

ABSTRACT

Soil is the fundamental and necessary natural resource for the agricultural production system. Due to the increasing global population and the impact of climate changes, natural resources are the major limiting factor to use widely for food production. The major factors responsible for the deterioration of natural resources are extreme events 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 to the deterioration of soil for the agricultural sector and healthy ecosystem conservation. Intensive agricultural practices are particularly caused by the acceleration of the soil erosion process. Therefore, the good and systematic management of soil resources is indispensable not only for sustainable agriculture or conservation agriculture but also for the protection and reduction of the natural ecosystem. Covering crop residues on soil enhances organic matter, protects the soil surfaces, maintains water and nutrients, improves soil biological activity and chemical composition, and contributes to pest management. Therefore, crop residue management is one of the conservation practices and is 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 an 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.

Keywords: climate, crop residues, natural resources, soil

1. 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 particularly used as feed for cattle especially rice crop residues. Rice is the pivotal importance of grain food and contribution to fulfilling for current and future food security

throughout the world. World rice crop production was 498.9 million metric tons in 2019-2020 [1]. According to Agricultural Statistics at a glance [2] in India, rice is grown in 43.91 million hectares nationwide and is produced 109.76 million tons. Rice crop residues such as 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. Remained rice stubbles on-farm after harvesting can be burned or incorporated with the soil by tillage for preparation of next crops. Most farmers use rice crop residues not only for themselves but also sell them to landless households who further sell them to industries as well as make cottage industries. Likewise, it plays a vital role not only in nutrient recycling to improve soil quality and sustain crop productivity system but also in adaptation to climate changes. The recycling of rice crop residues has huge benefits to return the number of plant nutrients to the soil. Crop residues of rice on the soil surface act as a covering of mulching to decrease soil temperature and maintain higher soil moisture as well as adapting to the variability of changing climate which is an unpredictable event that 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 for the nutrients, water, etc. based-needs for growth and developments thereby improving soil fertility and increasing 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 agriculturists to manage crop residues effectively and efficiently according to enhance the sustainability of crop production under climate changes [3]. Therefore, the management of crop residues has a crucial role in agricultural practices to achieve higher crop production against changing environmental conditions.

2. GENERATION OF CROP RESIDUES IN INDIA AND WORLD

Hegazy and Snadro [4] 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 [5], the production of major crops in India was 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. The 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 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 fibers (66 Mt), oilseeds (29 Mt), pulses (13 Mt), and sugarcane (12 Mt). Generated crop residues of all crops contribute in Figure 1. While 70% of the contribution of cereal crop, while rice crop alone contributes 34% to the crop residues [6].

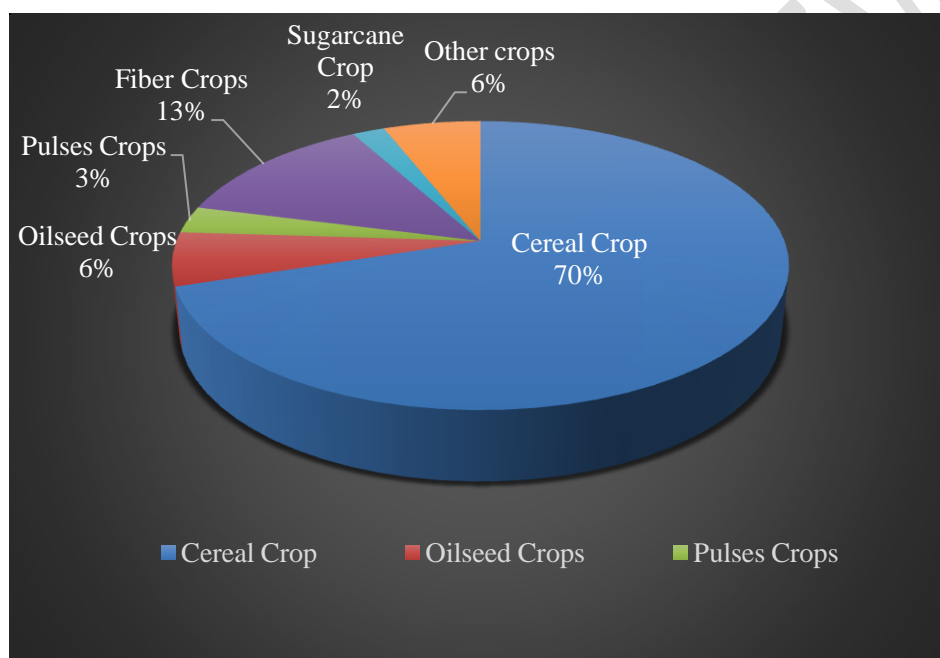


Fig. 1. Generated Crop Residues in Different Crops in India

Table1. Rice [State Wise Yield (kg/ha)]

