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# Crop Residue Management under Changing Climate Scenario

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

An effort has been made to study the effect of climate change on crop residues and need of crop residue management in present environmental condition. Crop residue management as an important practiced in the rice–wheat cropping system. In present condition, cropping season is shifted according to changing rainfall pattern. In case of wheat and rice-based cropping system, there is a chance of crop loss due to occurrence of rainfall at harvesting stage so, to cope with that situation combine harvesters become more popularize among farmers because of effective harvesting in less time, less effort and minimum labour cost. But it lefts a huge amount of loose straw in their field and farmers face difficulties in the disposal of huge straw in the field in short time has compelled to go for crop residue burning to save time as well labour. Farmers can use that residues in vermi-composting, can be fed to animals after urea treatment etc. without burning. In recent year 30-40% maize crop have been damaged due to hailstorm at its grain filling stage so these residues can be used in making silage. Removal of straw or stover can result in significant loss of soil organic carbon (SOC). If they are used as bedding for livestock, then much of the carbon may be returned to the soil as manure (Lal et al., 1998). When crop-residue is incorporated into soil, the soil's physical properties and its water-holding capacity are enhanced. Unlike in earlier conservation farming systems wherein retained stubble was mulched and slashed, now it is mostly burned by the farmers. Vermicomposting, waste decomposer, Green Manuring, use of zero tillage machine, silage making and urea treated straw are the best option to crop residue management. The study aimed to examine the present status of crop residue management of major crops and its impact on farmers' livelihood covering eleven blocks in Banka district of Bihar.

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*Keywords: Climate change; burning of crop residues; effect of burning and crop residue management.*

## 1. INTRODUCTION

Crop residue burning in farms is not new to India. Large quantities of residues are generated every year by agriculture. Cereals, grass, sugar beet, potatoes and oilseed rape are arable crops that generate considerable amounts of residues [1]. In Bihar, rice is the most important crop from the perspective of production volume, value, land coverage and employment generation. Rice based cropping patterns are the most intensive production system in the country. Rice-wheat are the most intensive cropping patterns. But the conventional agricultural production practices are comparatively lower-yielding and it seems difficult to change this yield with reachable resources under the prevailing situation. Due to growing repeated cereal crops, soil fertility and crop productivity are reducing over the time. This has occurred through inappropriate management of fertilizers, tillage and crop residues [2]. Crop residues are the materials left in an agricultural field after the crop harvested. These residues include stalks, stems, leaves and seed pods. Normally, these are either harvested as fuel, animal bedding or are burnt in the field. As harvest remnants, crop residues play an essential role in nutrient recycling to improve soil quality and ensure higher level of crop productivity. It can be composted by various methods on the farm and used in the field for mulching. Incorporation of crop residues in the field alters the soil environment, which in turn influences the microbial population and activity in soil and subsequent nutrient transformations [3,4]. The recycling of crop residues has great potential to return a considerable amount of plant nutrients to the soil. Left on the soil surface, crop residue serves as a mulch to decrease soil temperature and maintain higher soil moisture as well as reduce carbon emission in the atmosphere. Crop residue practice is suggested for the purpose of preserving and enhancing productivity [5]. It results in substantial saving in irrigation water and fertilizer and thereby improves soil fertility and enhances crop productivity. In addition, these can be used as animal fodder. The collected residue can be composted by using it as animal bedding and then heaping it in dung heaves. It aims to help farmers to earn more income with reduced amount of labour, fertilizer, irrigation and other input costs [6,7]. However, it is a great challenge for the agriculturists to manage rice residues effectively and efficiently in order to enhance crop production. Sharma and Prasad [8] conducted a study on coupling of green manuring with residue incorporation for increased and sustained grain productivity.

According to a 2014 study by the Indian Agricultural Research Institute (IARI), in 2008-09 the country generated 620 million tonnes of crop residue, of which close to 16 percent was burnt on farms [9,10]. Of this, 60 per cent was paddy straw, while wheat accounted for just 22 per cent. Of late, courts and governments have issued stern regulations and guidelines on burning crop residues. On December 10, 2015, the National Green Tribunal (NGT) banned crop residue burning in states of Rajasthan, Uttar Pradesh, Haryana and Punjab. Parts of these states constitute the National Capital Territory. In 2014, the Union government released the National Policy for Management of Crop Residue, which NGT directed the states to implement. Under this policy each state needs to have an action plan to stop residue burning by involving people at different levels—from communities to panchayats to state governments. It also calls for a mechanism to alert to cases of crop burning. Moreover, crop residue burning is punishable under the Air (Prevention and Control of Pollution) Act, 1981.

## 2. MATERIALS AND METHODS

The data required for this study was collected from the farmers of different villages of Banka district and interviewed personally using standard procedure with pre-module questionnaires. The study was conducted at different villages where farmers have been following crop residue practices. Field surveys and key informant inter-views were followed to collect primary data. A total of 72 farmers was interviewed for this study. Data were collected from respondents using structured questionnaire. Secondary data and information from different reports, publiccations, notifications, etc. relevant to this study were also collected and analyzed for this research.

