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Generation and Impact of Crop Residue and its Management

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Net Cultivated Area

India has the total geographical area 329 million hectares (m ha), which includes 195 and 140 m ha is gross cropped and net sown area, respectively. However, net irrigated area is only 83 m ha and rest of that is rainfed. About 47.7% of total agricultural land in India was reliably irrigated. The cultivation area is about 51% of total geographical area of India than 11% of the world. India has the cropping intensity 136 % which is increased 25 % since independence. The rainfed drylands is 65 % of the total net cropped area.

Cropping Rotation

The cropping system of rice (*Oriza sativa*)-wheat (*Triticum aestivum*) is grown on largest area of the world. These crops grown on 13.5 mha and are recognized as the important crops for food security in South Asia. Rice-wheat is followed in Indo-Gangetic Plains (IGP) of Bangladesh, India, Nepal and Pakistan of South Asia and this plain has the fertile alluvial soils. Similarly, this system is practiced as most profitable system in IGP states of Punjab, Uttar Pradesh, Haryana, Bihar and West Bengal. It is also known as Indian Green revolution region, "food bowl" or "food basket" and registered about 15% of the total geographical area of India. This plain which is suitable for taking double / triple crops in a year for providing food security to the IGP population with production of about 50% of the total food grains of the country to feed 40% of the population.[1, 2] However, rice -wheat rotation of the IGP, occupies 53 % of the total area and about 42% of the total farming area of the India.[3] India has the second rank in the production of rice and wheat in the world, these crops producing large amount of residue. In the four zones of IGP, the three cropping systems of rice-wheat, rice-fallow and rice-mustard-summer rice are grown but the rice-wheat is the predominant system in this area which has the 72% of the total arable area.[4]

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Factors for Spread of Rice-Wheat System

- More adoption ability than other cropping systems
- Availability of improved cultivars
- Mechanized cultivation of rice and wheat

Factors for Higher Productivity of this System

- Better favourable conditions of production i.e. fertile alluvial soil
- Better irrigated conditions
- Favorable conditions as hot and humid summers and cold to mild winters for the growing of rice and wheat crops than other grain crops.

It is also reported that the adoption of rice-wheat cropping system is increasing by the farmers of central plain zone. The western (Haryana, Punjab, parts of central, western & northern) and eastern part (Eastern UP, Bihar and West Bengal) of IGP are dominated by rice-wheat and rice based production systems, respectively.

Main Challenges of IGP Areas

- Climate change is the global environmental issue, which impact the crop productivity, natural resources as soil, irrigation water, freshwater supply and health of the population of IGP.
- Growing of same crops for longer period
- Excessive irrigation
- Shifting of population from rural to urban area means urbanization
- Increasing of insect-pest
- Nutrient imbalance
- Burning of rice and wheat residue
- Depletion of water[5]
- The global warming
- Fast increasing of population
- Deterioration of soil health (Punjab)
- Occurrence of soil salinity (Haryana, South –west Punjab)
- Declining of underground water (Central & Western UP, Punjab, Haryana)
- Floods during rainy season (Bihar & West Bengal)[6]

Production and Consumption of Residue

The residue from the rice-wheat system reported as 34% comes from rice and 22% from wheat crops, most of which is burnt on-farm. In India, on an average 500 million tons generated of crop residue per year.[6] While a maximum crop residue is used as fodder, fuel for domestic and raw material for different industrial purposes as energy and paper production. The majority of residues from rice, wheat, maize, jowar, ragi and bajra are used as cattle feed and cotton, chilli, pulses and oilseeds are used as fuel for household needs. Rice husk is mainly used as fuel in boilers and bagasse in energy or paper industries.

Crop Residue (CR) Surplus

The amount of surplus crop residue available in India is about 141 million tons a year, out of which 92 mt is burned each year.[7] The two crops as rice and wheat are produced large amount of residues in India. Globally, biomass production from agriculture is pegged at 140 billion metric tons reported in Feb. 2019. Sugarcane tops is generally surplus residue, which are burnt after the harvesting by the farmers in the fields. Other crops as oilseeds, pulses, chilli and cotton are generate surplus residue which is used as fuel. The residues after the harvested of these crops are burnt in the fields or used as fuel at home by farmers. There is also available potential biomass of bamboo plant of 4 million metric ton. There is no surplus residue from fodder crops which is used as cattle feed.

Surplus Crop Residue Density

The surplus crop residue density as per square kilometer availability was found maximum in the states of Uttar Pradesh, Haryana and Tamil Nadu..

In Punjab

Rice -wheat is predominant cropping system in Punjab. These crops are producing CR of 51 mt in Punjab. The paddy produced CR as estimated of 22.9 m t and wheat about 23.1 m t and reported about 95% of paddy straw and 23% of wheat straw is burnt in the fields.[8] The major reasons for the burning of residue are lack of buyers for power generation or other purposes, little time for planting succeeding crop, lack of labour and financial assistance from government.

The management of crop residues in crops and livestock has the considerable importance to supply the large amount of nutrients to soil in rice growing areas,[9] both are benefited through resource interdependences.[9] The farmers are benefited from management of rice straw by improving soil properties as soil health, water contents and reducing the use of less amounts of fertilizer, irrigation water for the planting of next crops. Ultimately increasing the productivity of, succeeding crop, annual income of the farmers significantly. Rice straw are poor cattle feed due to higher content of silica in rice so its straw management is great challenge.

