties, water-holding capacity, and ensure higher crop productivity. Organic fertilizers such as vermicomposting and composting are the best one for crop residues management for the soil health and plant nutrient availability resulting in higher crop yields besides getting healthy environment. The increasing of germination and plant growth could probably be due to increase

in enzymatic activity, increase in microbial population and activity, increase the soil moisture holding capacity, accelerating the population and activity of earthworm and easy availability of macro and micro nutrients by application of vermicompost. It has a significant positive influence on seed germination and seedling ~~vigour~~vigor. It is the microbial composting of organic fertilizers which contain higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities. Preparing of compost is one of the traditional usage of crop residues and composting of rice crop residues from one hectare land give about 3 tons of manure as rich in nutrients as farmyard manure (FYM) (Sharma *et al.*, 2017).

4.7 Fodder and Animal Bedding

Crop residues is a major source feed for animals in a long time until harvesting of next paddy crop. Though rice straw is high in lignocelluloses, silica and insoluble ash, it is a poor-quality feed in protein and mineral content. The preferences of straw residues by animals depends on straw type and chemical compositions of straw etc. In general, fine (slender), soft, long, leafy and stored rice straw is preferred by animals. However, farmer also have been providing the rice straws along with green fodder especially prepared concentrates or compound feed such as soya meal, ~~molasses~~molasses and salt etc. for animals specially cattle and buffalo whereas most of farmers want to increases the yield of milk and meat from their animal as well as need to apply effectively their animals in crop production system. Crop residues are the best for increasing the production of these compound feeds for animals. –According to the project report of the International Livestock Research Institute (ILRI), the chemical analysis taken from two different sources on a dry matter basis are given in Table-2. Animal bedding by using collected residue is a traditional management and then heaping it in dung heaves. The recycling of crop residues for bedding has great results to return a considerable amount of plant nutrients to the soil, in substantial saving in irrigation water, fertilizer and reduced other input costs and thus, it improves soil fertility, enhances crop productivity and conserves environment. (Uddin and Fatema, 2016). Each one kilogram of rice straw in animal bedding absorbs about 2-3 kg of urine, which enriches it with Nitrogen source (Avadhanam *et al.*, 2020).

Table - 2 Chemical composition of rice straw (% on dry matter basis)

Items	(%)
Organic matter	82
Crude protein	4
Crude fiber	37
Non- fatty esters	43
Total ash	18
Calcium	0.14
Phosphorus	0.05
Neutral detergent fiber	75
Neutral detergent fiber	54
Cellulose	37
Lignin	8
Silica	8

5. Conclusion

Soil is the most important factor for all living organisms as well as our friendly planet to fulfill based-needs of living and need to create healthy environment condition climate change adaptation. Among ~~every ways or techniques~~ all ways or techniques, systematic agronomical practices ~~contributes~~ contribute high in the long term sustainable agricultural farming. Therefore, Crop residues management plays an essential event in agricultural crop systems. Moreover, the adoption, awareness and capacity building of farmers who are house head with their education level and agricultural income in villages should be more effectively driven how to apply systematically and act easily the knowledge of managements based on their adversities and occurrences related to the impact of climate changes, weakness in their technical interventions, diversified use of crop residues and planning in long term and short term the through the consulting of scientists concerned with crop residues management. This paper reviews the management practices of crop residues and its role in soil conservation, job opportunities for landless, increasing extra income besides farming for farmer.

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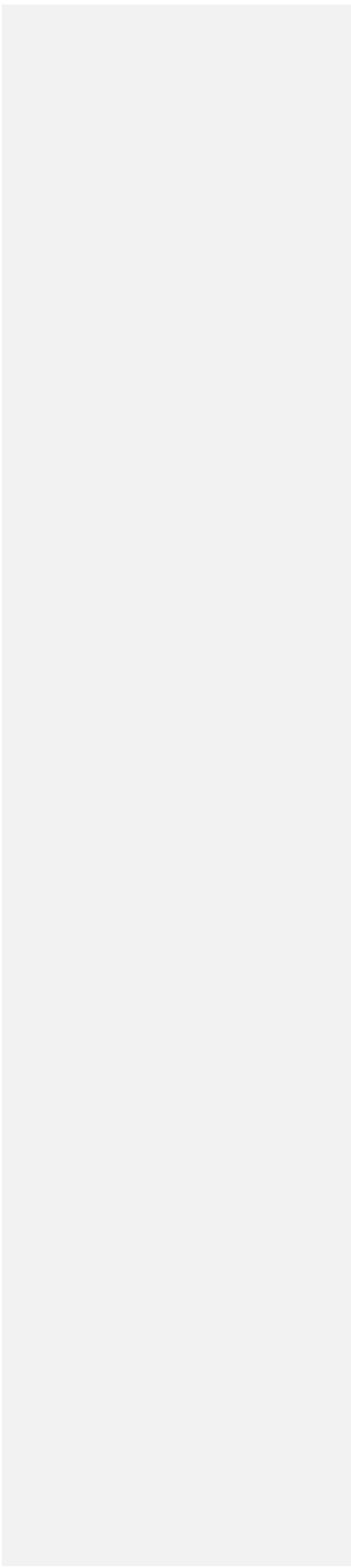
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