	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

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 unpredictable events like erosions, landslides, mudslides heat and cold waves, cyclones, floods, drought, etc. and effects on agriculture and 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 [7]. To achieve a sustainable crop yield and stable farm income every year, there is needed to perform systematically maintainable one of the agricultural practices in the 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 the side of agriculturalists, there is needed to manage efficiently without affecting a healthy 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 their adverse impact on agricultural productivity and sustainability (Fig. 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 [8].

4. POSSIBLE SOLUTION TO CROP RESIDUE MANAGEMENT IN PADDY

There are various management practices in crop residue in the field, varying from region to region and from country to country depending upon the based-need of the human being (Fig. 2).

4.1 Crop Residue Burning in Field

Even though farmers have the aims of rice straw burning after harvesting process, the main reason for 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 rainfed 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 straw is the cheap and easy traditional farming practice, improving soil fertility, the clearance of land, shrubs, and weeds, and controlling pests. In order to India is an agrarian country and produces more than 500 million tons (Mt) of crop residues annually. There is so much environmental risk concerned with straws burning. These risks followed by continuously burning maybe reduce soil quality and make land more susceptible to the 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 2, 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 [9], highlighted that the losses of nutrients in the 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 an impact on climate change like in atmospheric pollution [10]. Furthermore, the burning of agricultural residues releases 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 [11].

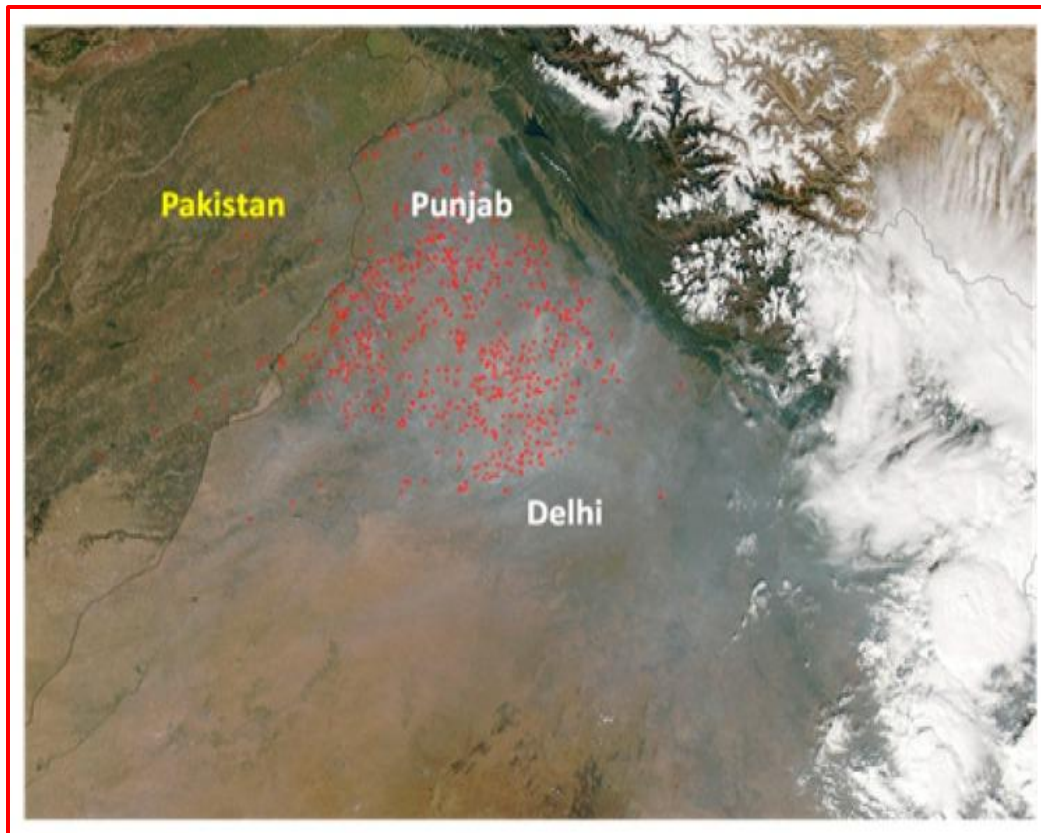


Fig. 2. Crop Burning captured by NASA (2015)

