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Crop residues utilization: Wheat, paddy, cotton, sugarcane and groundnut

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Abstract
Crop residues are plants part which are left in the field after harvesting. These are good source of nutrients when added to the soil. These are not waste but they are the good natural resources. They contain all nutrients which are requiring for plant growth. Among these the important crops like Wheat, Paddy, Cotton, Sugarcane and Groundnut left large amount of residues in the ground which might be utilize by many ways. The aim of this article is to provide the use of such crop residues which has been left after harvesting in the field and it might be used in different fields like industry, nutrient and energy production etc.

Keywords: crop residues, waste, nutrients, industry

1. Introduction
Plant parts left after crop harvesting called crop residues which are the good source of soil nutrients. It is not a waste whereas a good natural resource and it is the largest part of agricultural harvests which contains huge amount of carbon and other nutrients *viz.* nitrogen phosphorus, sulfur, potassium etc. These elements must be recycled for the sustainable development of agriculture. Crop residues are not waste but it is a providers of essential environmental services, assuring the perpetuation of productive agro-ecosystem [1]. Crop residues can be a valuable resource for carbon sequestering and/or power generation [2]. It is also as organic material remains left behind on fields after harvesting, such as corn stalks and husks. Often this bulk holds more carbon than the crop itself. During a growth season, crops store carbon from air, and then exhale it as the crop residues rot, giving no net change in atmospheric CO_2. Removal or burning of residue ensures farmers quick seedbed preparation and avoids the risk of reduced crop yields associated with incorporating wide C/N ratio residue that immobilizes N during decomposition. The benefits of sequestering soil organic C (SOC) to sustaining crop productivity by applying organic amendments and crop residue and including legumes in crop rotations have been well documented in the temperate regions [3]. Although large numbers of green manuring studies have been conducted with rice in Asia, few studies have looked at comparative effects of crop residue management with or without fertilizer N and legume green manure on crop yields and SOC [3-4].

2. Characteristics of crop residues
Crop residues are characterized by low digestibility, low metabolisable energy content, low crude protein content, low intake and low content of available mineral and vitamins. Crop residue is a vital natural resource for conserving and sustaining soil productivity [5-6]. Additionally, residue incorporation can improve physical and biological conditions of the soil and prevent soil degradation. In South and Southeast Asia, large amounts of crop residue are burned or removed after harvest which causes loss of organic matter and nutrients ultimately atmospheric pollution enhances. Different compositions of different components in crop residues are shown in table-1. In the developing world, most agricultural residues burnt as fuel are used in their natural state with some pre-treatment like drying, and cutting, and compacting in rare occasions. Crop residues are characterized by its seasonal availability and have characteristics that differ from other solid fuels such as wood, charcoal, char briquette. The main differences are the high content of volatile matter and lower density and burning time [7].

Table 1: Elemental analysis of crop residues

Crop Residues	Elemental analysis (%)											Ash (%)	Calorific Value(MJ/kg)
	C	H	N	Na	K	P	Mg	Ca	SiO_2	O	S		
Arhar Stalks	53.30	4.70	0.60	0.05	0.57	0.08	0.40	0.11	0.68	-	-	1.98	-
Bagasse	48.20	6.10	0.20	0.06	0.51	0.04	0.36	0.14	1.30	44.40	0.01	3.01	18.18
Cotton Sticks	51.00	4.90	1.00	0.09	0.61	0.08	0.43	0.12	1.33	43.87	0	3.10	17.4
Groundnut Shell	41.10	4.80	1.60	0.05	1.20	0.12	0.40	0.10	2.52	-	-	4.43	-
Maize cobs	46.20	4.90	0.60	0.03	0.54	0.07	0.28	0.09	2.00	-	-	3.02	-