Work had been stared with the following objectives: - Control of burning of crop residue to prevent environmental degradation and loss of soil nutrients and minerals by promotion of in-situ management (incorporation in soil, mulching, baling/binding for use as domestic/industrial fuel, fodder) of crop residue. Diversified use of crop residue was for various purposes like power generation, as packing material, paper/board/ panel industry, composting and mushroom cultivation etc. Capacity building and awareness

programme was needed about ill effects of crop residue burning and its effective utilization and management.

## 3. RESULTS AND DISCUSSION

### 3.1 Crop Residue Production as Well as Burning Status of India

India, with 17% of the world population and an agrarian background generates large volumes of food grains such as rice and wheat for domestic consumption as well as for export. The crop residue production status of India is given in Table 1. According to the Directorate of Economics and Statistics, in 2012–2013, India generated 361 Mt of sugarcane, 94 Mt of wheat and 105 Mt of rice. There are many environmental risks associated with stubble burning. If followed continuously burning can reduce soil quality and make land more susceptible to erosion. Tanvir et al. [11] examined farmers' choices for rice residue burning in Pakistan and found that an increase in the burning of rice residue after the entry of the combine harvester.

### 3.2 Possible Solution to Crop Residue Management

- Incorporation of crop residue into soils through adoption of conservation agriculture practices to prevent soil erosion from wind & water and to augment the soil moisture. Conservation agriculture is a cropping system that is based on three principles which are minimum soil disturbance, maintenance of a permanent soil cover by the use of crop residues and cover crops; and diverse plant associations. In situ in solutions will not only manage the stubble but will also add necessary organic matter and nutrients to the soil, thus, decreasing the requirement of fertilizers in it.
- Promotion of use of crop residue for preparation of bio enriched compost/ vermi-compost and its utilization as farm yard manure Waste decomposer: In this a solution is formed with microorganisms in it that that propel in-situ composting of the crop residue. However the process takes at least a month.
- Use of crop residue for cultivation of mushroom particularly Agaricus bisporus (white button mushroom) and Volvriella Volvacea (straw mushroom)
- Incentivize purchase of happy seeder/turbo seeder / shredder/ baling machines and zero- seed-cum-fertilizer drill to facilitate in-situ management of crop residue and retaining the straw as surface mulching. It is a machine which is mounted on a tractor and can plant the wheat seed within the stubble of rice. It cut sand lift the rice straw, sows wheat into the bare soil and deposits the straw over the sown area as mulch. A lot of time is also saved as there is not requirement to clear the field.

### 3.3 Crop Residue Management in Paddy, Wheat and Maize

As per the information collected from questionnaires, Nov-Dec and March-April are the crucial period for harvesting of Paddy and Wheat respectively. Main reason behind burning of paddy straw are most importantly pressure of preparing the field for the next cropping season (harvest rice and cultivate wheat in a space of 15-20 days.) makes burning the cheapest and quickest method. In case of wheat, alternative methods require additional investment in machinery, oil etc. which costs too much and this becomes more difficult for the farmers with small and marginal land holdings. Use of combine harvester for quick harvesting, makes lowering of straw quality which was not palatable to animals. But after treatment with urea, it becomes palatable and more nutritious and can easily be eaten by animals. Apart from this, huge crop loss was noticed in these crops if rainfall/hailstorm occurred at harvesting stage (Table 2). In recent year, 30-40% crop loss found in case of maize, wheat and onion in Banka district due to hailstorm in the month of April. So, these crop residues can be used for silage making to make round the year fodder availability to animals.

Through forecasting we harvest grains only and green straw use to make silage and preserve for long time and they were not spoiled. Maize residues can be utilized as animal feed after urea treatment. In case of maize crop, if grain setting affected due to low temperature then that stubbles can be utilized in silage making of animals which is easy and cost effective and can preserve tons of maize straw in one day and use as per need. Due to low and erratic rainfall, weed problem become more prominent in crop field. These weeds can be preserved as silage daily 50-100 kg and preserve for long time to use during scarcity period which requires less space. There are some suitable crops used for silage making such as maize, sorghum, oats, pearl millets and hybrid napier. Quality of silage can be improved with the use of suitable additives such as molasses, urea, salt, formic acid etc.