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 in 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 while expanding agricultural crop production. Therefore, agro-industrial residues accumulate in fields and factories, 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 of 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 [12]

4.3 Baling of the Straw

Hegazy and Snadro [4] 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 of making 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 are no clear technologies for straw collection and few balers have been used in the project area in the 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 are no techniques and baler machines in Myanmar. Even though Myanmar has 7.256 million hectors of rice sown area and production of rice was 28.09 million metric tons according to Myanmar Agriculture at a glance [13], most of the farmers are using rice straws as animal fodder by themselves as well as selling it to others for the cultivation of mushroom, cottage industries, etc. and the remains have been used 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 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 are increasing as a valuable commodity, due to their abundant availability as a raw material for the production of biofuels. Many countries apply their crop residues to generate bioenergy [10].

4.5 Cottage Industry

Cottage Industry is generated one of the crops residues managements and provide livelihood support to farmers or traditional artisans and craftsmen [14]. Household families in rural areas can earn extra income through the cottage industry by using crop residues. This has a significant role in creating jobs on the farm that mainly depend on family members especially the jobless who are eldest, housewives, etc. Therefore, its management acts on benefits 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 the inheritance of its craft as well culture as from generation to generation.

4.6 Composting

Crop Residue is incorporated completely or partially into the soil by ploughing and improves 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 ones for crop residues management for soil health and plant nutrient availability resulting in higher crop yields besides getting a healthy environment. The increase of germination and plant growth could probably be due to an 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 micronutrients by application of vermicompost. It has a significant positive influence on seed

germination and seedling vigor. It is the microbial composting of organic fertilizers which contain a 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 usages of crop residues and composting of rice crop residues from one-hectare land gives 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 are a major source of feed for animals for a long time until harvesting the 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 depend on the straw type and chemical compositions of straw etc. In general, fine (slender), soft, long, leafy, and stored rice straw is preferred by animals. However, the farmer also has been providing the rice straws along with green fodder especially prepared concentrates or compound feed such as soya meal, molasses, and salt, etc. for animals especially cattle and buffalo whereas most of the farmers want to increase the yield of milk and meat from their animal as well as need to apply effectively their animals in the 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) [15], the chemical analysis taken from two different sources on a dry matter basis is given in Table2. Animal bedding by using collected residue is 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 savings in irrigation water, fertilizer, and reduced other input costs and thus, it improves soil fertility, enhances crop productivity, and conserves environment [3]. Each one kilogram of rice straw in animal bedding absorbs about 2-3 kg of urine, which enriches it with a Nitrogen source [17].

Table 2. Chemical composition of rice straw*

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

* % on dry matter basis

4.8 Advantages of CRM

- Create job opportunities for youth and the edged people in families especially jobless people
- Earn extra income
- Maintain craftsman from generation to generation
- Upgrade creative power related to craftsman
- Clear the field fast in time before the next crop
- Kills soil born diseases, pathogens, and unwanted plants
- Improve soil structure, environment, and nutrient content
- Conserve soil temperature and moisture
- Reducing evaporation and carbon emission
- Maintain water holding capacity and infiltration rate
- Prevent wind and water erosion
- Weed control

4.9 Disadvantages of CRM

- Deteriorate soil fertility, quality and kill beneficial soil and microorganisms and insects by burning crop residues
- Loss of soil organic matter (SOM)
- Causes soil erosion by straw burning

- Increase many environmental problems (emission of greenhouse gases, GHGs) and air pollutants such as CO₂, CO, NH₃, NO_x, SO_x, etc. associated with straw burning

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 all ways or techniques, systematic agronomical practices 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 management 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 the farmer.

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