Maize stalks	41.10	4.20	0.60	0.04	0.42	0.05	0.45	0.08	0.90	-	-	2.10	-
Rice husk	37.80	5.00	0.30	0.02	0.30	0.03	0.17	0.10	15.77	35.45	0.03	16.5	14.4
Rice straw	36.80	5.00	1.00	0.09	2.50	0.06	0.53	0.08	15.60	40.50	0.02	19.2	11.7
Wheat Straw	43.80	5.40	1.00	0.06	0.78	0.04	0.35	0.10	7.08	-	-	8.47	-

(***Source*:** Dubey *et al*... [8])

2.1. Advantages of crop residue

- Agricultural residue is a fuel which is available free of cost to the poor rural families.
- It is also a useful way to dispose of the crop residues in the field, instead of burning them *in situ*.
- Agricultural wastes remain safer than LPG which poses some safety concerns in local transport and use.
- It is easy to handle and transport.
- Low impact on women's time for harvesting.
- Agricultural wastes are much easier to light than wood and charcoal.

2.2. Disadvantages of crop residue

- It is responsible for extreme cases of air pollution when it is burned in open fires.
- It is very bulky and has to be carried to the homes.
- The seasonal availability of crop residues can be limit for its use.
- Its burning time is worse.
- Its storage requires more space in house.

3. Economic and Environmental Implications

The advantages of using crop residues as energy source are two folds: economic, and environmental [9].

3.1. Economic

For the farmer, agricultural residues can be a cash crop. Traditionally farmers have harvested grain and burnt or otherwise disposed of straw and other residues. The marketability of crop residues will boost local economies by providing jobs and services. An increase in farm earnings will diminish the need for farm subsidies, which will eventually reduce farmer's reliance on the government for support. For industry, 4 kg of crop residues could replace the one liter of furnace oil.

3.2. Environment

The burning of agricultural wastes causes' air pollution, soil erosion, and a decrease in soil biological activity, which eventually leads to lower yields. A tonne of crop residues is used to replace 0.5 tonnes coal prevents addition of 1.5 tonnes of CO_2 to the atmosphere. Proper use of 150 Mt of anticipated biomass could reduce CO_2 emission by over 250 Mt each year.

4. Crop Residue Management (CRM)

Crop residues are good sources of plant nutrients and are important components for the stability of agricultural ecosystems. About 400 million tons of crop residues are produced in India alone. In areas where mechanical harvesting is practiced, a large quantity of crop residues is left in the field, which can be recycled for nutrient supply. Both rice and wheat are exhaustive feeders, and the double cropping system is heavily depleting the soil of its nutrient content. A rice-wheat sequence that yields 7 tons per ha of rice and 4 tons per ha of wheat removes more than 300 kg N, 30 kg P, and 300 kg K per ha from the soil [10].

Crop residue management should serve a double function, both confronting global warming and food security by increasing carbon sequestration in agriculture and increasing grain yields [3]. Historically, the North China Plain has experienced different crop residue management practices. While direct burning in the field remains an environmental problem in the region, crop residue amendment triggers benign cycling of C and nutrients in agriculture. Data showed that soil organic carbon (SOC) in top soil increased by 0.174 to 1.74 g kg^{-1}, with an average of 0.79 g kg^{-1} after wheat residue amendment collected from 35 sites in the North China Plain [11-12]. CRM practices are used to conserve soil and water [13-15].

- CRM systems include conservation tillage practices such as zero-till, reduced till, bed planting, and other practices that provide sufficient residue cover to protect the soil surface from the erosive effects of wind and rain.
- CRM is a year-round system, which includes all field operations that affect the amount of residue, its orientation to the soil surface and prevailing wind and rainfall patterns, and the evenness of residue distribution throughout the period requiring protection.
- Crop residues and their appropriate management suppress the weeds: through their physical presence on the soil surface as mulch; by restricting solar radiation reaching below the mulch layer; by direct suppression; and by controlling N availability.
- CRM and tillage practices also influence the efficiency of soil-applied pre-emergence herbicides. Because pre-emergence herbicides are applied to the soil, the amount and quality of residues and also ash left behind after residue burning might affect their effectiveness. This means that a higher rate of herbicide application is often needed to achieve effective weed control.
- The main advantages of CRM over conventional systems include fuel and labor savings, as well as long-term benefits to soil structure and fertility.