**Table 1. Crop residue production of major crops in India**

| S. No. | Crop | Area (M ha) | Residue: Grain ratio | Residue production (Mt) |
|---|---|---|---|---|
| 1. | Wheat | 25.1 | 1.5 | 93.5 |
| 2. | Rice | 42.7 | 1.5 | 180.0 |
| 3. | Barley | 0.8 | 1.5 | 2.7 |
| 4. | Maize | 6.2 | 1.0 | 8.9 |
| 5. | Millet | 13.5 | 1.5 | 15.8 |
| 6. | Sorgham | 11.7 | 1.5 | 15.8 |
| 7. | Beans | 10.6 | 1.0 | 4.1 |
| 8. | Chickpea | 7.3 | 1.0 | 6.0 |
| 9. | Soybean | 4.9 | 1.0 | 4.2 |
| 10. | Groundnut | 8.0 | 1.0 | 8.0 |
| 11. | Sunflower | 2.2 | 1.0 | 1.5 |
| | Total | 133.0 | | 340.5 |

*Source: Advances in Agronomy, 2006*

**Table 2. Rainfall/Hailstorm activities (during crop harvesting period) for the year 2018**

| Month | Crops | Crop Stages | Rainfall(mm)+ Hailstorm | Impact |
|---|---|---|---|---|
| April | Wheat | Maturity/ Harvesting | 26.5 | The yield of different crops was reduced due to both rainfall and hailstorm activities at peak period of crop growth (30-40% crop damaged in April month) and left a large amount of crop residues in field. |
| | Maize | Flowering/Grain setting | | |
| | Onion | Vegetative/Flowering/ Bulb initiation | | |
| May | Wheat | Harvesting | 54 | |
| | Maize | Grain formation/Maturity/harvesting | | |
| October | Rice | Dough/Milking/Ripening | 34.2 | |
| November | | Ripening/Maturity/Harvesting | 0 | |
| December | | Harvesting | 7.8 | |

### 3.4 Methods of Silage Making

- Harvest the green crop at flowering stage
- Wilt the harvested fodder to bring down the dry matter to 30-35%, if required.
- Chop the fodder into small pieces of 2-3 cm size.
- Fill the chopped fodder into the airtight plastic bag.
- Press the chopped fodder in the plastic bag layer by layer of 30-45 cm.
- Filling and pressing should be completed as fast as possible.
- Use additives during filling of fodder in the plastic bag, if required.
- After filling and pressing, plastic bag should be sealed with thick polyethylene sheet.
- After 45 days the plastic bag should be open for feeding to animal as per need.

### 3.5 Benefits of Urea Treated Straw and Silage Feeding

Urea treatment of straw (UTS) costing average 0.84 Rs/kg and feeding of UST 6.8kg/day/animal, decreased the concentrate requirement by 20% and saved concentrate and cost of feeding 492± 0.2 kg, Rs.8503±428/inter calving period/cow (Table 3). Similarly, Mallik, et al. [12] reported cost of urea treatment was 0.96Rs/ kg and animal fed 8kg UTS/day/animal. This may be due to increased crude protein through added non-protein nitrogen (NPN) digestibility of treated straw. Urea treatment increases microbial protein synthetic activity in the rumen making more microbial protein yield available in the lower gut for higher milk production.

Costing of Silage making was 0.72Rs/kg and feeding of silage increased the milk yield and net

**Table 3. Economics of urea treated straw and silage feeding**

| Parameters | Performance |
|---|---|
| **Urea treated Straw feeding** | |
| Cost of UST (Rs) | 0.84 |
| Reduced Concentrate requirement (kg) /lactation | 492±22 |
| Net income cow/lactation | 8503±428 |
| **Silage feeding** | |
| Cost of silage (Rs/kg) preparation | 0.72 |
| Net income/ cow/lactation | 10516±322 |

income by 10% and 10,516 Rs/Animal/ ICP, respectively. Halden et al. [13] reported not any effect on milk production or milk composition on grazing cows yielding 32 kg of milk received 2.3 kg/d of corn silage DM.

In year 2015, Krishi vigyan Kendra, Banka organised one day training program on benefits of feeding urea treated straw and gave concept of digestion and others benefits. When green fodder is not available, due to feeding of urea treated straw (UTS) milk production decreased by only 10% and when both are not available then by 20%.

## 4. CONCLUSION

From the above studies we concluded that one of the relevant reason for crop residue burning is mechanized farming. To avoid burning of rice (and wheat) stubble, management of agricultural waste for alternate uses is being practiced and promoted. Agricultural waste includes paddy and wheat straw, maize stubbles etc. and keeping in view the increasing problems associated with crop stubble burning several initiatives for its proper management have been taken up. These include use of rice residue as fodder, mushroom cultivation, as bedding material for cattle, bio-gas and in situ. Various departments and institutions are promoting alternative uses of straw instead of burning. Major utilization options of crop residue were identified which are: animal feed, cooking fuel, incorporation with tillage for organic fertilizer and mulching. However, farmers' perceptions about the use of crop residues were mostly adding organic matter to the crop field followed by mulching and feeding animal. Finally, the study pointed out the recommendations as (i) farmers should be encouraged to utilize their rice crop residues which will facilitate their farming operations profitable; (ii) farmers should be informed about the various benefits of utilization of crop residues by extension agents or other government and non-government organizations to encourage for utilizing their rice crop residues efficiently which will improve soil fertility; (iii) farmers should be encouraged to attend training on the proper utilization of different crop residues and (iv) proper technique and technology should be provided to the farmers at reasonable cost so that those could be used to minimize the gap of yield of different crops in order to improve their livelihood.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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