Management Options[10]

- Residue burning in the fields
- In-situ incorporation of residue
- Surface management of residue and mulching
- Residue baling for the use in industries and removal of straw

Burning

Air Deterioration Causes Respiratory and Cardio Vascular Problems Due to

- CO_2 increases 70%
- Carbon monoxide rises by 7%
- Nitrogen dioxide shoots up 2.1%

on Burning of a Tonne of Straw Releases the Following in the Air as Reported by Hyderabad, Centre of Sustainable Agriculture

- Particulate matters 3kg
- Carbon monoxide 60 kg
- Carbon dioxide 1460 kg (13 tha^{-1})
- Ash 199 kg
- Sulphur oxide 2kg

Besides above, with the burning residues great loss in terms of nutrients, micronutrients and soil organic matter (SOM) from the soil particularly SOM loss has potential impact on the sustainability of rice-wheat system.

Department of Soils, Pau, Ludhiana, Reported the Following Nutrient Loses with the Burning of a Ton Straw during 2010 as

- Nitrogen 6-7 kg (80%)
- Phosphorus 1-1.7 kg (25%)
- Potassium 14-25 kg (21%)
- Sulphur 1.2-1.5 kg (4-60%)
- To restore the formal condition of soil after burning of residue very costly

Other Losses of Soil/ha

- Organic carbon 95 lakh ton
- Urea 80 kg
- Diammonium phosphate 13.75kg
- Potash 128 kg

Deterioration of Soil Causes

- Loss of wheat yield one q/ha
- Reduction in yield and nutrient loss due to burning monetary loss may be of Rs 500 crore per year

Effect of Paddy/Wheat Straw Burning on Temperature

- The temperature of 7 cm top soil rises after straw burning
- Variation in equilibrium of micro organism like fungi (9:1), the percent bacteria (4:1) and carbon: Nitrogen ratio (11.1)

In-Situ Incorporation

In-situ incorporation of residue in soil can be manage by using technologies for sowing of wheat after rice like conventional tillage (7-8 times) is very costly practice. Rotavator can also be used for the in-situ management of rice residue. Another technology is chopper for incorporation the residue in soil which is practiced for sowing wheat in Punjab. In-situ incorporation of residue increases the soil nutrient as N, P, K and SOM. The incorporation of residue causes the immobilization of inorganic N. It is found that straw incorporation with starter dose N of 15-20 kg ha^{-1} enhances wheat and rice yield than burning[8] (Kaur, 2017).

Surface Retention

Surface retention of residue in soil can be managed by the technology of happy seeder and zero tillage. Happy seeder is used in the combine harvested paddy fields for planting of wheat. Zero tillage is also used in standing stubbles of combine harvested rice after removing loose straw. It was also observed that with the practice of surface retention of residues enhances the soil NO_3 by 46%, N uptake by 29%, and yield by 37% than burning.[9] The soil physical properties viz. soil moisture, temperature, aggregate formation are affected by residue management practices. Surface retention is also act as mulch and mulching play important role in suppression of weeds.

Removal

Removal/bailing practice is comprised of utilizing as animal feed, preparation of cardboard, energy, compost and lower the wages of manual harvesting. Grow the new crop varieties producing lesser residue.[8] This practice is also producing lesser quantity of residue during harvesting.

It has been also reported as surplus residue is used in the preparation of power about 1194 MW / year in Punjab which is helpful to reduce the environment pollution by residue burning but the burning of paddy straw as still continue in the fields.[11] The management of crop residue scientifically and used for energy generation would be beneficial to reduce the use of fossil fuel, coal, wood, save the foreign exchange, employment generation and also helpful to raise the income of farmers.

Water Saving

The management of residue play significant role in protection of soil surface but also reduce the evaporation losses and water saving by the use of crops. The residue on the soil surface reduces the touching of sunlight and reducing the air exchange which resulted in less use of energy for the loss of water from the surface of soil (evaporation). The water saved with the management of residue is used by the crop for transpiration.[9]

Table 1: Water saving from different source

S. No.	Source of water saving	Water saving (cm)
1.	Reduction in evaporation	5-9.5 cm (2-3.8 inches)
2.	Elimination of tillage	0.75-1.75 cm per pass (0.3-0.7 inches)
3	Increased winter storage	2.5-5.0 cm (1-2 inches)
Total		**8.25-16.25 cm (3.3-6.5 inches)**

Source: Uddin and Fatema (2016)

Crop Productivity

The management practices of rice residue impact the soil physical and chemical properties and productivity of crops.[9] The studies reported that rice-wheat sequence gave the yields of 7 t ha^{-1} of rice and 4 t ha^{-1} of wheat which resulted in removal of more than N 300, P 30 and K 300 kg ha^{-1} from the soil and produced the residue about 7-10 t ha^{-1} yr^{-1}.of rice and wheat in the study area. In South Asia, rice crop is produced the residue of 9-10 t ha^{-1} and the farmers of this area need to manage the residue while wheat sowing.

Recommendations for Residue Management

- To reduce the cost of cultivation operations, need to encourage the farmers to utilize the rice residues.
- To enhance the soil fertility needs to aware the farmers about the different benefits of management of crop residues.
- To encourage the farmers to participate in the training of crop residue management.
- Provide the cultivation techniques at reasonable prices.
- Creating of awareness among farmers about the extent of cause of pollution by burning of straw in the fields.
- To check the burning of crop residue in the fields implement the law strictly.

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