4.1 Burning of crop residues

With the advent of mechanized harvesting, farmers have been burning large quantities of crop residues, particularly in areas with high yield potential. As the crop residues may interfere with tillage and seeding operations for the next crop, many farmers prefer to burn the residues left in the field. Table-2 shows the state wise burn crop residues in India. According to Sardar Patel Renewable Energy Research Institute (SPRERI), 2004, 71.6 Mt crop residues burnt in a year.

Table 2: Crop residues burnt in India

Crop	Major producer states having surplus crop residues	Amount of crop residues (million tonne)	Surplus crop residues (million tonne)
Rice	Punjab, Haryana	18.6	15.0
Wheat	Punjab, Haryana, UP, Rajasthan, M.P.	67.6	15.4
Sugarcane	UP, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat	26.9	21.6
Groundnut	Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh	15.4	3.3
Mustard	Rajasthan, UP, MP, Haryana, Gujarat	9.4	4.5
Cotton	Gujarat, Maharashtra, Haryana, Punjab, Rajasthan, Karnataka	29.4	11.8
	Total surplus		71.6 Mt

(***Source*:** Dubey *et al*... [8])

5. Use of agricultural crop residues

Field produced Crop residues are used as crop mulches and animal bedding as well as animal feed. Crop residues have always been used in many ways. They have been an important source of household fuel and building material in many low income countries and providing indispensable bedding and feed for animals. Different uses of crop residues are as follows:

5.1. Animal feed

In many parts of the world (particularly in areas with low yield potential), crop residues are essential for feeding to animals. Animals are left to graze freely on harvested fields or straw is collected off the land and taken to the pen to feed livestock and prepare bedding. This scenario, if not managed sustainably, often results in deteriorating soil fertility; nutrients are removed from the land and not returned and the bare soil is exposed to wind and water erosion. Some nutrients may be returned to the soil through the manure left by grazing animals; however, most of the nitrogen is lost to the air.

5.2. Building Material

In many poor countries or the low income families used crop residues for house purposes. Mainly the straw of paddy, wheat, etc. is used for this purpose.

5.3. Ethanol Industry

Availability of feed stock in India of different crop residues are as follows: -

Sugarcane bagasse	-	119.4
Rice straw	-	153.36
Wheat straw	-	113.6
Maize stover	-	29.5
Sorghum stover	-	15.6
Pear millets over	-	13.0
Cassava bagasse	-	1.11

The realistic scenario with 3% of major feed stock (wheat and rice straw, and Sugarcane bagasse) being used for production and at 75% theoretical yield, the projected ethanol yield will be 3.645 billion liters annually [16].

5.4. Biofuel Industry

The feedstock is introduced into the reaction unit. The additive is introduced into the processing unit under ambient temperature and pressure. The oil is directly extracted from the crops leaving behind empty undestroyed shells. The oil/water/additive mixture is then separated in the separation tank. There is no requirement for heating, water and steam, and the process can be performed in batch or continuous process. The empty shells can be sold to paper making companies or production of construction materials.

5.6. Agricultural Uses

The advantages of the use of crop residues are in agriculture to increase soil organic carbon and the soil microbial activities. Legumes can grow well before rice, producing large amounts of residues and fixing atmospheric N_2, leading to considerable increase in yields of succeeding rice crops. So the legumes residue is important for agricultural management [3].

5.7. Energy Production

For the functioning of the sugar/alcohol industry, sugarcane is ground and the resulting soup is used to extract sugar or used in a fermentation process to produce alcohol. Currently, sugarcane bagasse is burned in a boiler to produce steam which is utilized in the factory's processes and also to power turbines for the production of electrical energy [2]. The combustion yields ashes (bottom and fly ashes) containing high amounts of charcoal (~30 % by weight) and silica as major component. Aluminum, calcium, iron and magnesium oxides are the main minor components. Approximately 70% of the ash weight is inorganic material. In Kenya data obtained from the preliminary study indicates that if the country's sugar industry were to all switches to the use of advanced gasification technology, then it would be possible to generate more than 457,569 MWh of electric power annually in excess of the on-site requirements, and which can be supplied to the national public grid systems.

6. Use of wheat, paddy, ground nut, cotton and sugarcane residues

6.1. Wheat

1. Bran, germ and middling are valuable feed and stack.
2. Straw is used as bedding for cattle, for packing fragile foods, for thatching etc.
3. Straw also useful for furfuryl alcohol.
4. Straw pulp is utilized in the manufacture of paper, straw board and building material.
5. Straw is also use as biogas generation.
6. Bran, straw etc. also useful for mushroom culture. And
7. As a raw material for industry.

6.2. Paddy

Much rice straw is used for bedding, fuel and paper manufacture. It is assumed that only 0.6 kg of rice straw and chaff is fed for each kilogram of rice grain harvested.

1. Husk is used as a fuel and for making hardboard and as a row material for alcohol and furfural.
2. Bran serves as cattle feed and edible fatty oil is also obtained from bran.
3. Straw is used as fodder, as soil mulch and in the manufacture of straw board.
4. Straw is also used for thatching, making heats, mats, sacks, ropes and baskets.

6.3. Ground Nut

1. Oil cake is used as feed for cattle and other farm animals and also used as manure.
2. The best quality cake of ground nut into flour for human consumption as a protein rich food supplement.
3. After harvesting the residues are left in the field and use for maintaining N-availability in the field.

6.4. Cotton

Cotton seed and the leaves of cotton plants are important livestock feeds, and the woody stalks are used for fuel. Plant residue, a by-product of the cotton harvesting operation, has high yields of cellulose biomass that can produce significant thermal energy.

1. Cotton seeds are rich in protein and vitamins of the B-complex and are use as cattle feed.
2. The decoction of seeds is used in the treatment of dysentery and intermittent fevers.
3. Cotton seeds oil is an edible vegetable oil and also useful for the manufacture of soap, lubricants, sulfonated oil and protective coatings.
4. Cotton seeds oil is also a substitute for olive oil in pharmaceutical industry.
5. Root bark used as an ergot like drug.
6. Stem used for fuel and paper pulp.

6.5. Sugarcane

It is assumed that only one kilogram of sugar-cane residue dry matter (stripped leaves and bagasse) is offered to livestock for every 10 kg of raw cane harvested. This considers that about 60% of the bagasse is used for fuel in the sugar mills.

1. Bagasse used mostly as fuel, in the manufacture of paper and wall board.
2. Bagasse is also used as mulch for plants and as a litter or bedding for poultry and livestock.
3. Molasses is used as food stuff for candy making and also for cooking.
4. Molasses widely used in the manufacture of rum, vinger, glycerol, lactic acid, industrial alcohol and monosodium glutamate etc.
5. Sulphitation filter mud is used as manure.
6. Sugarcane wax obtained from sulphitation filter mud, used as a substitute of carnauba wax in the manufacture of carbon paper, wax paper and shoe and other polishes.

7. Conclusion

The intelligent management and utilization of crop residues is essential for the improvement of soil quality and crop productivity under rice-based cropping systems of the tropics. Crop residues, usually considered a problem, when managed correctly can improve soil organic matter dynamics and nutrient cycling, thereby creating a rather favorable environment for plant growth. Crop residues contain large quantities of nutrients, and thus the return of crop residues to the soil can save a considerable quantity of fertilizers. Residues rich in lignin and polyphenol contents experience the lowest decay. Decomposition of crop residues occurs at a rapid rate under the warm and humid conditions of the tropics. Crop residues caused marked increases in microbial populations and microbial biomass in soils. The addition of crop residues to flooded soils enhanced biological N fixation by phototrophic and heterotrophic bacteria. So that finally concluded that the crop residues are not the agricultural waste but it is most valuable for the managing system as well as for the human welfare.

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